Skin processing technology in eurasian Reindeer cultures

A comparative study in material science of Sàmi and Evenk methods – perspectives on deterioration and preservation of museum artefacts

PhD thesis
Torunn Klokkernes

2007

LMR PRESS

ISBN 978-87-88509-33-5

Published by LANGELANDS MUSEUM,
Jens Winthersvej 12, 5900 Rudkøbing

Designed by Torleiv Sverdrup

Skin processing technology in Eurasian reindeer cultures

A comparative study in material science of Sàmi and Evenk methods – perspectives on deterioration and preservation of museum artefacts

PhD thesis

Torunn Klokkernes

The Royal Danish Academy of Fine Arts
The School of Conservation

MUSEUM OF CULTURAL HISTORY
UNIVERSITY OF OSLO

2007

PREFACE

My interest in reindeer skin as a material for clothing and footwear was initiated in 1991 with the study of the Roald Amundsen collection from the Netsilingmiut Inuit culture at the Museum of Cultural History, University of Oslo. As I was reading Roald Amundsen's diaries from the Gjøa-expedition (1903-1906) in pursuit of information on the skin artefacts from this expedition, he inadvertently answered one of my questions regarding a cracking feature I had observed in the epidermal layer of the reindeer skin. Whereas I, as a conservator, was inclined to relate this feature to deterioration, Amundsen revealed that it most likely was part of the skin processing method.

Historic sources are invaluable for the understanding of skin and fur artefacts. However, the traditional knowledge of skin processing, which is still being taught and used, is even more important. My respect for the expertise and the diversity in the skin processing technology was renewed in a meeting with Evenk women in Chapo Ologo, in Siberia some years later, in 1998. This resulted in several travels to Siberia and the idea of a project arose, where the science of traditional knowledge and the science of conservation could be joined. But it was not until I came in contact with the Sámi Culture Museum (Samiid Vuorká-Dávvirat) in Karasjok, Norway that I found that such a project was realisable. In this co-operation the foundation for an application to the Sámi research programme in the Norwegian Research Council was laid, a project that would bring together traditional knowledge, material science and the preservation of skin artefacts currently housed in museum institutions.

I would also like to direct a heartfelt thanks to my husband Dr. Ole Grøn who, through his research, introduced me to the Evenk culture and included me and my project in his travels to Siberia and to conservator and friend, Anne May Olli, at the Samiid Vuorká-Dávvirat who introduced me to the Sámi culture and to her family.

This project has been carried out at the Royal Academy of Fine Arts, The School of Conservation in Copenhagen, and at the Museum of Cultural History, at the University of Oslo where I have been located in the project period. I would like to thank both institutions for their enthusiasm and support. Dr. Jane Richter, Head of department, and Rector Dr. René Larsen from the School of Conservation in Copenhagen are responsible for the supervision. In addition, Professor emeritus of social anthropology, Tom G. Svensson at the Museum of Cultural History, UiO has been supervising me during the project period. Thank you all for your invaluable guidance and support, and your critical and constructive feedback, from beginning to end.

My gratitude goes in particular to the informants and tradition bearers from the Sámi and the Evenk culture that, for hours, patiently answered all my questions and generously gave of their knowledge. This also encompass the interpreters who translated questions and answers, during the study visits to Chapo Ologo, Sredniy Kalar, Nichatka, Olenek and Kharyyalach in Russia and in Karasjok, Suotnju, Masi and Kautokeino in Norway. Thank you all.

The assistance during and the organisation of interviews with tradition bearers would not have possible if not for the co-operation with the following institutions: Samiid Vuorká-Dávvirat in Karasjok, Norway, the Academy of Sciences, Department of Arctic Research, in Yakutsk, Russia, Olenek Historical-Ethnographical Museum of North Peoples in Olenek, Russia, Kalar Folk Museum in Chara, Russia, and Chita Technical University in Chita, Russia.

The museums in Russia, Finland and Norway which gave access to collections and artefacts, and, in addition, gave permission to obtain samples from historic artefacts, have my greatest appreciation and, I thank the employees who made this possible. I would also like to thank Ganna Zaitseva and Tatyana Smekalova and their families for their help and hospitality during my visits in Russia.

My gratitude goes to CRCDG (Centre de Recherches sur la Conservation des Documents Graphiques) in Paris, France, where the HPLC analysis was done and, a particular thanks to Frédérique Juchauld and Sylvie Tao for the work they did and for their support and feedback. My thanks also go to Jens Glastrup at the National Museum in Copenhagen, Denmark who did the GC-MS analysis and helped me

in the interpretation of the results. I would also like to thank statistician Judith L. Jacobsen who performed the statistical analysis in the thesis.

All photographs in the thesis, unless otherwise stated, are taken by the author and I would like to thank photographer Ann Christine Eek, at the Museum Cultural History for her work in making the photographs look their best.

I would like to express my appreciation to graphic designer Torleiv G. Sverdrup for the layout of this thesis and to his wife, Karin Eng Rusten Sverdrup. Thank you both for your hospitality and kindness during my stay in your house. Librarian Nancy Frank has proofread the manuscript and I thank her for her work. All errors present in the text are my responsibility.

Special thanks goes to curator Susan J. Matland and Magne Bolstad who during these three years have been of invaluable help and support, not only in reading and commenting on the work, but also in their encouragement and friendship.

Finally I would like to thank colleagues, friends and not least my family for their patience and support, and my husband for inspiring discussions and enjoyable travelling experiences.

Torunn Klokkernes
Oslo, 23.5.2007

TABLE OF CONTENTS

INTRODUCTION

Being comfortably dressed and surviving the cold winters in the Eurasian arctic and sub arctic depends entirely on the clothing you are wearing. Maintaining body heat and being able to work up a sweat without the subsequent formation of icicles on the skin requires a material that insulates, yet breathes, and that is available to the indigenous peoples inhabiting these regions. This has been achieved through many generations by the use of reindeer skin and the ability to transform, through skin processing, raw reindeer skin into comfortable, serviceable, and yet beautiful clothing.

Skin processing in Eurasian reindeer cultures represents an important craft and economic activity essentially related to the women's sphere. Skin processing has not been thoroughly described in the available literature, and the knowledge is not easily accessible from the artefacts themselves. As this project was taking shape, the importance of understanding the practical methodology of skin processing was recognized as a significant part of the study. In order to obtain this information, people who were familiar with the technology of skin and fur processing and who were willing to share their knowledge were contacted, mainly through local museum institutions. Their knowledge is interesting, not only from a technological or preservation point of view but also from a cultural and social point of view, as it conveys the history of past generations.

The knowledge of skin and fur processing is less widespread in the population today and, there is specific knowledge which is important to record, not just to be able to preserve collections of historic importance, but also to ensure that information is available in the future for those interested in studying past technologies. The information put forward in this study undoubtedly represents only a fragment of the total traditional knowledge related to skin processing technology within the Eurasian cultures.

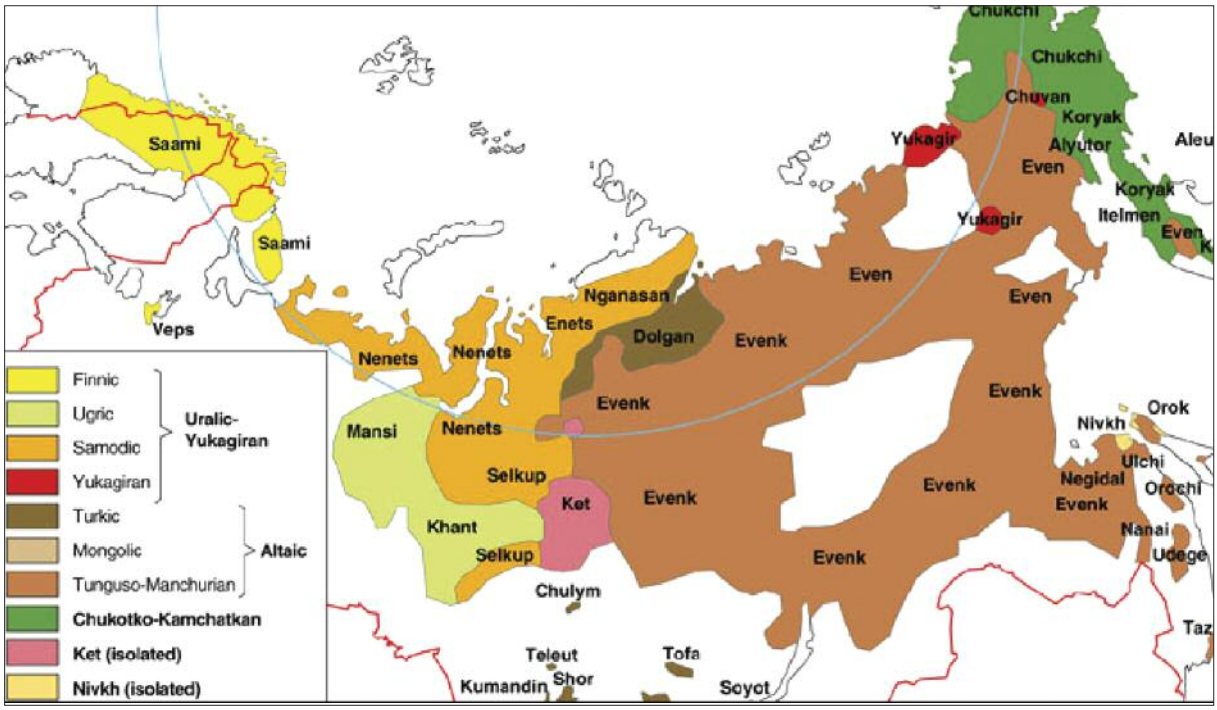


Fig. 0.1. Indigenous peoples of the North, Siberia and Far East of the Russian Federation, subdivided in language groups, March 2000. Excerpt from map: http://www.npolar.no/ansipra

If two cultures at a considerable distance from each other, and at a specific time in each its exploitation area, have had comparable access to natural resources as well as comparable demands with regard to clothing, how similar would their skin processing methods be? This question led to the selection of two culturally distinct groups: the Sámi culture in northern Norway and the Evenk culture in Siberia, Russia. (Fig. 0.1) The Sámi and the Evenk culture are geographically far apart, and one would expect little contact between these groups, at least historically. They are both originally hunter-gatherers, although their occupational activities today vary greatly, and they still depend to some extent on reindeer (*Rangifer tarandus*) for clothing and footwear. Apart from the comparative aspect of skin processing technology, the line of investigation elucidates the methodological dynamics in the introduction of other clothing materials, such as textiles and waterproof materials, and what effect the access to various potentially useful tanning substances has on the skin processing technology in both cultures.

It is obvious that the principal skin materials, from which clothing and footwear are manufactured, are similar across the Arctic and Sub Arctic; it is just as obvious that the processing technology, the tanning substances and the tools display a significant variation. Through the interviews and during the examination of museum artefacts from the Sámi and the Evenk culture, the question arose as to whether variations in the tanning substances would have a significant impact on the future preservation of skin artefacts, as the appearance and the properties of the finished products seem to be relatively different.

The field of conservation relates to material science and technology as fundamental aspects to understand artefacts' material properties and deterioration. The prerequisite for treatment of any artefact in a museum collection is identification of the materials of which it consists and the technology used in its manufacture. On the basis of this knowledge the deterioration mechanisms and deterioration characteristics are investigated, recorded, documented, and related to the known history of the artefact. This information, and not least the treatment the artefact may receive, forms the background for preservation-based recommendations with regard to the conditions under which it should be stored, exhibited and handled to afflict minimal strain on the artefact.

For skin artefacts from Eurasian reindeer cultures, the investigation into material science is limited, at least in the published literature. In the American and Canadian arctic and sub arctic, published research concerning material science of indigenous cultures skin artefacts is more extensive (Young, 1990, 1992; Schmidt *et al.,* 1993; and others). Publications concerning preservation and conservation of skin artefacts from indigenous cultures in the circumpolar area has - with some exceptions - been mainly been related to the treatment of physical damage, insect infestations and issues referring to storage and exhibition (Lougheed *et al.,* 1983/84; Kaminitz & Levinson, 1988; Dignard, 1992; Richardson, 2002; and others). In studying the available publications on skin and fur skin conservation practices and research, it is plain to see that treatment schemes employed for indigenous cultures' skin artefacts have historically been based primarily on conservation methods of contemporary and industrially tanned skins or fur skins, or on the treatment of natural history specimens. Even though minimum intervention practices recently have been subject to scrutiny in the conservation world, and been accused of being a result of lack of knowledge and funding, in the case of indigenous cultures skin artefacts they are highly recommended, as opposed to some of the methods previously employed. The investigation into traditional indigenous maintenance practices provides an alternative path to follow and once again emphasises the obligation to interpret and understand the composition of materials at hand.

One of the objectives of this study is to establish links between the technological aspects of skin processing and the visual and analytical characterisation and identification of indigenous cultures' skin materials and substances used in clothing and footwear. To establish this link an interdisciplinary approach, which entails both a humanistic and scientific research, is required. The process of joining different fields of research in this manner is a challenge but also a precondition for the interpretation of skin processing technology and its relation to dynamic cultural systems. The dynamics involved in traditional technologies encompass the constant modification of materials, substances and tools to meet the requirements of present conditions. Furthermore, this objective entails a desire for continuing past technologies as well as for securing the transferral of indigenous knowledge systems related to skin processing. The result is a complex and extensive process of interpretation of documentation and information gathered through this study.

The analytical methods developed and applied by recent European projects such as the STEP Leather project, the ENVIRONMENT Leather project and

the more recent IDAP parchment project (Improved Damage Assessment of Parchment) have served as an inspiration to and a background for the choice of analytical methods in the present study. The focus of the two former is mainly concerned with vegetable tanned leather, while the latter focuses on parchment. In spite of these differences, these projects have brought the field of conservation and material science closer to an understanding of the processes that take place in skin materials before, during and after the tanning process. Furthermore they have provided a better and more detailed understanding of the deterioration processes of skin artefacts, although mainly in vegetable tanned leather and in parchment. This has resulted in recommendations for production, assessment, conservation, and storage of these material groups (Larsen *et al.,* 1996:189-198).

The analytic methods employed in this study are also chosen for their applicability to available artefact samples and by the purpose of the analysis, which is the characterisation and identification of indigenous cultures' skin processing methods. This is obtained through visual and microscopic methods, through chromatographic methods such as HPLC (High Performance Liquid Chromatography) and GC-MS (Gas Chromatography – Mass Spectrometry) of substances added to the skin, and through thermal methods such as MHT (Micro Hot Table) which primarily assess the hydrothermal stability of collagen, the main component in skin.

The thesis is organised as follows: Chapter 1 presents the environmental and cultural background for this study and the methodology employed. This includes a presentation of the study areas, the informants and the artefacts encompassed in the study. Furthermore, it outlines the methodology of data handling and analysis. Chapter 2 discusses influences on skin processing technology, how it develops and changes and also why it changes, particularly in the Eurasian arctic and sub arctic, raising questions of environmental interconnectedness and aspects of tradition and indigenous knowledge. Chapter 3 presents skin processing technology in Eurasian reindeer cultures. In the first part of the chapter the information available through the literature is presented. This is succeeded, in the second part of the chapter, by the skin processing technology of the Sámi and Evenk communities made available through interviews and discussions with informants and consultants in northern Norway and in Siberia, Russia. This chapter also explores the comparative aspects of the technology of skin processing in these two cultures.

Chapters 4, 5 and 6 encompass the material science and analytical perspectives of the thesis, where the materials and substances added to the skin are defined and explored. Furthermore these chapters convey the analytical methods used in the identification and characterisation of skin material types and substances used in skin processing technology. The investigations include visual, chemical and thermal analysis and examine the relation to deterioration and to preservation of skin artefacts. The results from the analytical and comparative approaches are discussed further in the final chapter, chapter 7.

1 BACKGROUND AND METHODOLOGY

1.1 Cultural background and the environment

1.1.1 Sámi culture in northern Norway

The Sámi perceive themselves as one people inhabiting four countries - Norway, Sweden, Finland and Russia - an area which today is called Sápmi in the Sámi language (Fig.1.1). The Sámi language is divided into three main dialects; south Sámi, central Sámi (north Sámi and lulesámi), and east Sámi (Hætta, 2002:111). Although the Sámi originally were hunter-gatherers, the traditional subsistence activity in the study area today is reindeer pastoralism. This study focuses mainly on reindeer pastoralists in the central Sámi area, where the main dialect is north Sámi. Clothing, footwear, and accessories in the Sámi culture vary in style and decoration from area to area and, to a certain degree, follow the language/dialect groups (Sámi Council web page, July 2006). Clothing style and decoration may furthermore vary from one extended family to another, enabling distinction both in family and social status (Kemi Eira, 2004, pers.comm.).

Fig. 1.1. Sápmi, outlined with the colours of the Sámi flag. From the Sámi Council web page.

Interviews have been conducted in four locations in Finnmark, Norway: Karasjok in Karasjok County, and Suotnju, Masi, and Kautokeino in Kautokeino County. (Fig. 1.2). Karasjok (69°N) is considered the Sámi capital in Norway and lies in a valley where the river Kárášjohka runs north along the border between Norway and Finland to the Barents Sea. The Sámi Parliament, as well as several of the administrative units, are situated in Karasjok. Karasjok has 2870 inhabitants (1.1.2005). In 2002, 556 people were formally associated with reindeer pastoralism. Sámiid Vuorká-Dávvirat - The Sámi Culture Museum is situated in Karasjok and has the largest collections of Sámi culture skin artefacts in Norway.

Kautokeino County has 2994 inhabitants (1.1.2005), and reindeer pastoralism is the main occupation in this county. Kautokeino is located on a mountain plateau 4-500 metres above sea level. Masi is located approximately 50 km northeast of Kautokeino and has 400 inhabitants (1.1.2005) (Source: Karasjok and Kautokeino County's web pages, May 2005). Suotnju is a small community situated 75 km south of Karasjok

Northern Norway (Finnmark) belongs to the northern boreal and alpine vegetation zone; it is dominated by deciduous and coniferous vegetation interspersed by marsh areas, meandering rivers that run through the landscape and with numerous lakes. Part of the mountain areas are above the tree line and are dominated by vegetation such as lower shrubs, moss and lichens (Fig 1.3). The coniferous vegetation (mainly pine) is limited to inland lower valleys, such as the Karasjok area. Deciduous vegetation is mainly restricted to birch (*Betula sp.*), alder (*Alnus sp.*), and willow (*Salix sp.*) (Fig.1.4) (Gaare, 1997:9-16). Berry bearing shrubs such as bilberry (*Vaccinium myrtillus L.*) and cowberry (*Vaccinium vitis-idaea L.*) are particularly numerous in open areas, while cloud berry (*Rubus chamaemorus L.)* is located in marsh areas (Den Virtuella floran, May 2006). The average temperature in the summer is +11 °C with a high of 25-30 °C, and average temperature in the winter is -15 °C with a low of -45 °C in Karasjok (Norwegian Meteorological Institute, 2006, web page).

Fig. 1.2. Study areas in northern Norway, marked by red arrows.
www.encarta.msn.com/encnet/features/mapcenter/

1.1.2 Sámi culture garments and accessories

The garments that have been investigated consist of coats, trousers, leggings, short boots and bags, all of which are made from reindeer skin. The majority of the garments are from the late 19th and the 20th century and primarily originate from the North Sámi area in Finnmark, Norway. The following description is merely an illustration of the clothing items and accessories included in this research and does not pretend to encompass the diversity or the historic changes of Sámi culture clothing.

The winter clothing consisted of an inner coat, with the fur against the skin, and an outer coat with fur side out. Gussets are inserted in the back to create

Fig. 1.3. Gathering reindeer for marking and slaughtering in a mountainous area near Lakselv, Norway. September 2004.

Fig. 1.4. Finnmark - landscape near Karasjok, Norway, 2005.

a comfortable shape for work and physical movement (Fig. 1.5). The common length is to the knee, although the woman's coat is slightly longer. The coat has no hood, but an upright high collar is found on men's coats and there is a much smaller collar on the woman's coat. Belly skin is used for the collar and cuffs, which

Fig.1.5. The back of a child's coat exhibiting the inserted gussets, to obtain a comfortable shape. The coat is turned inside out for storage. SVD-2322, Sámiid Vuorká-Dávvirat, Karasjok, Norway.

Fig.1.6. A coat from the Sámi culture, turned inside out for storage. The pocket is situated in the front part of the coat. SVD-1549, Sámiid Vuorká-Dávvirat, Karasjok, Norway, 2004.

Fig. 1.7. One of the informants, Ellen Marie Gaup Hætta in her white festive coat. Masi, Norway. March 2004.

may be replaced when they are worn out. The neck opening is fairly small. A belt is worn low on the waist, creating a pouch for keeping objects inside the coat. In addition most of the coats have an inner breast pocket (Fig.1.6). The thickness of the Sámi culture coat is regulated by need for insulation and through the choice of skins. Thicker skins are used for the herders' coats and lighter skins for festive coats and children's coats (Fig. 1.7). An important feature in the Sámi culture coat is how the shape of the reindeer skin influences the design of the coat, with the inclusion of the head skin in the coat's upper part (Fig. 1.8). This also allows the manufacturer to obtain a correct length of the coat without adding any material. The decoration of the coat may include strips of coloured cloth inserted in shoulder seams, and bands of cloth, often wool cloth, added to the collar. A string made from wool yarn is often used to further close the neck opening. These strings can also be made from depilated reindeer skin.

Leggings used in the winter are made from the leg skin of the reindeer, while summer leggings are made from depilated reindeer skin (Fig. 1.9, 1.10). The lower part of the winter leggings consists of a piece of cloth, which is hidden when the woven wool bands are

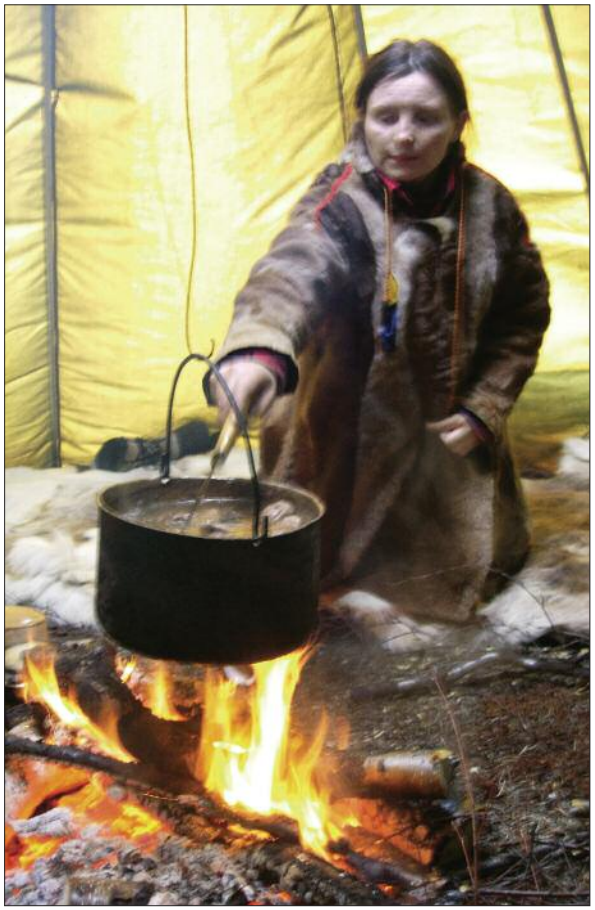


Fig. 1.8. Margrethe Vars, from Karasjok, Norway, wearing a reindeer skin coat while attending to the boiling meat. Note the head skin in the upper front part of the coat. Photo: turgleder.com

Fig. 1.9. Winter leggings, TM-1231a+b. Tromsø Museum, Norway, 2004.

Fig. 1.10. Summer leggings made from depilated reindeer skin. SVD-2158 a+b. Sámiid Vuorká-Dávvirat, Karasjok, Norway, 2004.

wrapped around the leg to secure the boot to the foot (Fig. 1.11). The leggings may have been secured to the hip with strings, but may also support themselves through the addition of a decorated band on the upper thigh. The trousers examined in this study consist of an upper part made from depilated skin and lower legs made from the leg skin.

The short boot is characteristic for the Sámi culture. The boot is made from reindeer leg skin and is mainly seen in two different designs: one, where the upper part of the boot is shaved to facilitate the wrapping of the woven bands, and another where the tying of the boot is done with laces made from wool string or depilated skin strings (Fig.1.12, 1.13). Short boots may also be made from the head skin of the reindeer. These boots are mainly made to be used as working boots, because the head skin is considered to be a very strong and tough part of the reindeer skin.

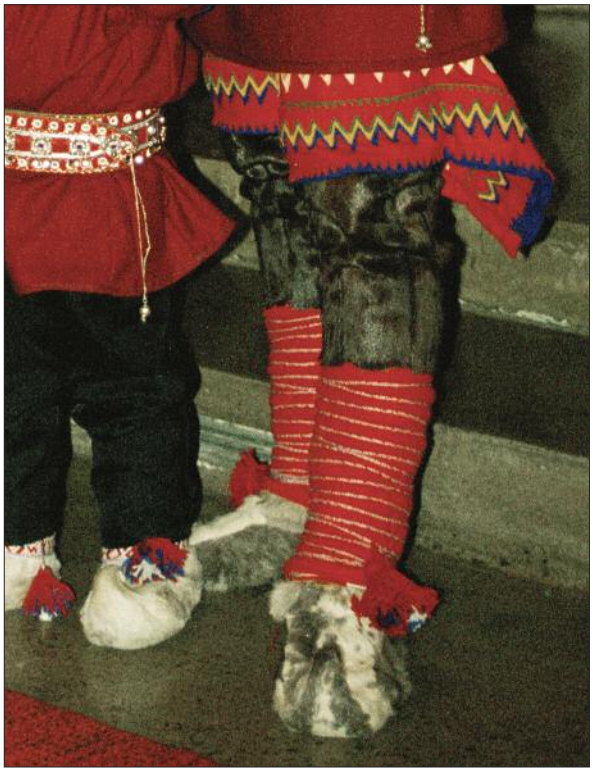


Fig. 1.11. Winter leggings with a decorative band on the upper thigh, patterned wool bands for securing the boots and the leggings to the foot, and at the same time inhibiting snow from entering the boots. Karasjok, Norway, 2004.

A number of bags and rucksacks are also included in the study. These consist mainly of bags made from depilated reindeer skin, although some bags are made from combinations of depilated skin and leg skin (Fig. 1.14, 1.15)

1.1.3 Evenk culture in Siberia, Russia

The Evenk inhabit a vast area from Okhotsk Sea in the east to the Ob River in the west and from the Arctic Ocean in the North to the Manchuria and Sakhalin in the south (Fig. 0.1) (Humphreys & Mits, 1993). They are formerly known as Tungus; Orochons is used for a southern subgroup that also included several other indigenous groups which now have separate names, for example the Evens (ANSIPRA, 2006, web page).

Fig. 1.12. Sámi culture short boot where the hairs are shaved off the upper part of the boot to make sure the layers are not too thick to be comfortable for the wearer. SVD-1069. Sámiid Vuorká-Dávvirat, Karasjok, Norway, 2004.

Fig. 1.13. An assembly of Sámi culture short boot with various forms of wool string closing. Sámiid Vuorká-Dávvirat, Karasjok, Norway, 2006.

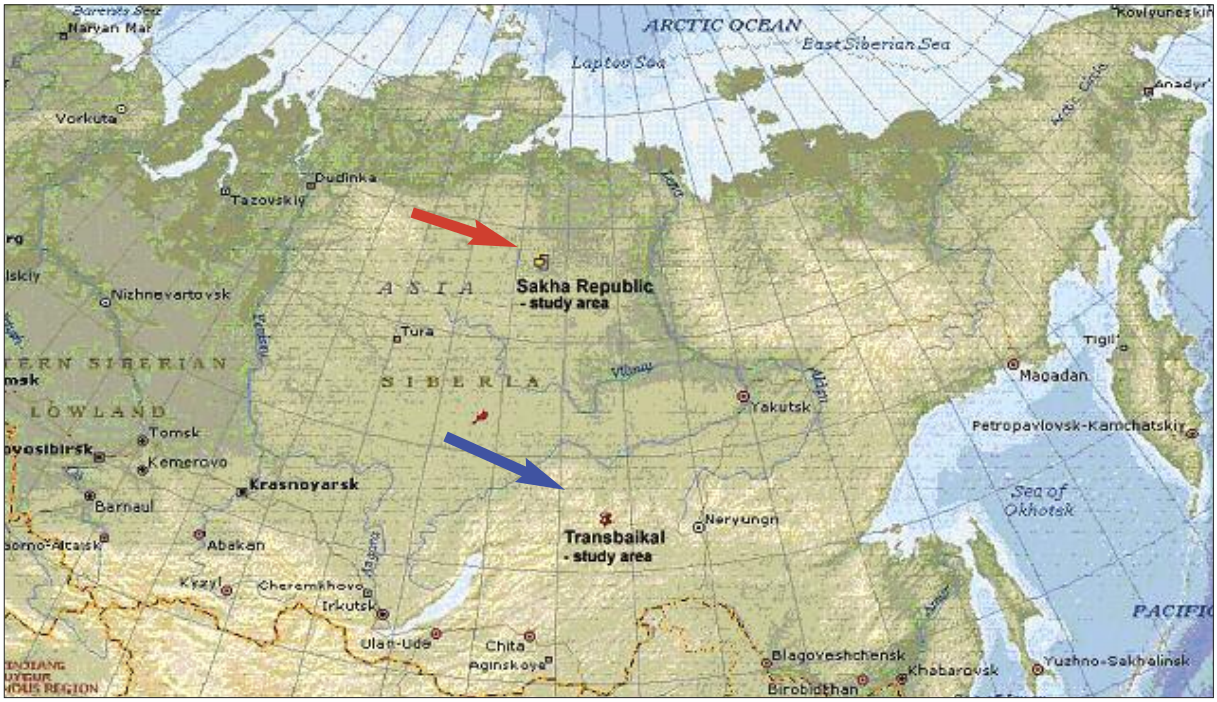

Fig. 1.14. Left: Bag made from depilated skin and leg skin. TM-0545. Tromsø Museum, Norway, 2004.
Fig. 1.15. Right: Rucksack made from depilated skin. TM-0491. Tromsø Museum, Norway, 2004.

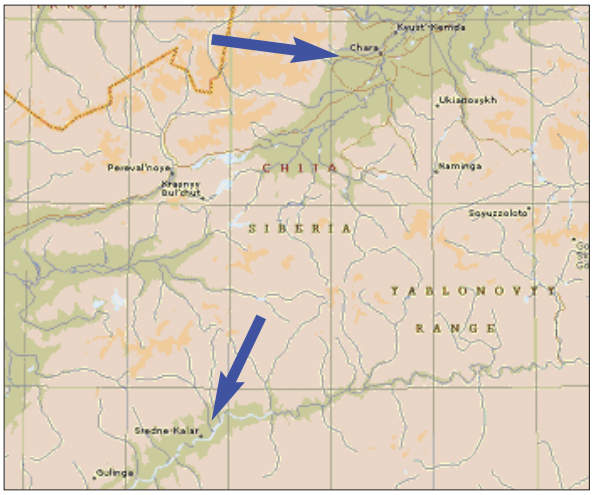
With regard to the Siberian Evenk the study focuses on two regions; Olenek in northern Sakha Republic (Yakutia), and Kalar in Northern Transbaikal (Fig. 1.16). These include the villages of Olenek and Kharyyalach in Northern Sakha Republic (Yakutia), the villages of Chapo Ologo and Sredniy Kalar, and the northern Lake Nichatka settlement, in Kalar County in the Northern Transbaikal area.

Northern Transbaikal is a mountain region with mountains up to 3000 metres (Fig. 1.17). The landscape is characterized by smaller and larger rivers that meander through the valleys. The vegetation is taiga: deciduous coniferous vegetation, mainly larch (*Larix sp*) and some coniferous forest, such as pine (*Pinus sp*), cedar (*Pinus cembra sp*), and juniper (*Juniperus sp*). The landscape is open and, due to the permafrost, often moist, with arable lands in the valleys (Grøn & Kuznetsov, 2003:217). Deciduous vegetation, such as birch (*Betula sp*), willow (*Salix sp*), and alder (*Alnus sp*), although not very tall, often grows in the vicinity of rivers and lakes. Berry bearing shrubs such as bilberry (*Vaccinium myrtillus L.*) and cowberry (*Vaccinium vitis-idaea L.*) are particularly numerous in open areas and areas where forest fires have moved through the landscape. Temperatures vary from +30 °C in the summer to -50 °C in the winter (Kamenskaya *et al.,* 1997:17). Chara is the largest village in the area with approximately 9000 inhabitants. Chapo Ologo is a village lying 50 km east of Chara (56°N) and has approximately 200 inhabitants, while the village of Sredniy Kalar lies 125 km south of Chara and has around 100 inhabitants. In Chapo Ologo and in Sredniy Kalar the majority population belong to the Evenk culture.

The Evenks, in the study areas, were originally hunter-gatherers, but became reindeer pastoralists during the Soviet period. Chapo Ologo, Sredniy Kalar, Olenek and Kharyyalach are all former soviet kolkhoz units, practicing reindeer pastoralism until the end of the Soviet period. After the fall of the Soviet Union a number of families have returned to hunting, keeping a few reindeers for transportation purposes, while others work in the local community or have moved away for education or work.

Olenek and Kharyyalach are situated in the Northern Sakha Republic (Yakutia). The landscape is characterised by rolling hills (up to 600 m) and rivers which run through the landscape. (Fig. 1.18) The forest taiga lies within the boreal forest belt and is dominated by coniferous trees such as larch, interspersed with pine, and with deciduous trees such as willow, birch, and alder along with low shrubs, lichens and moss. The underlying permafrost leaves the ground partially moist in the summer. The two villages are situated one on each side of the Olenek River, which runs north to the Laptev Sea. The village of Olenek has approximately 2000 inhabitants, including inhabitants from several





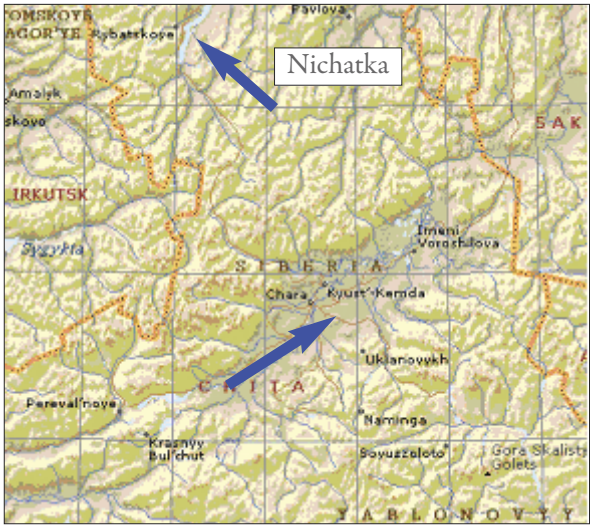


Fig. 1.16. Study areas in Russia; Sakha Republic (red arrows) and Transbaikal (blue arrows) as marked on the map. www.encarta.msn.com/encnet/features/mapcenter/

indigenous cultures, including Evenks. Kharyyalach has approximately 700 inhabitants, where the majority belong to the Evenk culture. The temperatures vary from +30 °C in the summer to -55 °C in the winter (Kamenskaya *et al.,* 1997:17).

Fig. 1.17. Northern Transbaikal, Russia. July 1999.

Fig.1. 18. Northern Sakha Republic, south-east along the River Olenek, Russia. July 2001.

1.1.4 Evenk culture garments and accessories

The Evenk culture skin garments and accessories vary in style and decoration, depending upon the region, and they are also, in contrast to the Sámi culture, subject to the influence of other indigenous cultures inhabiting the region. The garments and accessories which have been investigated consist of a relatively small selection of coats, trousers, boots, and chestpieces. In addition, a selection of bags and containers for storage has been included in the investigation. The majority of the artefacts were manufactured in the late 19th or early 20th century, with a few dating to the late 20th century.

The coat (knee length coat) of the Evenk culture is either a heavily decorated open coat, which does not close in the front, or a simpler coat, interpreted as an every-day or hunting coat (Fig. 1.19, 1.20, and 1.21). The heavily decorated coats are composed of panels and strips from various parts of the reindeer skin. This includes using strips of leg skin and other skin to create an elaborate pattern. In addition the coat may have been decorated with hair and fur from a variety of animals, with beads and reindeer hair embroidery, and with strips of various textiles in a variety of colours. Parts of the coat may also be composed of a textile fabric. These coats have been used with a chestpiece, decorated in the same style (Fig. 1.22) that is tied around the neck and waist (Vasilevich & Smolyak, 1956:640-641). Some of the coats have mittens in a continuance of the sleeve, with a slit for the hands.

The trousers included in this study consist of short trousers made from depilated skin (Fig. 1.23), and winter trousers, made from late autumn skins, for especially cold weather. These trousers are the same type of trousers as the ones worn by Svetoslav Dmitrievich in figure 3.17. The short trousers have been worn in

Fig. 1.19. Evenk culture open coat (front), elaborately decorated with skin strips, beads and hairs. IMRS-0345-1. Irkutsk Museum of Regional Studies, Irkutsk, Russia, 2005.

Fig. 1.20. Evenk culture open coat (back), elaborately decorated with skin strips, beads and hairs. IMRS-0544. Irkutsk Museum of Regional Studies, Irkutsk, Russia, 2005.

Fig. 1.21. Evenk culture coat for hunting and every day usage, closed with depilated skin thongs. REM-11121-54. The Russian Ethnographic Museum, St. Petersburg, Russia, 2005.

Fig. 1.22. Evenk culture chestpiece. On the left, a woman's chestpiece, REM-5589-19, with a straight edge, and to the right a v-shaped man's chestpiece, REM-6804-44. The Russian Ethnographic Museum, St. Petersburg, Russia, 2005. See also chapter 4, figure 4.37.

combination with thigh-high boots that are entirely made from leg skins, or from a combination of leg skins, depilated skins, and textile fabric.

There exists a large variety of boots in the Evenk culture. These are ankle high and knee-high boots, made from either depilated skins, leg skins or a combination of these skins, in addition to the thigh-high boots. The boots are attached with depilated skin ties around the ankle, and/or below the knee. The thigh-high boots are often attached with skin ties, made from

Fig. 1.23. Short trousers from the Evenk culture. Made from depilated reindeer skin. MAE-1524-168. Peter the Great's Museum of Anthropology and Ethnography (Kunstkammer), St. Petersburg, Russia, 2005.

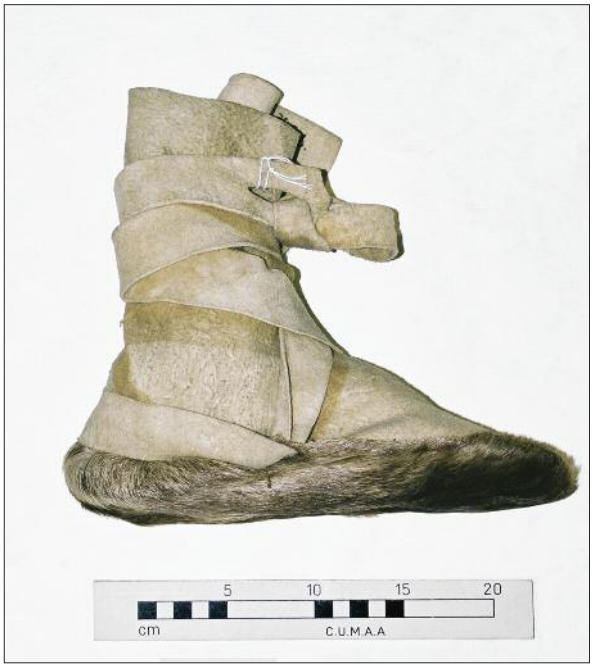


Fig. 1.24. Left: Ankle-high boots made from depilated skin, with leg skin soles. CUMAA-1935-786 a-b Museum of Archaeology and Anthropology, University of Cambridge, Cambridge, UK. 2005.

Fig. 1.25. Right: Knee high boots made from depilated skin. REM-809-8. The Russian Ethnographic Museum, St. Petersburg, Russia, 2005.

of depilated skin, to the waist. A selection of boots is presented in figures 1.24 to 1.28.

Short ankle-high boots are often worn with leggings. The only legging type included in this study is leg skin leggings, which may be secured to the waist by depilated skin thongs.

A characteristic feature of the decoration in Evenk skin and fur clothing is the use of blue, white and black beads (Fig. 1.29), although a variety of decorative components are applied. This is confirmed by the informants, who also indicate that the three colours reflect the three worlds in their cosmology (Benchik, 2001, pers. comm.). In addition to the colour from the tanning agent, surface colouring as part of the decoration of the artefact is observed (Fig. 3.51 and 3.52).

Bags and travel or storage containers from the Evenk culture include bags for storage of tools, such as skin scrapers, and bark containers covered with reindeer or elk leg skin. The artefacts also include bags

Fig. 1.28. Thigh- high boots heavily decorated with beads and coloured cloth. The lower part is made from depilated skin the upper part is made from wool textile. REM-4871-213. The Russian Ethnographic Museum, St. Petersburg, Russia, 2005.

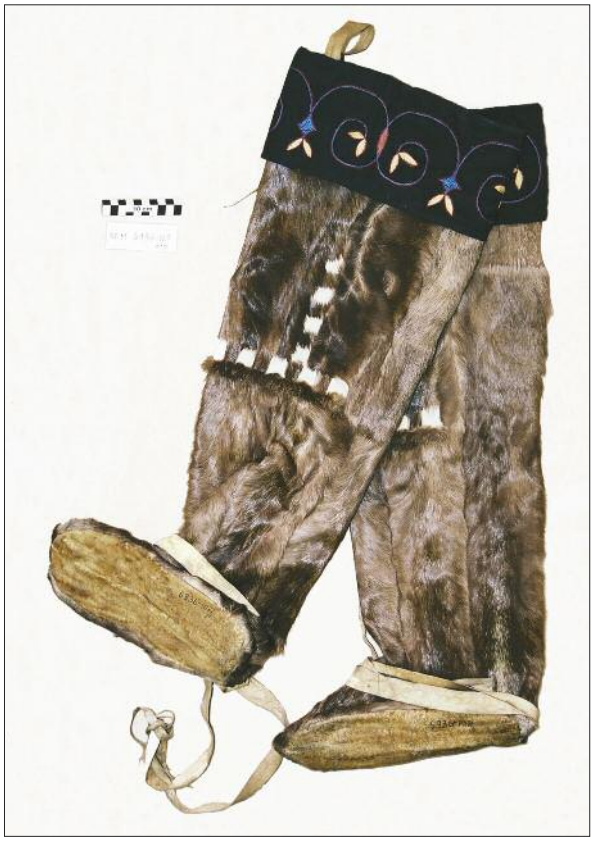


Fig. 1.26. Left: Knee-high boots made from leg skin, and toe skin soles. Behind this boot, is the inner boot made from reindeer skin, with the hairs inside. Made by Ambrosieva Vera Aleksandrovna, Olenek, Sakha Republic, Russia, 2004.

Fig. 1.27. Right: Thigh- high boots made from leg skin. Decorated with textile and embroidery. REM-6936-107. The Russian Ethnographic Museum, St. Petersburg, Russia, 2005.

Fig. 1.29. Bead and reindeer hair decoration on chest-piece at lower front side. IMRS-92-4 Irkutsk Museum of Regional Studies, Irkutsk, Russia, 2005.

Fig. 1.30. Left: Bag made from reindeer head skin. VK-6161-25. Museum of Cultures. Helsinki, Finland 2004.

Fig. 1.31. Right. Bag made from leg skin and textile. For storing tools, for example skin scrapers. VK-6161-16. Museum of Cultures. Helsinki, Finland 2004.

Fig. 1.32. Birch bark container covered with leg skin. CUMAA-1935-814. Museum of Archaeology and Anthropology, University of Cambridge, Cambridge, UK.

made from reindeer or elk leg skin and head skin. A selection of these is illustrated in figures 1.30 to 1.32.

1.2 Methodology

The idea-basis and starting point of this study is my MA-thesis dealing with the preservation of caribou skin artefacts from the Roald Amundsen collection at the Museum of Cultural History, at the University of Oslo (Klokkernes, 1994). Furthermore, inspiration was gained from the work of conservator Anne Lisbeth Schmidt, at the National Museum in Copenhagen, on Inuit skin tanning processing and assessment of condition (Schmidt, 1991, Schmidt *et al.,* 1993), and from Jillian Oakes' and Betty Issenman's extensive work in Nunavut and the Canadian arctic on Inuit clothing and footwear, both in design, the use of tools, production and skin processing (Oakes, 1991; Oakes *et al.,* 1996, Oakes *et al.,* 1998 and Issenman, 1997).

From 1998 onwards I had the opportunity to carry out preliminary field work, studying Evenk skin processing technology in Transbaikal and in the Sakha Republic, Siberia. These preliminary studies of skin processing methods, as well as studies of museum collections, suggest that certain skin processing methods may have an impact on the artefacts' condition and that it could be relevant to operate with different preservation strategies in relation to collections with objects processed in different ways (Klokkernes & Sharma, 2005).

The PhD stipend (2004-2006) made it possible to carry out substantial fieldwork with regard to the skin processing technology in the Sámi culture in Northern Norway and to supplement the Siberian field data, so that a comparative perspective could be added to the basic focus on skin processing technology, as well as to encompass the characterisation and identification of these complex material groups.

In order to acquire access to available skin processing technology from Sámi informants in northern Norway, contact was made with Sámiid Vuorká-Dávvirat in Karasjok. The museum recognised the opportunity for gaining information on skin and fur processing, which would be important for the museum's future reference, and an agreement was made to allow access to the collections. The museum assisted in selecting informants and in translation and transcription of the interview material, which ultimately is transferred to the museum at the project's conclusion.

In Russia the inquiries concerning access to locations and informants was initially made on the spot as the project independently joined larger international projects already working in the areas. Through these projects, which were facilitated by the Academy of Sciences, Department of Arctic Research in Yakutsk, and Chita Technical University in Chita, contacts were made to Kalar Folk Museum in Chara and Olenek Historical-Ethnographical Museum of North Peoples in Olenek. These museums likewise gave permission to study their collections and they cooperated in the selection of informants.

Guidelines for conducting research in indigenous cultures have been considerably improved through the last decades. Earlier experiences have not always been positive for the indigenous cultures with regard to collection of artefacts, data handling, local participation and in the return of information. Today, research in indigenous cultures requires a formalisation and implementation of guidelines. This study is incorporating research guidelines which include local participation, obtaining informant and institutional consent, informing on goal, time frame and content of the project, using native language whenever possible and providing the local informants and institutions with the results at the conclusion of the project (Alaska Native Knowledge Network, 2000 and NESH, 2002). This project does not contain sacred or secret information, or personal information from the informants other than name, age and location of birth.

1.2.1 Language and interpretation

Language is an important part of the knowledge associated with skin processing methods and materials (Helander, 1996:2). It was an objective to document not only the processes themselves but also at the same time to record the technological terms related to the processes. The interviews were therefore carried out in the native language, or the language which was used in the daily life of the informants. It was, however, pointed out that many of the terms used in the native language could hardly be translated into single English or Norwegian terms but had to be explained with a series of words. The accuracy of some native terms associated with skin processing required not only a description of the process itself but also reference to the stage that has been reached in the process and, furthermore, to the finished product (Eira Buljo, 2004, pers. comm.). Achieving this required simultaneous translation during the interviews in order to be able to rephrase or expand the questions during the interviews. This form of interview, where one enters into a discussion concerning details in the skin processing method, requires a thorough previous knowledge of the subject from the interviewer.

Interpretation from Sámi to Norwegian was conducted by Elen Kirsten Hansen Anti and Aage Hegge both from Sámiid Vuorká-Dávvirat in Karasjok, Norway. Interpretation from Russian to English was conducted by Dr. Elena Piterskaya, Institute of Anthropology, State University Moscow, Russia and interpretation from Yakut to German was conducted by the linguist Fedor Datsjkovsky from the Linguistic Department, Academy of Sciences in Yakutsk, Russia. The interviews in the North Sámi language have been transcribed into Sámi and Norwegian by Elen Kirsten Hansen Anti and Berit Åse Johnsen at Sámiid Vuorká-Dávvirat and are supplemented by notes taken during the interview. The interviews from Transbaikal and the northern Sakha Republic are summarized in English by listening to the recordings and supplemented by extensive field notes.

1.2.2 Informants

The selection of informants in Finnmark, Norway was conducted by the Sámiid Vuorká-Dávvirat in Karasjok. In Siberia the selection of informants was facilitated by the museums in Olenek and Chara and, furthermore, by asking initial informants if there were other persons that could be contacted in the villages.

In Finnmark, information on skin and fur processing methods was conducted in four different locations in two periods in 2004. A total of fourteen women and two men have been interviewed or consulted. The informants in Finnmark are: Inga Guttorm, Karen Marie Somby, Maret M. Somby Anti and Petter N. Anti, Marit Berit Bær, Nils Nilsen Eira and Anne Kirsten Kemi Eira, Lilly Guttorm, Ellen Marie Gaup Hætta, Karen Marie Eira Buljo, Marit Ragnhild Mikkelsdtr Buljo, Risten Marja M. Buljo, Ellen Sara M. Sara, and Ellen Kristine Buljo Sara. Two informants have chosen to remain anonymous.

In the northern Sakha Republic the interviews took place in 2001 and in 2004. A total of twelve women have been interviewed or consulted. The informants are: Benchik Kristina Afanasievna, Kristoforova Fedosia Prokofjevna, Matvejeva Kristina Kirillovna, Konstantinova Rosalia Prokopievna, Stepanova Valentina Vasilievna, Egerova Maria Ivanovna, Tomskaya Rosalia Ivanovna, Semekova Varvara Kristoforovna, and Kombagir Ludmila Afanasievna, who all live in Kharyyalach in northern Sakha Republic. Interviews were also conducted with Ambrosieva Vera Aleksandrovna who lives in Olenek and Afanasieva Tatyana Kambagir and Nikolaeva Maria Vladimirovna who live in settlements north of Kharyyalach.

In Transbaikal the interviews took place in 1998, 1999, and in 2000. A total of eight persons were interviewed or consulted in these areas. They are: Malchakitova Ludmila Vasilievna, Aleksandra Ivanovna, Gabisheva Anna Mikhailovna, Praskovia Innokentievna all from Chapo Ologo in the northern Transbaikal area. In Sredniy Kalar interviews were conducted with Kirillova Janna Iosifovna, Kirillova Ekaterina Innokentievna, and Romanova Vera Dmitrievna. Kuzmina Julia Anatolievna was interviewed and lived at the time (in 2000) in a settlement at the Nichatka Lake; she now lives in Chapo Ologo.

A total of 34 women and two men have been interviewed and are between the ages of 16 and 87 years old, although most of the informants are more than 45 years old. All informants were asked whether they wanted to remain anonymous or if their names could be used in the thesis. Most informants thought it important that their name followed the information they had given.

1.2.3 Interviews, observation and learning by doing

There was a desire to create an informal atmosphere throughout the interviews. It was at the same time an intention to let the informants direct the course of the interviews to avoid preconceived ideas from the interviewer. To maintain a focus in the interviews, three areas of skin processing were chosen as the principal topics of the interviews; the skin processing of whole skin with hairs attached (SWH), depilated skin (DS) and leg skin (LS, always with hairs attached). Within these topics the interviewer let the informant describe the various processes and materials from the initial stages to the final product. A set of questions was specified to ensure equal coverage of the main topics and to aid the interpreter during the interviews. These questions were revised in the course of the interviews. The informants were all asked the same set of basic questions. Sometimes it was possible to observe first hand elements of the processes used as well as to participate in these processes. The latter was mainly possible during the fieldwork in Siberia, as more time was spent with each informant.

Observation and learning by doing are the ideal methods of acquiring information of this type, because skin processing is a practical process which is easier to demonstrate than to describe in writing and explain orally. During the interviews and demonstrations, additional features of skin processing methods could be observed, such as positioning of the body and the handling of the tools.

Recorded interviews, photography and field notes were chosen in an early phase of the project as the method of documentation. The use of film or video was considered but found less feasible, as it was not possible for the author to be present during the entire skin processing procedure. This would be difficult to plan and would require significantly more time spent with the single informants. Furthermore, experiences from fieldwork in Siberia demonstrate that film or video has a tendency to cause diversion, to attract more people and generally to make the informants feel less comfortable. Taking photographs during the interviews is less intrusive and gives a good perspective of the processes involved. Most interviews and consultations were recorded on micro cassettes and transferred to digital form.

1.2.4 Studies of museum collections

Studies of Sámi and Evenk culture artefacts were made at the following museum institutions:

- Sámiid Vuorká-Dávvirat (SVD/DSS), Karasjok, Norway. Abbreviation: SVD.
- Tromsø Museum, University of Tromsø, Norway. Abbreviation: TM.
- The Norwegian Museum of Cultural History, Oslo, Norway. Abbreviation: NFSA.
- Museum of Cultural History, University of Oslo, Norway. Abbreviation: KHM
- Museum of Cultures, National Museum of Finland, Helsinki, Finland. Abbreviation: VK.
- The Russian State Museum of Ethnography, St. Petersburg, Russia. Abbreviation: REM.
- Peter the Great's Museum of Anthropology and Ethnography (Kunstkammer), St. Petersburg, Russia. Abbreviation: MAE.
- The Irkutsk Museum of Regional Studies, Irkutsk, Russia. Abbreviation: IMRS.
- University of Cambridge Museum of Archaeology and Anthropology, Cambridge University, Cambridge, United Kingdom. Abbreviation: CUMAA.

Institutions where artefacts in exhibitions were studied:

- The exhibition at Kalar Folk Museum in Chara, Chita County, Russia.
  Collection of artefacts documenting the construction of the BAM railway, a collection of natural history specimens, geological, botanical and zoological, and a unique collection of objects related to the Evenk culture in the Kalar region.
- The exhibition at the Olenek Historical-Ethnographical Museum of North Peoples in Olenek, Sakha Republic, Russia. Opened in 1986 and exhibits artefacts mainly from the Evenk but also from the Yakut culture. The Museum also has a few archaeological finds but is mainly oriented towards historic and contemporary artefacts from the local region.

A total of 187 historic skin artefacts were visually examined for presumed tanning agents or added substances and observed for characteristic features of the physical skin processing method. At the same time the artefacts have been studied with the purpose of assessing the condition of each artefact. The questionnaires used in the examination were open to changes as the assessment proceeded, and the records are presented in a database (appendix 1). The 187 artefacts are distributed as evenly as possible according to the three material types - DS, SWH and LS - and according to locality and age, and they are drawn from larger populations within each museum collection (Fig. 1.33).

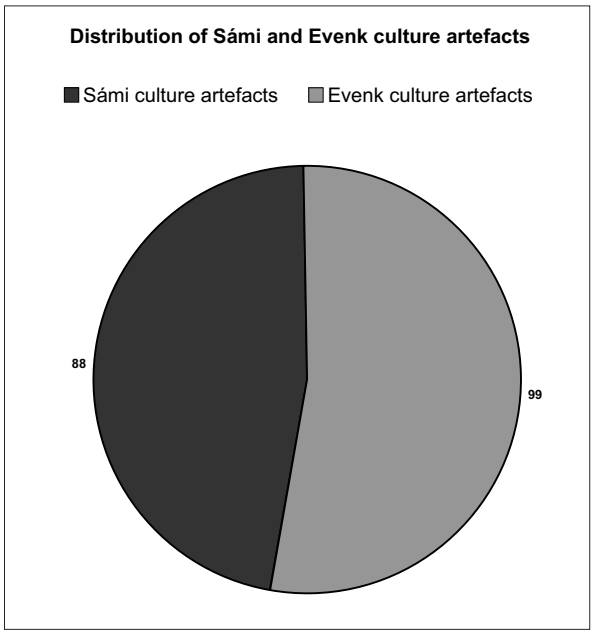


Fig. 1.33. Distribution of Sámi and Evenk culture artefacts in the visual examination of 187 artefacts.

1.2.4.1 Visual characterisation and identification of processing methods of historic artefacts

Using sensory evaluation in describing skin processing methods that may have been used on a specific artefact is challenging. The visual descriptions are based on the person's knowledge and experience with similar to and alike artefacts. It is also based on a person's perception of the terms that are used, such as colour, stiffness and smell. Different people will experience these terms differently, and the information must be used with care. The first eight questions of the identification process are, however, based on existing knowledge and should be recorded for all artefacts that are studied.

1. From which culture does the artefact originate? Location?
2. What type of artefact is it?
3. Is it a ritual artefact, a festive artefact or an artefact of daily use?
4. What is/are the material/materials used in the artefact? Description of material features, such as cutting of the hairs, type of skin, etc.

5. What type of thread is used in the artefact?
6. Is there any information in the literature on technology of skin and fur processing from this culture?
7. Has the artefact been published?
8. When did the artefact arrive to the museum/institution? Approximately how old is the artefact

The next eight questions are used in the visual examination of the artefact material to assess the possible identification parameters for suggesting the processing method.

9. What is the colour on the flesh side/grain surface of the material? Using Munsell® soil colour chart.
10. How deep has the tanning substance or colouring penetrated the skin? (⅓, ½, ⅔, 1/1)
11. Is there a raw streak visible? Yes/no.
12. Is there a distinct smell, which can be recognised (subjective parameter)? Care must be taken as the artefact might be treated with a pesticide.
13. Are there tool marks or other marks on the artefact and what do they look like or resemble?
14. Are there any observable characteristics in the epidermis - dermis area (skin with hair)? Parting of hairs on a scale from 0 – 4.
15. Is there a characteristic root pattern on the flesh side or the grain surface of the artefact? On a scale from 0 – 4.
16. Are hair follicles visible on the flesh side of the material (skin with hair)?

In depilated skin (DS) the colour profile is normally examined on the suede surface or on the grain surface. In skin with hairs attached (SWH and LS) the colour profile is examined on the flesh side.

1.2.4.2 Physical characterisation of the condition of historic artefacts

Previous results indicate, although the visual and analytical link is not overwhelming, that there is a relationship between the visual and analytical characteristics (Klokkernes, 1994). Preliminary results further illustrate the complexity of the deterioration activity of skin artefacts, and this makes identification of certain specific factors and actions of deterioration a challenge. The next ten questions in the assessment visually evaluate the condition of the artefacts.

17. What is the general visual impression of the artefact? On a scale from 0 – 4: Very good, good, fair, fairly poor, and poor.
18. The history (exhibition, treatments, pesticides, etc) of the artefact in the institution/museum.
19. Wear and tear from the time when the artefact was still in use.
20. Are there surface dirt and/or dust on the artefact?
21. Description of visible damage.
22. What is the thickness of the corium (all artefacts)? How does it vary throughout the artefact? (Dependent on the type of skin used.) Measured with a slide gauge where possible.
23. Are there or has there been mould on the artefact? Suggested on a scale from 0 - 4.
24. Are there or have there been insect infestations? Suggested on a scale from 0 - 4.
25. How does the colour of the surface appear? Even, or uneven on the flesh side or grain side of the artefact.
26. How does the mechanical action appear? Smooth, fairly smooth, fairly rough or rough on the flesh side of the artefact.

The scale is a sliding scale from 0 to 4, where 0 (zero) is assigned to artefacts with minimal damage, lowest cracking of the epidermis-dermis area, no soiling, very little or no insect infestation, and no visible hair follicles. The number 4 (four) is assigned to artefact with maximal damage, highest cracking of the epidermis/dermis area, heavy soiling, highest degree of insect infestation, and high visibility of hair follicles, etc. In terms of the overall condition, a scale from 0-4 is suggested. This scale is also a sliding scale, as there may be great variation within the artefact: 0 = very good, 1 = good, 2 = fair, 3 = fairly poor and 4 = poor.

Descriptions of the surface of various types of skin are divided in *grain surface* for depilated skin with full grain intact, *suede surface* for depilated skin where grain layer is removed or partly removed, *hair side* for skin with hair attached to the skin and *flesh side* for the flesh side of the skin.

For descriptive purposes, leg skins are divided in three parts: Upper part, middle part, and lower part (Fig.1.34).

At the museums in Norway, Finland and United Kingdom the author has been able to make a choice of which artefacts to study, either based on museum collection database selections or based on access to storage facilities. In Russia the selection of artefacts is made by the museum personnel based on a request for a num-

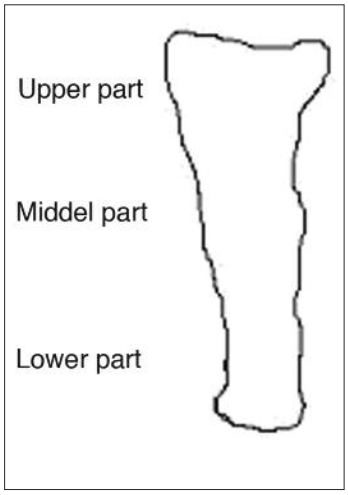


Fig. 1.34. Outline of leg skin

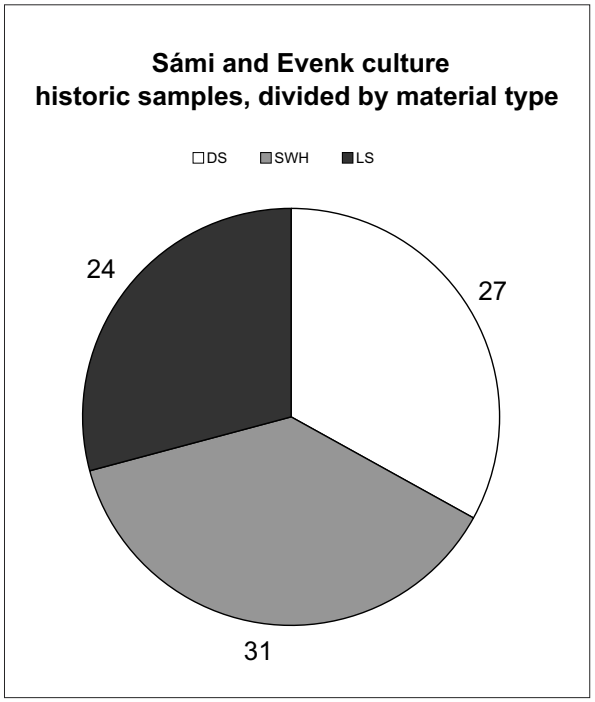


Fig. 1.35. Distribution of Sámi and Evenk historic skin samples.

ber of specific artefact types and material types. It has not been possible to fully control the population distribution of the historic samples at all the museums, and the museum's personnel chose the artefacts which were available for sample collection. Still, the representation of historic samples has been adequately successful, taking into consideration the historic value of the artefact material. As the sample series are obtained using a destructive method, it was important that the institutions themselves suggested the sampling-locations on the artefacts to minimise visible damage to the artefact and, furthermore, to keep the sample sizes at an absolute minimum. Obtaining samples from museum artefacts will always be a pro/con discussion in a museum context. From the 187 historic artefacts, it has been possible to obtain 82 historic samples for microscopic, chemical and thermal analysis.

It is important to be aware that the collections, although vast, may show a disharmony in composition of artefact types, discriminating against the everyday clothing types at the time of acquisition. Compared to more simple working clothes, elaborately decorated clothing types have a strong representation in the collections. Because of this the study does not claim to present a representative range of clothing elements in the selected cultures.

Contemporary samples from the informants' own skin processing were collected to be used as reference samples in the analysis of historic material and for the investigation of characteristics and properties inherent in the materials used for garments and accessories today. These samples were collected during the interviews, ensuring that the material and the tanning substances used in these samples are known.

1.2.5 Sample material

The artefacts and historic samples are divided into the study of three material types for each of the two indigenous cultures in focus (Fig. 1.35). These material types are 1: depilated skin (DS), 2: whole reindeer skin with hairs attached (SWH), and 3: reindeer leg skin (LS, always with hairs attached). Not all samples have known origin, geographically. There may therefore be artefacts included which belong to other Sámi culture groups. There may also be artefacts included in the sample material, marked as belonging to the Tungus culture, which today are perceived as belonging to a different culture.

The sample material, consisting of both reference samples and historic samples is presented in table 1.1, 1.2 and 1.3. For the reference samples the processing method is known, and the description is based on the informants' information on tannins, lubricants and mechanical processing. The skin samples cover two of the assumed main tannins, willow bark and brown rotted larch wood, in addition to a variety of added fats and other substances.

The historic samples are divided into three groups for each culture (group 1, group 2, and group 3), each group constituting a representative selection of material types, age variation and geographic variation (Table 1.3). The historic samples are marked with an abbreviation based on the museums name, in front of the museum number, in order to separate the collections from one another, geographically and culturally

(see section 1.2.4). The total sample size obtained from each artefact, for all chemical and thermal analyses, varies from 0.02 g to 0.04 g.

The reference samples (Table 1.2) are chosen from a selection of skin samples obtained from the informants. The selection is based on variation in substance and processing method and are marked according to material type (DS, LS, or SWH), according to nationality (N = Norway and R = Russia), and according to informant (by number). LS-R16-08 would then be a leg skin sample from the Evenk culture, made by informant number 16, and being reference sample number 8.

In addition to the reference samples collected during the interviews, a series of experimental samples has been produced to test certain properties in the skin material. The experimental samples (XSM-series) include whole skin with hair, where raw reindeer brain has been applied, and whole skin with hair where a variety of fats and mixtures of fats, vegetable tannin extract, flour, salt and fermented milk have been added. These experimental samples were produced primarily to investigate the substances' effect on the shrinkage temperature of the skin material, but were also very useful in the investigation of fats in the course of the chromatographic analysis (GC-MS). The different fats used in the experimental samples are locally purchased skin processing oils (bought in Karasjok and Kautokeino, in the north of Norway) and one is produced by the author (cod liver oil, F4), and are examples of the fats/emulsions used by tradition bearers from the Sámi culture today. The fats have been given successive number from F1 to F5. F1 is an opaque, beige, thick emulsion and F2 is a semi-opaque, light brown/yellow oil, F3 is clear, light yellow oil and F4 is a clear brownish red cod liver oil (CLO), while F5 is an opaque white emulsion. Apart from the cod liver oil (F4), the composition of these fats are unknown.

The experimental samples, furthermore, include depilated reindeer skin tanned with willow bark extract, called SNF, and depilated reindeer skin tanned with willow bark extract and fat (F5) called SWF, produced by Anne Kirsten Kemi Eira and Nils Nilson Eira in Karasjok, Norway. These were produced primarily to test the shrinkage temperature on multiple locations on the skin, which was also performed on an untreated whole skin with hairs attached (dried only). In addition, depilated reindeer skin treated with brown rotted larch wood, birch inner bark extract and alder bark extract was produced, all by the author. These are called Ref-Larix, Ref-Betula, and Ref-Alnus and were primarily used in the chromatographic analysis of vegetable tannins.

The aim of the analyses are to characterise and identify sample material from the various visual, chemical and thermal analysis and to compare and correlate results and/or groups of data to examine possible relations or structures in the data sets. The information and results are divided into five data sets, based on the different physical and chemical analysis performed on the material. Data set 1 includes data from the visual examination of all 187 historic artefacts, while data set 2 contains data from the fibre assessment analysis from 82 historic artefact samples (all three artefact groups). Data set 3 consists of data from the analysis of hydrothermal stability and of the pH measurements from 82 historic artefact samples (all three groups). Data set 4 consists of data from the analysis of vegetable tannins (HPLC) from 48 samples (group 1 and 2), and data set 5 consists of data from the analysis of fats and lubricants (GC-MS) from 82 historic artefact samples (all three artefact groups). The reference samples and some experimental samples have been subjected to the same analysis as the historic samples, for comparative purposes.

It must be noted that the results from the analyses is based on a minute sample from each artefact. It is not possible to determine the condition or the nature of the artefact, based on this one location. The condition and the nature of the artefact vary within the artefact and the results from the analyses must therefore be viewed as an example of the condition and the nature of the artefact.

Following the comparative analysis of the Sámi and the Evenk skin processing technology and the identification and characterisation of the skin materials, in the reference samples and in the historic artefacts, the following questions will be discussed: Is there a relation between the methods and materials used in the skin processing technology and the presumed condition of the artefacts. Furthermore, what are the possible implications of skin processing technology, as well as the changes taking place in skin processing technology, on the preservation prospective of this type of artefacts?

Experimental samples – reindeer skin

Number	Method	Type	Year
Ref-Larix	Brown rotted larch wood extract	DS	2006
Ref-Alnus	Alder bark extract	DS	2006
Ref-Betula	Birch bark extract	DS	2006
XSM-1	Cod liver oil (CLO) (fat number 4 = F4), fermented milk (FM) , wheat flour, salt	SWH	2005
XSM-2	Oil (fat number 3 = F3), fermented milk (FM), wheat flour, salt	SWH	2005
XSM-3	Oil (fat number 2 = F2), fermented milk (FM), wheat flour, salt	SWH	2005
XSM-7	Cod liver oil (CLO) (F4)	SWH	2005
XSM-9	Willow bark extract, cod liver oil (CLO) (F4), wheat flour	SWH	2005
XSM-10	Cod liver oil (CLO) (F4), water, fermented milk (FM), wheat flour, salt	SWH	2005
XSM-11	"White" oil/emulsion (fat number 5 = F5)	SWH	2005
XSM-13	Reindeer brain - raw	SWH	2005

Table 1.1. Experimental samples produced by the author.

Reference samples – reindeer skin

Number	Method	Location	Collected - year
LS-N13-01	Willow bark extract, fat	Kautokeino, Norway	2004
LS-N3-04	Willow bark extract	Karasjok, Norway	2004
LS-R16-08	Larch brown rot wood, smoke, reindeer liver	Kharyyalach, Siberia	2004
SWH-N13-09	Willow bark extract, fat, flour	Kautokeino, Norway	2004
SWH-N1-11	Fat, flour, fermented milk	Karasjok, Norway	2004
SWH-R10-12	Larch brown rot wood, reindeer liver	Kharyyalach, Siberia	2004
DS-N9-14	Willow bark extract, fat	Kautokeino, Norway	2004
DS-N7-16	Willow bark extract, fat (grandmother)	Karasjok, Norway	2004
DS-N7-17	Willow bark extract, flour, fermented milk, salt	Karasjok, Norway	2004
DS-R10-20	Larch brown rot wood, smoked	Kharyyalach, Siberia	2004
DS-R10-21	Larch brown rot wood, reindeer liver	Kharyyalach, Siberia	2004
DS-R16-22	Larch brown rot wood, smoked, reindeer liver	Kharyyalach, Siberia	2004
REF-Untreated	Dried reindeer skin	Karasjok, Norway	2004

Table 1.2. Reference samples obtained from the informants.

Historic samples from the Sámi and the Evenk culture

Museum number	Material	Artefact type	Geographic location	Age type
Sámi culture - Group 1				
TM - 0712	DS	Bag	Karasjok, Norway	Unknown
NFSA - 4066b	DS	Leggings, winter	Finnmark, Norway	100
SVD - 0023	DS	Bag	Norway	Unknown
SVD - 2158	DS	Leggings, summer	Kautokeino, Norway	30
TM - 1273b	SWH	Coat	Kautokeino, Norway	40
NFSA - 4064	SWH	Coat	Finnmark, Norway	100
SVD - 2240	SWH	Coat	Karasjok, Norway	Unknown
SVD - 2565	SWH	Coat	Beskenjarga, Norway	Unknown
TM - 1138a	LS	Short boots, winter	Karasjok, Norway	55
NFSA - 3934a	LS	Short boots, winter	Nesseby, Norway	100
SVD - 2220	LS	Short boots, winter	Kautokeino, Norway	30
SVD - 3374	LS	Short boots, winter	Beskenjarga, Norway	Unknown
Evenk culture - Group 1				
VK - 6161:17	DS	Bag	Evenkia, Siberia, Russia	15
MAE - 0376-59c	DS	Thigh high boots	Siberia, Russia	115
IMRM - 0736-1	DS	Coat	Barguzniski Rayon, Chita Oblast, Russia	120
REM - 1210-2	DS	Short trousers	Krasnoyarsk, Russia	100
VK - 4934:170	SWH	Coat	Yenisei, Russia	95
MAE - 0273-1	SWH	Coat	Eastern Siberia, Russia	110
IMRS - 0345-1	SWH	Coat	Lena River, Irkutsk Oblast, Russia	100
VK - 5275-1	SWH	Coat	Siberia, Russia	85
VK - 4934:175	LS	Boots	Yenisei, Russia	95
MAE - 0376-59c	LS	Thigh high boots	Siberia, Russia	115
IMRS - 0544 A	LS	Coat	Nizchni Tunguska River, Irkutsk, Russia	100
LS-REM - 6749-5	LS	Chestpiece, male	Yenisei, Krasnoyarsk, Russia	75
Sámi culture - Group 2				
TM - 1954	DS	Bag	Kautokeino, Norway	30
TM - 2239b	DS	Leggings, summer	Finnmark, Norway	Unknown
NFSA - 3930	DS	Bag	Finnmark, Norway	100
SVD - 2205	DS	Bag	Kautokeino, Norway	Unknown
TM - 1149	SWH	Coat	Norway	65
NFSA - 0582	SWH	Coat	Kautokeino, Norway	100
NFSA - 3715	SWH	Coat	Finnmark, Norway	100
SVD - 2110	SWH	Coat	Kautokeino, Norway	65
TM - 0545	LS	Bag	Kautokeino, Norway	55
NFSA - 4066a	LS	Leggings, winter	Finnmark, Norway	100
SVD - 0790	LS	Leggings, winter	Norway	Unknown
SVD - 2212	LS	Leggings, winter	Kautokeino, Norway	Unknown
Evenk culture - Group 2				
VK - 4934:174	DS	Boots	Yenisei, Russia	95
MAE - 1524-168	DS	Short trousers	Siberia, Russia	100
IMRS - 0092-4	DS	Chestpiece	Buryatia, Zabaikal, Russia	120
IMRS - 0344-5	DS	Thigh high boots	Lena River, Irkutsk Oblast, Russia	100

VK - 4934:182	SWH	Coat	Yenisei, Russia	95
VK - 6161:14	SWH	Coat	Evenkia, Siberia, Russia	15
MAE - 1524-3	SWH	Coat	Turukhansk, Krasnoyarsk, Russia	100
IMRS - 0510A	SWH	Coat	Nizchni Tunguska River, Irkutsk, Russia	100
VK - 4934:176	LS	Boots	Yenisei, Russia	95
VK - 6161:25	LS	Bag	Evenkia, Siberia, Russia	15
MAE - 1004-62/2	LS	Thigh high boots	Siberia, Russia	100
MAE - 1524-2	LS	Coat	Turukhansk, Krasnoyarsk, Russia	100
Sámi culture - Group 3				
TM - 0491	DS	Bag	Tysfjord, Norway	Unknown
TM - 1153	DS	Trousers, winter	Kautokeino, Norway	55
NFSA - 3445	DS	Bag	Finnmark, Norway	50
SVD - 0429	DS	Bag	Norway	Unknown
SVD - 0459	DS	Bag	Norway	Unknown
SVD - 1171	DS	Bag	Norway	Unknown
SVD - 1511	DS	Bag	Norway	Unknown
SVD - 0078	DS	Leggings, summer	Norway	Unknown
SVD - 1458	DS	Leggings, summer	Norway	Unknown
TM-unr-toolmarks	SWH	Coat	Finnmark, Norway	Unknown
TM - 2272	SWH	Coat	Karasjok, Norway	30
NFSA - 3838	SWH	Coat	Masi, Norway	30
NFSA - 0361	SWH	Coat	Pasvik, Norway	100
SVD - 2210	SWH	Coat, child	Kautokeino, Norway	Unknown
SVD - 1553	SWH	Coat	Norway	Unknown
SVD - 1567	SWH	Coat	Iskusjokka, Norway	Unknown
SVD - 2109	SWH	Coat	Enare, Finland	65
SVD - 2246	SWH	Coat	Karasjok, Norway	Unknown
TM - 1833	LS	Short boots, winter	Kautokeino, Norway	35
SVD - 1069	LS	Short boots, winter	Norway	Unknown
SVD - 2099	LS	Short boots, winter	Norway	Unknown
SVD - 2337	LS	Short boots, winter	Karasjok, Norway	Unknown
SVD - 1502	LS	Leggings, winter	Karasjok, Norway	Unknown
SVD - 2879	LS	Leggings, winter	Norway	Unknown
SVD - 3592	LS	Leggings, winter	Norway	Unknown
SVD - 2219	LS	Short boots, winter	Kautokeino, Norway	Unknown
Evenk culture - Group 3				
VK - 4934:183	DS	Chestpiece	Yenisei, Russia	95
VK - 4934:178	DS	Coat	Yenisei, Russia	95
MAE - 0330-4	DS	Boots	Eastern Siberia, Russia	110
VK - 4934:180	SWH	Coat	Yenisei, Russia	95
VK - 4934:171	SWH	Coat	Yenisei, Russia	95
REM - 9996-2	SWH	Coat, child	Tugur, Khabarovsk, Russia	30
MAE - 3957-1	SWH	Coat	Siberia, Russia	75
IMRS - 4408-118	SWH	Coat, child	Aldan River, Yakutia, Russia	110

Table 1.3. Historic artefacts where samples have been obtained.

2 INFLUENCES ON SKIN PROCESSING TECHNOLOGY IN THE EURASIAN ARCTIC AND SUB ARCTIC

In the Eurasian arctic and sub arctic a number of basic principles determine why certain clothing items or footwear appear as they do, and also play an important role for the choice of specific materials and methods. In addition it is difficult to discuss cultural traits without considering the interaction between human culture and environment (Müller-Wille, 2001:285). This closeness between people and nature is not only reflected in their technology, but is also present in the general holistic worldview of most indigenous groups.

'Tradition' is a complex term and is explored widely in the literature. According to Shils it may simply be defined as: "anything which is transmitted or handed down from the past to the present" (Shils, 1981:12). A working definition introduced for this study is: *The knowledge related to specific skills that each generation finds important to pass on to the next generation; to enable this generation to uphold and continue a way of life; and to enable this generation to pass on the same knowledge to the following generation.* Through this transferral of skills each generation adds or removes elements. Each generation will likewise have conceptions of which traditional knowledge or skills that is important enough to be handed down and, furthermore, which traditional knowledge or skills they will continue unaltered or in a modified form to fit their present lifestyle. People are continuously making choices, consciously and subconsciously, regarding how to treat what has been handed down, demonstrating that tradition is a highly dynamic cultural feature.

In this chapter I will look at some issues concerning knowledge transfer, which have an effect on skin processing technology, and what these mean for the continuity and practice of skin processing technology today. Preserving or maintaining indigenous traditional knowledge in its variety of forms is furthermore, an important issue and will be discussed, as will also the concepts of revival and reinvention of cultural elements. Are specific methods and materials confined to distinct ethnic groups or cultures, or is there a general Eurasian or perhaps circumpolar methodology? If so, what are the principles that regulate this methodology?

2.1 Tradition

The attachment to nature is looser now than before, and many cultural traits have been adopted from the majority culture. It can be discussed whether this is a form of acculturation, in the meaning: "...processes by which individuals, families, communities, and societies react to inter-cultural contact..." (Rudmin, 2003), or whether detraditionalisation has occurred and is continuously occurring in societies today (Giddens, 1994:100-104). Both the definition of tradition and whether one is discussing acculturation or detraditionalisation on a small-scale or on a large-scale level must be taken into consideration. In relation to skin processing, the small-scale level is the most important, as this technology was and is primarily passed on within the family, from one person to the other. However, on a large-scale level, institutions, such as schools and the community administration are today playing an increasingly important role in transferring traditional knowledge and skills. There is in Sámi and Evenk cultures a strong sense of tradition connected to skin processing; this is not only linked to the usage of specific materials but also to language, and to knowledge systems of when and where to find appropriate materials which enable one to perform a specific activity or skill. Tradition serves to direct people within a community or nation: "as guiding elements for commonly accepted conduct" (Svensson, 2003:1). Tradition, in this way, forms a basic foundation from which people can perform, maintain and develop traditional skills or crafts. Furthermore, traditional skills contain an element of adaptability, which allows the manufacturer of garments to make choices as to what is available, what is suitable in a given situation, and what will provide the desired properties to the manufactured garment.

In addition, it is appropriate to suggest that the performance of traditional crafts provides people with an identity, a belonging to an ethnic group or a nation, whether it is on a micro or macro structural level. Constructing and using traditional garments demonstrates distinctiveness and shows a joint manifestation, even though the variety within an ethnic group is consider-

able. Maja Dunfjeld (2003:167) accentuates this point when she merely states: "a costume communicates the bearer's identity".

Transferring culturally significant features, for example by incorporating artefacts in museum collections, is an established system of handing down tradition, and at the same time it is a way of making traditional features available to a larger audience. An artefact which is allocated status as a traditional artefact increases in value as a cultural artefact. The artefact may also benefit by increasing local awareness, relating to traditional technology, and national and international awareness (Shils, 1981:69).

2.1.1 Reading tradition

Is it possible to read past traditions from artefacts in museum collections today? Skin processing leaves traces or characteristic features on an artefact, but learning to read these features is complicated. It demands a prior knowledge of skin processing technology and an understanding of the basic material characteristics. It furthermore requires close communication between the tradition bearer and the researcher and eventually provides vital information of consequence for the prospective preservation of the artefacts.

The artefact displays the decorative qualities and specific materials used. Simultaneously it is a product, mirroring culture-specific skills, technology, and ideas. The existence of similar artefacts from different time periods does not mean that integral or invisible characteristics are the same in all historic periods, even in the same type of artefact. Each generation adds an element or changes some features; these may be justified as improvements, as due to availability, demands of modernisation, intercultural exchange or as a consequence of individual preference.

Previously developed perceptions of the mechanisms that regulate skin processing technology are, however, helpful in interpreting cultural artefacts. One example is the use of fat among Evenks in processing reindeer skin. During the interviews one informant repeatedly stated that bear fat or marmot fat was the only fat used in the processing of reindeer skins. A few days later this information was revised, as it became clear that hardly any bears or marmots had been killed in the village in the last years. The informant became almost annoyed at my continuous questions regarding which fats that could be used if there was no bear or marmot fat. I had to understand that it was possible to use almost any fat available! This example not only shows the diversity of material use and that a variety of materials can be used to obtain a specific property; it also demonstrates that even though the literature may state that a certain material was traditionally used on specific types of artefacts, it does not necessarily mean that the artefact in question has been treated in the same way.

2.1.2 Inventing tradition

"No tradition has come about without being an invention or recirculation of expressive marks and gestures", writes Regis Debray in his book *Transmitting Culture* (1997:2). Debray's statement is justifiable: for example, in the way of doing a specific operation which must have originated at a certain point in time. This is the foundation in any discussion concerning the aspect of tradition. When asking informants working on skin processing why they do things in a certain way, the answer often is "because we have always done it like this; it is our tradition". Even though there can be changes in the process, such as using a modern fat instead of cod liver oil or a quebracho tannin powder instead of willow bark extract, the changed process is not seen as an invented tradition, and it will still remain a traditional process under constant evaluation.

In the introduction to the book *The Invention of Tradition* Hobsbawm defines invented tradition like this: "'Invented tradition' is taken to mean a set of practices, normally governed by overtly or tacitly accepted rules and of a ritual or symbolic nature, which seek to certain values and norms of behaviour by repetition, which automatically implies continuity with the past." And he continues: "In short, they are responses to novel situations which take the form of reference to old situations, or which establish their own past by quasi-obligatory repetition" (Hobsbawm, 1983:1, 2). So far his views are rather uncontroversial, but a few pages later he continues: "On the other hand the strength and adaptability of genuine traditions is not to be confused with the 'invention of tradition'. Where the old ways are alive, traditions need be neither revived nor invented" (Hobsbawm, 1983:8). This indicates a separation of the world into 'we' as in western societies and 'them' in other possibly so-called 'traditional' societies where one cannot speak of invented tradition and where traditions are genuine. It would here be pertinent to ask how old a tradition must be to be genuine, and it is also appropriate to propose that what we consider genuine tradition also has been invented at one point in time. Nesheim (1964:201, 207) suggests, through linguistic research, that the tanning

Fig. 2.1. Summer festival (Ysyakh) in Olenek, Sakha Republic, July 2001.

of depilated reindeer skin with bark was not originally a Sámi technology, but that the Sámi had learnt this process from their Finnish and Scandinavian neighbours. He bases this on the fact that terminology used to describe this procedure, for example the skin types, *sis'te* or *sasnē*, was based on loanwords from Finnish or old Nordic language. At what point in time this possibly took place is not indicated. Although this process may not be original in the Sámi culture, the technology of vegetable tanning of depilated skins used in the Sámi culture is today defined as a traditional technology. In a Reith Lecture Anthony Giddens makes a comment on Hobsbawm's notions on invented traditions and so-called traditional societies: "You should say that all traditions are invented traditions, because all traditions grow out of a continuous reappraisal of the past. Most traditions are involved with power; most traditions involve conscious elements of artifice, invention, deliberate creation. There are few traditions, if any, which just grew up in a spontaneous way" (Giddens, 1999).

As in any society, the indigenous societies also have regenerated traditions to maintain and strengthen their common identity. The local costumes are an example of this. This is seen both in the majority society in Norway and in the Sámi and Evenk communities in Scandinavia and in Siberia. Reviving festivals and commemorating specific dates, along with religious and festive events, either a national day or a significant event in one's history, are markers of identity and are situations in which these costumes are worn. These are culturally significant but also important political markers (Svensson, 1992:71).

During the fieldwork of this study, among the Evenks in Olenek in the northern Sakha Republic in 2001, the summer festival (Ysyakh) was re-invented. The festival went on for several days and included sporting events, fashion shows, and performances by young and old. Even though this is originally a Yakut tradition, both Yakuts and Evenks attended the festival in Olenek. The highlight of the festival was the marking of the summer solstice and involved the participation of a shaman for the opening ceremonies. This was allegedly the first summer festival in this village for many years, and it was organized with the help of an advisor from the capital, Yakutsk. The clothing worn at the festival, the designs of the fashion shows and the costumes of the performers, showed very clearly the strong traditional elements as well as the modernised versions of costumes and accessories, both in decoration and material (Fig. 2.1).

2.1.3 Changing traditions

A different interpretation of tradition comes from the folkloristic academic field. It is here implied that "...tradition is process rather than content..." (McKean, 2003:49), which indicates that process is more important than the actual content. It does not indicate that content is not important at all, but merely that cultural traits are subject to change without losing their feature of being traditional. This agrees with the interpretation of tradition in this study. This continuous change, however, may also lead to a loss of knowledge. This is not a loss in the basic knowledge of skin processing technology but rather a loss in variety and breadth of the methods and materials, caused by the fact that the number of elders with knowledge of skin processing is decreasing. It is, moreover, caused by the fact that fewer and fewer girls and boys learn the methods of skin processing at home from an early age. If a garment or an artefact goes out of use, or if a natural resource is reduced, the skills and technology connected to it may be lost (Shils, 1981:81; Shirokogoroff, 1935:116). This is seen in the change of everyday clothing, where new materials are incorporated and older garments disappear (Buijs, 1997:27). An article by Patricia Cochran has a striking title which illustrates this: "What is traditional knowledge? *When an elder dies, a library burns*" (Cochran, 1997). This indicates not only that knowledge may be owned by the elders, as keepers of information or as guardians of knowledge (Giddens, 1994:79-80), but also that the knowledge must be transferred in order to continue traditional practices.

In the last decades there have emerged workshops and courses, locally as well as in the public school system, where one may learn skin processing techniques. These courses are taught by tradition bearers, but it is only reasonable to assume that the richness of a specific method must be somewhat reduced during the event of a course or workshop, as it would be difficult to encompass all relevant elements and varieties in the processing methods in a limited period of time. It is, nevertheless, incorrect to imply that processes thereby are lost, as over time there will transpire new varieties based on the methods taught. It may be more accurate to say that the processes change according to contemporary demands, and new traditions appear which also eventually may become rich and varied as the apprentice gains knowledge and experience. An example of this may be seen in a tour which Swedish Sámi women organised to Lovozero on the Kola Peninsula to teach crafts, such as skin processing, to Russian Sámi women. "They had realized that the Russian Sámi's had lost the knowledge of many parts of their own culture such as the crafts as a result of the communist collectivization" (Niemi, 1998:1-2). These visits to teach lost crafts would mean that the methods learnt during these workshops would be the Swedish Sámi methodology. In addition, the individual Swedish tradition bearers present at the workshop would be teaching the specific method which he or she was taught, together with the variations adopted with time. This would indicate that the methodology itself is not the main focus in manufacturing skin garments, and would more precisely indicate that design, symbols in ornamentation, is a more important feature in maintaining cultural identity than the material from which it is made (Dunfjeld, 2003:166).

Accepting changes in skin processing technology does not mean that it is unimportant to describe and maintain past traditional features, or that cultural traits are not important for the building of identity in a society. It is important to keep past traditions alive through encouragement and to allow people the opportunity to learn, thereby maintaining the complex knowledge systems encompassed in skin processing technology as a single cultural trait.

2.1.4 Changes in the use of materials and tanning agents

As other materials, such as wool, cotton, linen, silk, and synthetic fabrics in all varieties became available through trade and later in shops, they were incorporated in the range of materials utilized for garments and footwear. In both the Sámi and the Evenk areas one can observe today that for severe climatic conditions, especially during the low temperature periods in the winter, outdoor clothing is to a certain degree made from the fur of the mammals available in the local area, such as reindeer, elk, red deer, marine birds, bear, and wolf, whereas materials for summer clothing and clothing used indoors are manufactured from a variety of fabrics and materials obtainable in the shops. It is observed that among the elders in the Sámi and Evenk communities depilated reindeer skin is still used primarily for boots, whereas the younger generation seldom use depilated reindeer skin boots or garments in every day life (Fig. 2.2 and 2.3). This change in material use may be explained by the general modernisation of society. Today women, who in most cases were and still are responsible for the production of garments, have other priorities and need to rationalise the time spent on producing garments, especially if substitute materials are available and possess "the same" or "better" qualities.

Fig. 2.2 Garek Kombagir (in the middle) wearing thigh high rubber boots. Olenek River, Sakha Republic. July 2001.

Fig. 2.3. Afanasieva Tatyana Kombagir using depilated skin boots. Settlement north of Kharyyalach. July 2001.

Fig.2.4. Leggings made from reindeer leg skin (left) and from floss fabric. Karasjok, Norway. February 2004.

Furthermore, the practical aspects of maintaining skin and fur materials is more time consuming than are necessary for most of the fabrics available in the shops. An example is depilated waterproofed skin boots used in the wet areas in the spring, summer and early fall period. These depilated, tanned skin boots have to be sufficiently and repeatedly treated with fats and sometimes tar products to be able to withstand the moist ground, whereas rubber boots are made from waterproof materials and require little attention with regard to maintenance. There is, however, an issue of comfort for the user which must be taken into consideration, and which may be one of the reasons why trousers and boots from depilated, tanned skin are used today, although not in great numbers.

Another example of the changes in materials is the reindeer leg skin leggings used in the Sámi costume. These leggings are used when the costumes are worn for festive and ritual purposes and especially when these events take place indoors. Today, as it is more difficult for some people to obtain leg skins of the desired dark colour, alternative materials are used (it takes the legs from two reindeers to make a pair of leggings). Alternative materials are different floss fabrics, which from a distance give the impression of being correct. (Fig. 2.4) In addition they are easier to make, they are softer and lighter, and they are not as warm as reindeer leg skin leggings (Guttorm, 2004, pers. comm.).

There is a change in material use, and there is a change in substances used for tanning purposes and in the methodology. As mentioned above, in the Sámi culture the fat used in skin processing changes from cod liver oil to leather fats you can buy in the local shop, or to other available fats which give the desired properties in the skin material. This change also encompasses vegetable tanning agents, as ready made tannin powders such as quebracho and mimosa, which are used for tanning purposes (although few people admit to using them). In the increasing tourist trade, there is an emerging division of methods: one method used for artefacts for your own use, and one method for use in artefacts made for the tourists. Because of the complicated and time-consuming technology of processing skin materials, it is difficult to get a fair price for tourist items. Using ready made tannin powders and a washing machine in the tanning process reduces the time spent for each skin and thereby the price of the artefact that is produced and sold.

In the Evenk communities in this study, the tourist trade is very small, almost non-existent, and this division is not observed. There is however a division, between garments used for work and for climatic protection and garments or artefacts made for leisure or for festive occasions. The decrease in the number and type of skin which is smoked is a sign of rationalisation as well as an evaluation of what properties are required by the intended use of the skin: does the skin need to be waterproofed or does it not. If the skin material is not to be used in wet areas, there is no definite need to smoke the skin. The rationalisation of technology also includes using commercial fats and the extract of black tea in the tanning of skins.

2.2 Knowledge, resource use and environment

The adaptation to natural resources is described by Shirokogoroff: "The elements of the Tungus complex of clothing and household, beginning from the wigwam, are indicative of two facts, namely that the Tungus gradually and regardless of origin have accumulated knowledge of using the materials found-at-hand in the most economical way in the given conditions and that their complex of the clothing and household with a few exceptions is well adapted to the local conditions and needs of a hunting mode of life" (Shirokogoroff, 1935:93). According to the anthropologist Julian

Steward, certain aspects of a culture are influenced by the environment, or how to utilize and adapt to the environment around you (Steward, 1955:30, 37). This human environmental interaction (Müller-Wille, 2001:285) can be observed in all aspects of skin processing in the circumpolar area.

Even though a variety of materials, such as wool, silk, cotton and nettle has been used for clothing purposes in the arctic and sub arctic, as reported by Krasheninnikov in the 18th century, clothing production in indigenous cultures was and still is highly affected by available and local natural resources. The theory of possibilism, as described in the 1920 by Vidal de La Blache, suggests that people make choices from the possibilities offered by the environment. This school of thought in cultural geography succeeded environmental determinism, a school that implied that cultures were, in all respects, moulded by the nature that surrounded them (*Wikipedia*, 2006).

Even though possibilism is highly inadequate to describe indigenous cultural traits today, it is less so than its predecessor, environmental determinism, and can still be useful in illustrating the close relationship that exists between the environment and certain cultural traits, such as skin processing technology. Considering the flora and fauna in a region will indicate the choice of skin materials and also which substances are most likely used in the tanning of skin material. In regions where reindeer migration occurs or where reindeer herding is the basic subsistence activity, people will most likely use reindeer skin for winter clothing and reindeer leg skin for boots, simply because, based on experience, this material gives the best protection under certain conditions. In areas where reindeer are not migrating and where subsistence is mainly based on elk and other fur animals, elk skin and, for example, wolf fur will be used for clothing purposes. This is observed in the Evenk culture in the Katanga County in Siberia, where migrating reindeer are not present (Grøn, 2005, pers. comm.).

This basic variation in material use takes place even though it is generally understood that Evenk cultural clothing is mainly based on reindeer skin. Issenman illustrates the adaptation to available natural resources in her book *Sinews of Survival*, with a story of the Qikirtamiut of Sanikiluaq (Belcher Islands) who at one point in time began making parkas from marine bird skins instead of using the accustomed reindeer skin. The reason was as follows: In the late 1880s the winter temperature on the Sanikiluaq islands rose and then suddenly fell creating an icy layer on the ground, making it impossible for the reindeers to graze. The reindeer starved and died, and the Qikirtamiut did not have any available reindeer skins for their parka production. Instead they turned to what were available and made parkas from marine bird skins and used seal skin and dog skin as reinforcement and trimming (Issenman, 1997:159).

2.2.1 Indigenous knowledge and traditional practices

Knowledge can be separated into formal knowledge and non-formal knowledge. Formal knowledge is learnt in educational institutions or passed on to a larger audience through governmental bodies. This type of knowledge may be communicated verbally but is based on written sources or written down for individual study. Non-formal knowledge is passed on from one person to another or to groups of people; it is not written down and is transferred by communication, learning by doing or observation. Traditional knowledge may be characterized as non-formal knowledge. It may, furthermore, be described as silent or tacit knowledge with its parts not being consciously recognized, as it is part of the culture where a person is brought up. It can be individual (specialist) or collective (shared) knowledge. There are overlapping features between formal and non-formal knowledge both in the matter of skills and insights in various areas. Formal knowledge, also called scientific knowledge, is generally based on theories and hypotheses, and changes by refuting or replacing existing knowledge. Non-formal knowledge is part of person's culture and is accumulated through lifetime experience. It changes gradually into new experiences without necessarily discarding former knowledge (Borgos, 1993:8-9). Even though the term traditional knowledge is used, it is emphasized that all traditional knowledge is contemporary and dynamic, as it is continuously revised and updated (Cochran, 1997:96).

Ole Henrik Magga describes it as follows: "Indigenous traditional knowledge and traditional cultural expressions, i.e. what we today sometimes refer to as their cultural heritage, arises as a result of a particular way of life. It is not a result of one or a group of individuals' endeavours. All members of the society contribute. Indigenous traditional knowledge and traditional cultural expressions vests in the collective, rather than with specific individuals. It is modified and enlarged over time, from one generation to the next" (Magga, 2003).

As all indigenous traditional knowledge, skin processing is context-based and holistic, which means that

the practise of knowledge in one field may be closely related to knowledge in other fields, to spiritual aspects, environmental aspects, and to language.

Skin processing terminology includes more than a description of an actual process; a specific term may also give an idea of how far the process has gone and what material one is working on and towards (Eira Buljo, 2004, pers. comm.). Elina Helander makes a similar point: "The Sámi language expresses cultural knowledge, ecological know-how and knowing, and values in relation to a sustainable way of living. The Sámi language transmits knowledge from one generation to another" (Helander, 1996: 2). This means that systematically collecting information on knowledge regarding skin processing and providing opportunities to organize courses/internships to pass on knowledge to the next generation is a small but complex part of the effort to maintain traditional knowledge in a society. Sustaining subsistence practices and supporting the continuous strengthening of indigenous cultures is an important overall measure to achieve this. This is similarly expressed in the *Report of the Traditional Working Group* (Legat, 1991:3) where an important point in developing and sustaining traditional knowledge is that: "Traditional knowledge is best preserved through use". Elements of traditional knowledge are today being taught in schools and universities, taking into consideration the challenges as to how this knowledge can best be communicated within the formal educational system. The change of traditional knowledge from being non-formal knowledge to becoming formal knowledge will dramatically change the way traditional knowledge prospers. Is it, for example, possible to write down the entire process of making a traditional artefact? Is it from such a description possible to construe the subtleties and details included in an all-encompassing process? The answer is no, which implies that passing on traditional knowledge or specific skills must transpire between tradition bearers and learners and be developed over time.

Fors explains the Sámi term 'calbme', which may be translated as "the eye for another person"; in addition to dialogue and demonstration the term also includes the holistic, a cultural and spiritual dimension, with knowledge about ecology, sustainability, nature, materials, and about tools. *"Calbme* for someone also transfers cultural attitudes, skills and a spiritual dimension" (Fors, 2004: 86, 87, 98; author's translation).

"The preparation of skins, in general, requires good experimental knowledge of the methods and personal skill which are transmitted from one generation to another." This was written by Shirokogoroff in his book *Psychomental Complex of the Tungus* and captures the basic aspects of skin processing technology (Shirokogoroff, 1935:93). Skin processing technology, is based on traditional knowledge; this is accumulated knowledge and experience: knowledge of materials, how materials may be physically manipulated to acquire the properties that are needed for a specific purpose, and the ability to adapt materials and methods according to current conditions. Technology is both the production and use of tools and the selection of materials and substances that will result in manufactured items for specific purposes. There will be variations from person to person with regard to skill and experience, which means that some tradition bearers are more skilled than others and can be specialised in certain areas, such as in the production of boots or depilated skin artefacts.

2.2.2 Classic scientific research and traditional knowledge

Traditional knowledge has generally been regarded as unscientific and therefore given little weight in classic scientific research. However, recent studies have gradually acknowledged the significance of indigenous knowledge as scientifically valuable (Hobson, 1992). Until now this has primarily taken place in the natural sciences and is termed 'traditional ecological knowledge' (TEK), but it is also gaining ground in other fields, such as cultural heritage management (Clavir, 2002). This is mainly recognized in the American and Canadian arctic and may have been brought on not only by the realization of the amount and the quality of the information available but also by the indigenous populations' possibility, through self government, to demand interaction in indigenous and arctic research projects. Ethical guidelines for research drawn up by indigenous governmental bodies are strategies by which they can secure influence and interaction in projects and to enhance quality in gathered data. An example of this is "Guidelines for Respecting Cultural Knowledge" in the Alaska Native Knowledge Network. The Scandinavian research milieu still has a way to go with regard to the interaction of traditional knowledge and classic scientific knowledge (Magga, 2002:131).

The preservation of museum collections which include skin material is one field where traditional knowledge and classic science may interact. As mentioned, to understand and preserve an artefact, the knowledge of material use and technology is crucial.

The mutual interest of indigenous museums and museums with collections from indigenous cultures is the preservation of the artefacts. This requires the bridging of different fields of research and being able to communicate the needs and wishes of all involved, thereby to arrive at the best possible preservation proposal for the artefacts in question. At the same time the information encompassed in an artefact is incorporated in the local museum archival system and made available for research and study. This gathered documentation may serve as a backup of basic traditional knowledge information, but it can never be regarded as an archive of traditional knowledge in its full sense, as this can only be sustained by active tradition bearers in each culture.

Fig. 2.5. Benchik Natalia Vladimirovna outside her aunt's house in Kharyyalach, wearing a coat, hat, mittens, purse and boots made from reindeer fur. July 2004.

2.3 Concluding remarks

The assumption that the skin processing methodology itself is not closely associated with specific cultures or ethnic groups does not mean that there is no variation in technology from one geographic area to another. The variations are numerous and materials and methods differ, but these variations are not primarily culturally determined.

Within these variations individuals explore and develop the technological aspects as well as develop designs and decorative elements. Karen Marie Eira Buljo from Kautokeino, Norway is a seamstress and a tradition bearer who is preoccupied with the preservation and maintenance of traditional methods and materials, while at the same time she is both technologically creative and constantly refining and improving the current methods of skin processing. "There is always an ongoing development of processing methods and exploration of materials. You test new methods and materials all the time" (Eira Buljo, 2004, pers. comm.,). Benchik Kristina Afanasievna from Kharyyalach in Northern Sakha Republic, Russia, is famous in the Evenk community for being an artist and an excellent seamstress who goes new ways in modernising the traditional methods for making especially festive clothing. Her niece, Benchik Natalia Vladimirovna (Fig. 2.5) lives in Yakutsk in the Sakha Republic where she works as a designer and seamstress. On occasion she works with her aunt in making new but traditionally based designs.

These women represent their community and are fronted as strong tradition bearers with great knowledge of the traditional technology and as artists in their field. That is, they are both identity markers in the Sámi and the Evenk cultures and at the same time strong individual performers of skin processing technology. Using dress and decoration as political markers is perhaps more important now than before because of ever increasing globalisation, the continuous pressure on national and international natural resources, and on the ownership and control of these resources. To uphold their identity and a certain amount of self-government is difficult for minority populations within

an established nation-state; they are generally subject to external pressure and are forced to maintain pressure on both national and international level. Using cultural features as markers may serve as a visible element in coping with this pressure. Use of cultural markers may also be observed in the negotiations of intellectual property rights (IPR) and patents granted to traditional ecological knowledge and for the protection of traditional design elements and patterns (here concerning the amauti) used by indigenous cultures (O'Hearn, 2002:18). The emergence of the term 'intangible cultural heritage' and the recognition of non-formal knowledge as an important feature in cultural heritage protection provide and make available better tools for indigenous organisations and governments in their continuous endeavour to uphold and strengthen indigenous cultures' way of life. The adoption of the "Convention on Biological Diversity" at the United Nations Earth Summit in Rio de Janeiro in 1992, where world leaders agreed on a comprehensive strategy for *sustainable development,* and also the "Convention for the Safeguarding of Intangible Cultural Heritage" by UNESCO at the General Conference in 2003, are equally significant measures in this endeavour.

3 SKIN PROCESSING TECHNOLOGY IN EURASIAN INDIGENOUS CULTURES

The purpose of describing the technology of skin processing is to present the complexity and variety of materials, methods, tools and implements used in a selection of Eurasian indigenous societies as a basis for understanding the properties intrinsic to skin clothing items. An analysis of these technologies will make a platform for understanding the deterioration mechanisms and the future preservation prospectives of the skin materials used in these clothing items.

The knowledge of methods and substances that have been used and how they have been used has neither been fully documented in any museum collection nor in the literature. What exist are fragments of knowledge and examples of tools and artefacts from specific time periods in specific areas. The available literature sources, which describe skin processing methods and materials in indigenous cultures in the northern hemisphere, provide a general basis for understanding the theory of skin processing. These sources are, however, often insufficient in describing women's work, especially with regard to skin processing materials and methods; thus, they possibly lead to over-generalisations or direct misunderstandings. Major differences and similarities in the use of materials, and the use of tools between coastal and inland indigenous groups of the Nordic and Siberian area, will to a certain extent be illustrated. Material use and the use of tools in indigenous cultures in the American-Canadian arctic and sub artic area and in Greenland will be referred to whenever relevant.

The presentation will follow step by step the process of manufacturing skin material for clothing items from the choice of appropriate material through the following stages of processing to the final product.

Systematic names of mammals are based on *The New Encyclopaedia of Mammals*, edited by David MacDonald (2004) and systematic names of fish are based on the website: Fishbase, reading date 12.10.2005, http://www.fishbase.org/home.htm.

Systematic names of insects are based on Henri Mourier and Ove Winding's *Vilde dyr i hus og hjem*, and systematic names of plants are based on "Den Virtuella floran", first reading date April 8th 2005, http://linnaeus.nrm.se/flora/welcome.html.

3.1 The use of materials, tools, and tanning substances in Eurasian indigenous cultures

The purpose of the processing of skin is to obtain specific qualities for specific types of materials; examples are water repellence, flexibility, colouring, and to prevent putrefaction. The qualities that the processing aims at developing depend among other things on the climate in the specific geographical location, the natural resources present there as well as the local tradition and thus cultural identity. In parts of the northern hemisphere, where temperatures in the winter drop to minus 40 to minus 60°C, great care has to be taken concerning clothing and footwear. Therefore, the use of reindeer skin and other deer skin for clothing is and has been particularly important to the indigenous cultures living in these areas (Hatt, 1914:9).

Manufacturing clothing and footwear requires long term planning and is very time consuming. Women are required to know how many coats, trousers, leggings, boots, hats and mittens may be reused from last winter and how many new ones have to be manufactured for the coming winter. During the hunting season or the slaughtering periods it is important that the required skins for all the various specific purposes are gathered, processed and manufactured in time.

3.1.1 Reindeer, red deer, elk and roe deer as clothing material

In the deer family, the reindeer (*Rangifer tarandus*) (Fig. 3.1) in particular is adapted to the arctic and sub arctic area. Deer fur consists of long, brittle guard hair and dense, fine and curly under fur (woollen hairs). The length of the hair varies with species and season. The woollen hairs are more numerous than the guard hairs, and are fine and wavy, which insulates the surface of the skin (Fig. 3.2). In reindeer hair the medulla is the largest part of the guard hairs diameter. The cubical cells in the medulla are filled with air and separated by thin walls (Fig. 3.3) (Berge, 1949:290; Bohl & Nikolajewsky, 1931:6; Stenton 1991:603). This is what gives reindeer fur its excellent insulating proper-

Fig. 3.1. Early September assembly of reindeer in the mountains near Lakselv, Finnmark, Norway, 2004.

Fig 3.2. The difference in the hair's angle, in body skin (top) of the reindeer and in leg skin (below). The leg skin hair is angled closer to the skins surface.

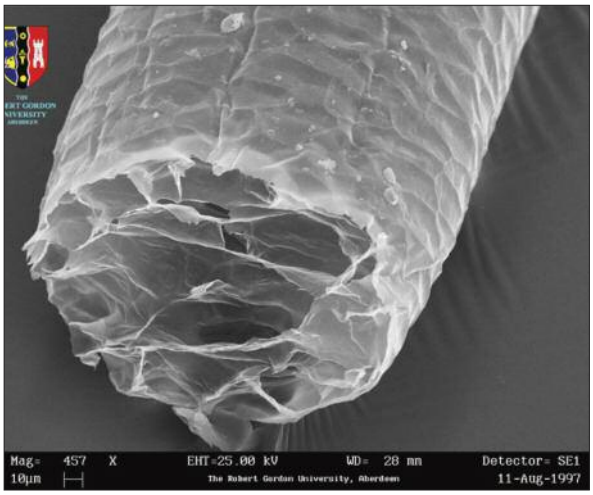


Fig. 3.3. SEM image of reindeer guard hair. Notice the air filled structure of the hair. With permission from The Robert Gordon University, Aberdeen, Scotland.

ties. For red deer (*Cervus elaphus*), roe deer (*Capreolus capreolus*), and elk (*Alces alces*), most of the skin's qualities are similar to the reindeer, but with certain limitations. For red deer and elk, where the skin is thicker and larger, the size and thickness in most cases constrains the usage of the skin for clothing, as it will be too heavy and uncomfortable to wear.

The composition of the particular skin determines what it can withstand in terms of processing and preservation. The effect of time on the skin is also a contributory factor in the choice of methods and tanning materials, or why certain skin processing techniques have developed. Reindeer fur has excellent insulating properties, but durability and preservation is quite poor. This is mainly caused by the nature of the guard hairs, which are brittle and filled with air. The hairs break easily, cannot be reshaped and are easily loosened from the skin (Berge, 1949:291-292; Banfield, 1974:384).

These characteristics affect the method of mechanical processing and influence the rate at which new clothes are made. Seasonal variations in colour, density and length of the fur are seen for reindeer as well as for other species of deer. Likewise there is a vari-

ation in the nature of hairs and the arrangement of hairs from different parts of the skin (Bohl & Nikolajewsky, 1931; Berge, 1949:291). The hairs on the legs of the reindeer are angled closer to the skin surface than the hair on the body (Fig. 3.2). This provides leg skin with a particular quality, which may be exploited in the subsequent skin processing stages. At the same time the hair density varies throughout the skin on the body of the reindeer – with higher density on neck and lower back than on the belly part of the skin.

3.1.2 Other materials used in clothing items

A range of other skin and fur materials are used in skin clothing, for decorative purposes but also as lining, trimmings, and edges. These include wolf (*Canis lupus*), wolverine (*Gulo gulo*), lynx (*Felis lynx*), dog (*Canis lupus familiaris*), hare (*Lepus sp.*), marmot (*Marmota sibirica*), pine marten (*Martes martes*), sable (*Martes zibellina*), mink (*Mustela sp.*), squirrel (*Sciurus sp*), and ermine (*Mustela erminae*). Bear skin, both from polar bear (*Ursus maritimus*) and brown bear (*Ursus arctos*) were and are also used. In coastal areas and in areas where there are and have been possibilities of trade or barter between the inland and coastal indigenous cultures, seal skin, gut skin and fish skin are used or have been used in the past (Bogoras, 1909:234). Different skins are also chosen for their properties, for example wolf and wolverine are especially suited for trimmings, as ice does not condense on the fur (Oakes, 1993, pers. comm.).

In today's indigenous societies there has been a general change from primarily using skin and fur materials in clothing manufacturing to a more varied use of materials which include fabrics such as wool, cotton, silk and synthetic materials (Hætta, 2002:101). In the Sámi communities in northern Scandinavia the use of wool as clothing material is mentioned as early as the mid 17th century in protocols concerning division of inheritance (Gjessing & Gjessing, 1940:14).

Krasheninnikov describes in his report from Kamchatka that in the 18th century the Itelmens used fabrics like wool and cotton in dresses, shirts, and trousers (Krasheninnikov, [1735-1741], 1972:224). Literature sources from the 18th, 19th and 20th century furthermore describe clothing manufactured from wool, cotton, silk and nettle (Sirelius, 1983:243; Levin & Potapov (Eds), 1964:528, 558, 598, 615, 641, 661, 689, 706, 726, 741, 754, 763, 774, 842, 887; Drake, 1918:165 and 168; Collinder, 1953:82; Castrén, 1852:133; Fjellström, 1985:474; Demant-Hatt, 1913:178-179; von Düben, 1873:156; Schefferus, 1956 (1673):232; Leem, 1975 (1767):73). The distinction between materials for winter and summer clothing is clearly marked. Skins with hairs attached are still used for winter clothing but summer clothing is made from various textile fibres. The need for appropriate clothing or footwear determines which materials are chosen in winter. The availability of resources and materials and the climate determine to a certain degree which materials are preferred for specific garments.

3.1.3 Tools

Tools employed in skin processing are various forms of scrapers and knives along with various implements to aid during the proceeding stages. Their main purpose is to remove substance from the surface, to work substances into the skin and to stretch the skin. Hands and also teeth play an important part as tools during certain steps in the processing technology. Scraping tools consist mainly of two types: One handed scrapers or end scrapers, with considerable variation in handle length, and two handed scrapers with variations in materials and shapes of both handles and blades as well as variations as to how the blade is attached to the handle. The additional series of implements which assist during the different stages of changing a raw pelt into a material suitable for clothing and footwear are frames or racks for drying and scraping, smoking constructions, scraping boards, softening chairs, wooden sticks, pegs, and nails.

The geographical and historical distribution of tools and implements used in indigenous cultures in the circumpolar area is a wide and fairly unexplored field of inquiry. In the last centuries tools and implements have changed according to the availability of natural resources, trading possibilities, and the continuous change and improvement of the technology itself. The creativity in constructing tools and implements has few limitations. As long as the tool provides the effect that is required, it may be constructed in a number of ways and from a number of materials. Still it seems as if the main shape of the various scrapers is maintained. The main tool types are mentioned in Gudmund Hatt's thesis from 1914 (23-24), and are one handed (end scrapers) and two handed scrapers made from various materials.

Knives are used in the slaughtering process and in the subsequent cleaning of the flesh side of the skin (Fig. 3.5 and 3.20). Knives are furthermore used in the removal of hairs from fresh or dried skin (Chukchi cul-

Fig. 3.4. Plate XLIX and plate L of tools; for cleaning skins (left) and for scraping skins (right) from North America. From Eighteenth annual report of the Bureau of American Ethnology, Nelson, 1899:112-116.

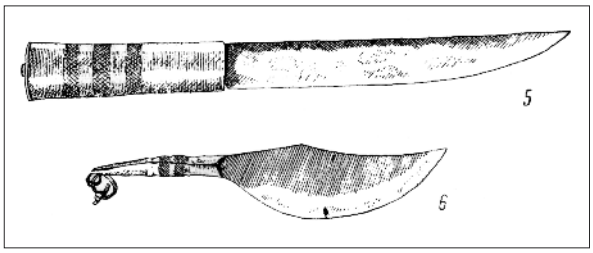
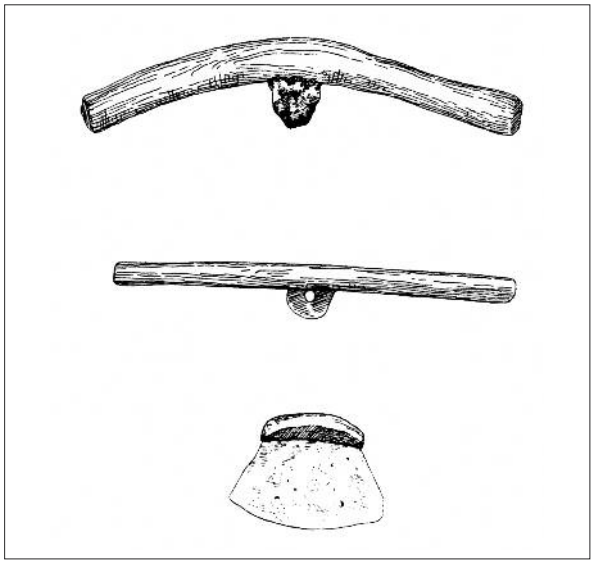


Fig. 3.5. Knives from the Koryak culture. Male knife top and female knife below. From Antropova, 1964:859.

ture in Bogoras, 1909:222; Inuit culture in Issenman, 1997:62).

Sharp scrapers (not as sharp as a knife) are used when the subcutaneous layer is removed from dry or slightly wetted skin. This is the initial process, which prepares the skin by opening up the collagen fibre structure for the tanning substances, which may be added at a later stage. The scrapers may be end scrapers or two-handed scrapers. Today the blade is primarily made from iron or steel but was earlier also made from stone, antler or bone. The blade is attached to a handle made of any available material, e.g. set in a slot, tied with a rope, sinew or leather straps, or attached with nails or screws (Chukchi culture in Antropova & Kuznetsova, 1964:807; Chukchi culture in Bogoras, 1909:216-218; Hatt, 1914:23, 24; Mason, 1895:73, 74, 75, 83; Nganasan culture in Middendorff, 1953:121; Nganasan culture in Popov, 1966:86). One handed scrapers and two-handed scrapers are also used when remaining hairs are removed in the depilation process.

Dull scrapers and scrapers with a serrated blade edge are used for stretching and softening the skin as well as for working the tanning substance into the skin. The skin is scraped while kept in position on a scraping board, or in a scraping rack, or they are pulled over a scrapers edge. Dull end scrapers, two-handed scrapers and scrapers with a serrated blade edge are also utilized in the removal of excessive tanning substance from the flesh side of the skin (Inuit cultures in Issenman, 1997:62; Chukchi culture in Bogoras, 1909:216-219; Hatt, 1914:23-24) (Fig. 3.4, 3.6, 3.7, 3.8, and 3.9). Scraping and softening may be performed standing up or sitting on a stool, the floor or the ground.



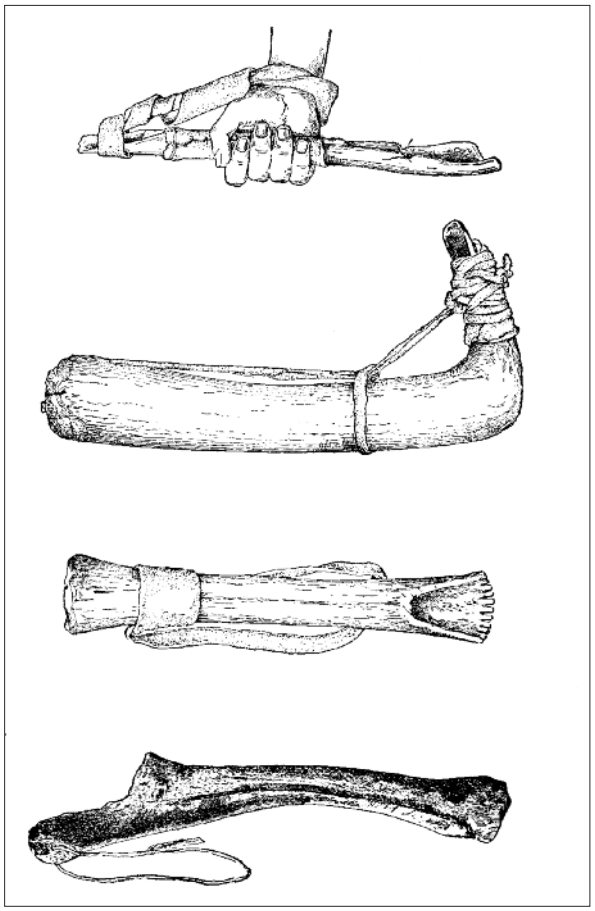


Fig. 3.8. Illustration of one handed end scrapers (North America). From Mason, 1895:83.

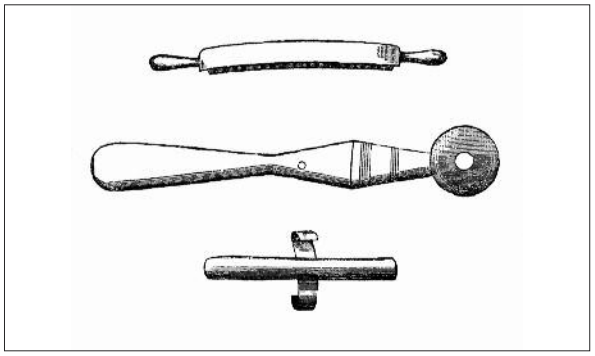


Fig. 3.7. Above. Illustration of one handed scraper (middle) and two handed scrapers (Nentsy and Nganasan culture). From Middendorff, 1953:121.

Fig. 3.6. Left. Two handed and one handed scraper (below) from the Chukchi culture. From Antropova & Kuznetsova, 1964:807.

Another softening tool, in Sámi skin processing, is the scythe shaped iron (Fig. 3.10) which may be fastened to the wall and where the skin is drawn back and forth across the dull edge (Sámi culture, in e.g. Drake, 1918:194; Fjellström, 1985:473; Nesheim, 1964:209; Hætta, 1993:53). In some areas in Siberia the skin press (talki, also called "crocodile"), is used for softening the skin. It is utilized on depilated skin as well as on leg skin (Fig. 3.49, 3.50). In this process the material is put under tension whilst constantly shifting position.

Teeth are used mainly for softening thick skins or rough parts of a skin by chewing the skin, as well as holding skins or parts of them in place during other operations. Hands are used during softening, stretching and drying of skin and are one of the main instruments in skin processing.

Regarding the distribution of tools and implements across the circumpolar area, the semi-lunar knife, the ulu, is a central tool in North America and Greenland, but this tool is not observed in the Scandinavian and Siberian arctic and sub arctic area. The ulu is known as a women's knife and the style of the ulu changes slightly according to location (Fig. 3.10) (Issenman, 1997:62). However, the ulu appears in the coastal areas of the Bering Sea in the Chukchi and Koryak culture (Antropova & Kuznetsova, 1964:807; Antropova, 1964:859; Bogoras, 1909:216), which would suggest contact across the Bering Strait.

The characteristic two handed scraper with the s-shaped blade in the Sámi culture (Fig. 3.11) is also found in the Nentsy and Nganasan's cultures (Popov, 1964:574; Middendorff, 1953:121) and in the Khanti culture (Sirelius, 1904:13) which as well would suggest contact between the Nordic/Russian Sámi and west Siberian indigenous cultures. As far as it can be

Fig. 3.9. The semi lunar Inuit women's knife called ulu and two one-handed scrapers. Churchill, Canada, 1993. Photo. K. Wattne.

Fig. 3.10 Scythe shaped iron for softening depilated skin. Sámi culture. Historic photo. © KHM

Fig. 3.11. The characteristic two-handed scraper with the s-shaped blade from the Sámi culture.

Fig. 3.13. Case skinned squirrel skin, reversed and stretched on a wooden pole called 'ivon'. Aleksandra Ivanovna, Chapo Ologo, Chita County, Russia, 1999.

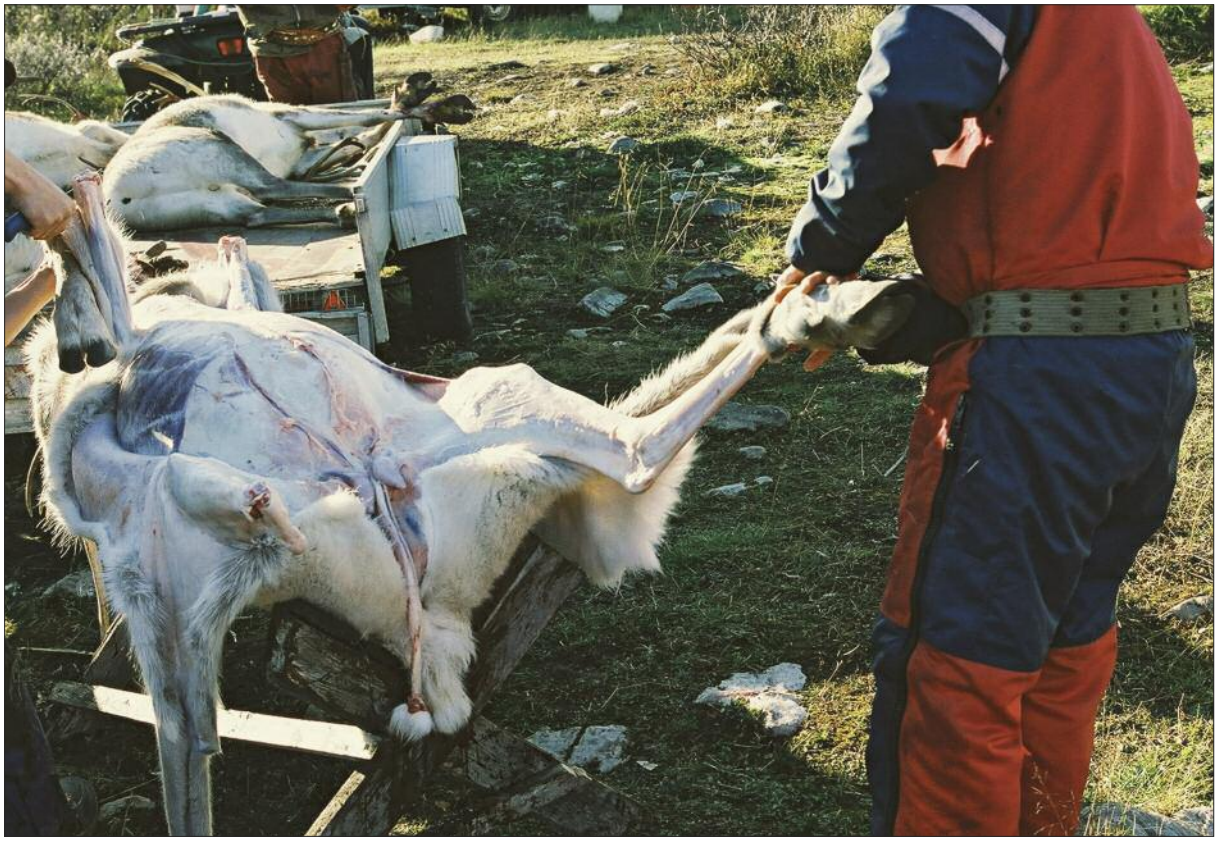


Fig. 3.12. Tor Mikkel Eira is flat-skinning a reindeer. Lakselv, Finnmark, Norway, 2004.

established the s-shaped blade or the ulu is not found in other parts of the Siberian arctic and sub arctic.

3.1.4 Pre-processing stages in skin processing

The slaughtering of animals is the first process in the processing of skin materials. During the slaughtering period, skins are chosen for specific clothing and household purposes. How the skin is treated during the slaughtering process also determines the use of the skin. There are mainly two methods of flaying the animals, flat skinning and case skinning. Flat skinning is primarily used for larger animals (reindeer, red deer, moose, roe deer, and bear) and case skinning for smaller animals such as lynx, wolf, wolverine, marmot, fox, sable, ermine, squirrel and birds (Fig. 3.12, 3.13) (Hatt, 1914:20; Kaplan, 1971:127).

In the pre-processing stage after the skin is removed from the flesh, the skins are either dried with the hairs attached or removed.

3.1.4.1 Drying of skins

In the drying process the collagen fibres stick together rendering the skin stiff. Drying skin in the sun may, apart from *burning* the skin, also lead to a much too rapid drying of the surface and leave the skin moist beneath this dry surface. This in turn leads to an increase in temperature beneath the surface, which increases because of bacterial action, which may lead to beginning putrefaction and thus eventually loosening of the hairs (Kaplan, 1971:128; Reed, 1972:49). Skins that have dried in the sun (or excessive heat) may furthermore develop blisters on the flesh side, suggesting that shrinkage of the collagen fibres has occurred (Kaplan, 1971:128).

The use of the skin, the type of skin, the weather and the availability of resources determines the drying method. Whole skins with hairs attached are either dried flat on the ground (fur side down), using stones or wooden sticks to fix the skin to the ground, stretched 'sewn' to a frame with a string, or dried by placing long sticks vertically and horizontally on the skin's inner hairless side. With the last two methods small holes are made on the skin's rim through which the string or the sticks are placed (Fig. 3.14). Skins may also be placed on the tent cover with the flesh side facing the cover (Eira Buljo, 1997:26), while another common method is to nail the skin to a wall, fur side facing the wall (Fig. 3.22). These methods are used for

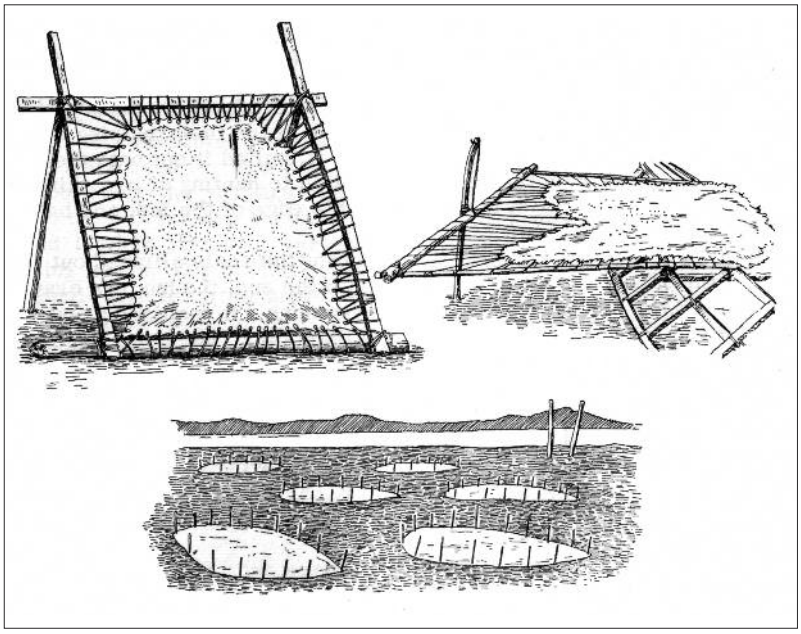


Fig. 3.14. Illustrations of different methods for drying skins in the Koryak culture and drying leg skin with sticks in the Selkup culture (right). From Levin and Potapov, 1964:858.

any larger skin such as reindeer, elk, red deer, seal, walrus, and bear (Tungus culture in Georgi, 1775:261; Inhabitants of Kamchatka in Dobell, [1830] 1970:80; Sámi culture in von Düben, 1873:135; Chukchi culture in Bogoras, 1909:217; Demant-Hatt, 1913:195-196; Sámi culture in Drake, 1918:192-193; Samoyed, Tungus, and Eskimo culture in Hatt, 1914:20-22; Koryak culture in Antropova, 1964:858; Chukchi culture in Antropova and Kuznetsova 1964:807; Selkup culture in Prokofyeva, 1964:592; Nanay culture in Levin and Potapov, 1964:703; Sámi culture in Fjellström, 1985:472; Sámi culture in Porsbo & Nordenhem, 1988:27; Sámi culture in Delaporte, 2004:267-268, 272). Smaller skin parts such as leg skins may be dried with wooden shavings (Fig. 3.21) or thick paper attached to the flesh side of the skin (Sámi culture in Hatt, 1914:20; Sámi culture in Fjellström, 1985:472; Sámi culture in Düben, 1873:135; and in Vorren, 1951:94). They may also be stuck with the flesh side against the tent cover or be stretched and dried with sticks (Fig. 3.13). If the weather is bad there is a possibility to dry the skins in the tent (behind the tent poles) or on a frame leaned against a house wall.

3.1.4.2 Depilation

The grain of the skin is preserved if the hairs are removed by controlled initial putrefaction with the aid of water and/or chemicals. Dry skin is placed floating in water, or buried under snow for a period of time (usually several months). Another method is to wet the flesh side of the skin with water or water and soap, fold it and place the skin in a plastic bag. The skin may also simply be folded fresh and put aside in a fairly warm spot for a period of time until the hairs loosen. A faster method of removing hairs and preserving the grain is to use the green stomach content of reindeer. This content is smeared onto the flesh side of the skin and left until the hairs loosen (Sámi culture in Hætta, 1993:30; Chuckchi culture in Bogoras, 1909:220). These processes are based on a beginning putrefaction of the skin ("sweating"). If it is not monitored and stopped at the right moment, there may be damages on the surface of the skin or the whole skin may rot and be destroyed (Hatt, 1914:24). These methods all preserve the grain layer of the skin. Alternative methods of removing hairs from dry skin are cutting the hairs off with a knife (cutting with the hairs' direction) and removing remaining hairs with a sharp scraper. Hairs may also be cut with a knife from fresh skin (Tungus culture in Georgi, 1775:261; Hatt, 1914:24; Chuckchi culture in Sverdrup, 1938:145 (illustration)) which often results in the removal of the grain, creating a suede surface.

The use of ashes (wood ashes) in skin processing technology can be seen as part of a preparation (liming/unhairing) for the tanning process. Mixed with water ash creates a basic solution that contributes to the removal of hair (Larsen & Rahme, 1999:31). Applied in a dry state to the hair side of the skin, it can also aid in the removal of hairs in for example sealskin (Oakes, 1993, pers. comm.).

3.1.4.3 Mechanical processes; scraping, stretching and softening

Throughout the skin processing, scraping and stretching is repeatedly executed. It is repeated to remove excess tanning material, to stretch the skin and to allow for tanning materials or dressings to enter the skin structure. It is also used to manipulate the tanning agents into the skin. In some geographical areas no tanning or lubrication substances are added in the skin processing. This means that the mechanical actions are

executed both to soften, stretch and to distribute the structural substances, such as naturally occurring fats present in the skin.

3.1.5 Tanning

The term to tan, or the process of tanning may be defined as: Treating processed hides or skins with suitable chemicals to give a fibrous product, imputrescible when wet, more or less soft and flexible when dry and capable of being wetted and dried without loss of these properties (IULTCS Glossary 2004). Using this definition, the finished skin material in some indigenous tanning processes can not be defined as a tanned skin but rather as a semi tanned skin, as all the end product properties mentioned in the definition are not fulfilled. Still, the processing methods in indigenous cultures render a material that to a certain degree may be defined as being tanned. There have been and still are a variety of tanning substances and combination of tanning substances used in skin processing in indigenous cultures. The application of, for example, bark extracts and the application of fats from land animals, fish or from vegetable sources does seem to give a certain stabilization of the fibre structure (Larsen & Rahme, 1999:55), and these could therefore be defined as tanning agents. Consequently the term 'tanning' will be used in this study when substances are added to a skin to give it specific desired properties.

3.1.5.1 Vegetable tannins (plant polyphenols) and methods of application

Vegetable tannins are present in materials such as leaves, fruit, bark, or wood of mainly higher plants. There are several types of plants or parts of plant material used as vegetable tannins in indigenous Eurasian cultures (table 3.1). These tannins are furthermore applied using a wide variety of methods and in combinations with other tanning and non-tanning substances

Name	Comment	Systematic name	Origin	Hydrolysable or condensed tannin	Tannin content %
Alder (outer bark, root)		*Alnus glutinosa, A. incana*	Europe (east) Scandinavia,	Condensed Russia	10-16 %
Birch (inner bark)		*Betula pubescens, B. verrucosa, B. pendula*	Northern Europe, Russia	Condensed	10-15 %
Larch (inner bark, decomposed wood)	UV: brilliant blue/pale blue	*Larix deciduas, L. sibirica*	Europe (mountain), Russia	Condensed	8-9 %
Willow (outer bark)	UV: distinct yellow – not bright.	*S. repens, Salix viminalis, S. fragilis, S. caprea* etc...	Scandinavia, Russia	Condensed	10 % in average
Quebracho (wood)	UV – brilliant yellow	*Quebrachia lorentzii*	Argentina, Paraguay	Condensed	23 %
Tea tannin	UV – insignificant	*Ex. Thea sinensis L.*	Hydrolysable-	ex.13-18 % Gallo tannin	

Table 3.1. Vegetable tannins used in indigenous cultures in the northern Nordic area and Siberian arctic and sub arctic (information collected from Rottsieper, 1946).

Fig. 3.15. Debarking tool from the Sámi culture. Historic photo. © KHM.

(Dobell, [1830] 1970:80; Fjellström, 1985:473; Hatt, 1914:29; Demant-Hatt, 1913:20; Drake, 1918:195-96; Fors & Enoksen, 1991:71; Krasheninnikov [1735-41], 1972:221; Sirelius, 1983:93, 243; Steller, [1753] 1973:125). It is suggested that vegetable tannins initially were used to give colour to the skin and that intentional tanning using the same substances came later (Drake, 1918:19; Hatt, 1914:29).

Vegetable tannins have characteristic properties. They are astringent and have the ability to form insoluble compounds with gelatine yielding tissue, like collagen (Howes, 1953:1). Vegetable tannins are generally divided into two main categories: Hydrolysable tannins (HT) and condensed tannins (CT). Hydrolysable tannins are further divided into two groups: Gallotannins and ellagitannins. A third group of tannins is complex or mixed tannins, which contain both hydrolysable and condensed structures. The composition of vegetable tannins will be described in chapter 5. The tannins used by indigenous cultures in the northern Nordic area and Siberian arctic and sub arctic seem mainly to fall into the category of condensed tannins (Howes, 1953:2; Rottsieper, 1946:7).

Vegetable tanning substances in the northern Nordic area and Siberian arctic and sub arctic are mainly limited to the vegetation of the specific areas (table 3.1). The most common types are the bark and the decomposed wood (brown rot) of larch (*Larix sp.*), the bark of willow (*Salix sp.*), birch inner bark (*Betula sp.*) and alder bark (*Alnus sp.*) but infusion of black tea leaves may also be used as a colorant and as a tannin (Rottsieper, 1946:17).

The bark is stripped off the twigs using a knife or a small debarking tool (Fig. 3.15) (Eira Buljo, 1997:28 photo) and is applied fresh or dried. For alder and willow, the outer bark is used and for birch, the inner bark is used (Hatt, 1914:30).

There are several ways of applying vegetable tannins to the skin and the method of application varies according to whether the skin is depilated or has hairs attached. For skin with hairs attached the tannin substance is applied to the flesh side as an extraction or a suspension in water, saliva, or urine (Chuckchi culture in Sverdrup, 1938:21; Chuckchi culture in Bogoras, 1909:219). Depilated skin may be soaked in the suspension of vegetable tannin and water for a specific time period, or the tannin is repeatedly rubbed onto the flesh side of the skin (Sámi culture in Linné, 1732:173; Sámi culture in Delaporte, 2004:276-277). There are a few descriptions from the Siberian or Nordic sub arctic and arctic areas in the early literature on the application of vegetable tannins. Krasheninnikov however describes in the mid 18th century how the Itelmens on the Kamchatka Peninsula apply alder bark to seal skin. The depilated sealskin is sewn into a sack filled partly with alder bark and water. The sack is hung from a tree and beaten with sticks until the tannin has penetrated the skin (Krasheninnikov [1735-41], 1972:221). Carl von Linné also describes the tanning of depilated reindeer skin in his Iter Lapponicum from 1732. The inner part of birch bark was removed and boiled in water for as long as it takes to boil fish. When lukewarm, the skins are soaked in the suspension. This is repeated three times and the skin is left to dry outside in the shade (Linné, 1732:173).

Johann Gottlieb Georgi describes how the flesh side of the skin (SWH) is stroked with alder bark extract mixed with ashes, using the hands, after an initial application of fat and a subsequent smoking. He also mentions the use of dried wood powder which is rubbed into the flesh side of the skin (Tungus culture in Georgi, 1775:261).

Alder bark, apart from its strong colouring properties, is also suggested to give the skin better stretching properties than the use of birch, and to a certain extent willow would give (Gansser, 1950:2943). This may be one reason the Sámi often use alder bark in the tanning of depilated skin for their cradles (in the Sámi cradle the skin is tightly stretched over a wooden frame).

The vegetable tanning process of depilated skin is often repeated until sufficient colour is obtained or until the skin is properly tanned. It is described that in depilated vegetable tanned skin, which is to be used for specific purposes, there is an intentional raw streak, which adds to the strength of the skin. This raw streak also contributes to the water repellence properties of the skin (Hætta, 1993:36).

3.1.5.2 Mineral tanning substances and methods of application

Alum tanning or tawing is believed to be an early form of mineral tanning (Forbes, 1966:7; Gansser, 1950:2952; Larsen & Rahme, 1999:39). Tawing produces white, soft and pliable leather and was especially used for finer leather articles (Larsen & Rahme, 1999:39). It is still used in indigenous cultures today, either as part of a tanning process (pre tanning process) or as a tanning process. Alum (potassium aluminium sulphate, $KAl(SO_4)_2 \bullet 12H_2O$) is sometimes used in a combination with sodium chloride (NaCl) in the curing of skins with the ratio of salt to alum varying. The manufacture of white depilated skin using alum does not seem to be a general historic skin processing method in indigenous cultures, even if it takes place today.

Krasheninnikov however, reports from his travels in Kamchatka in 1735-41 that alum is boiled with cowberries, alder bark and mineral oil to produce a very red colour on skin material (Krasheninnikov [1735-41], 1972:221). This means that alum has been known and used in indigenous cultures in Siberia at this time, in this case as decoration and not as a tanning agent. Alum is thought to increase resistance to certain factors such as moist heat and mould formation in leather and is furthermore used as a mordant in the colouring of wool fibres (Gustavson, 1956:335). Alum tawed leather is also thought to be resistant to pollution, but it is not resistant to humidity and hydrolyses easily (Chambard, 1958:350). Water seems to remove the loosely bound aluminium in the leather and thereby weakens the leather's resistance to pollution (Sharphouse, 1995:151; Vest, 1996:100).

3.1.5.3 Fat as tanning substances and lubricants

Fats and oils have been used as tanning agents, fillers, lubricating agents and for obtaining a water repellence effect. Only fats and oils that have the capacity to oxidize and form insoluble bonds in the collagen structure are called tanning agents. Fish oil is one of the most important oil tanning substances in this respect and the process is generally called chamois tanning (Gansser, 1950:2943; Gustavson, 1956:295; Haines, 1991:25; Sharphouse, 1995:212-219). Indigenous cultures throughout the circumpolar area use fat or oil in skin processing, applied during the process or as a fat liquoring or lubricant applied at the end of the process. These include fat from terrestrial mammals, brain substance (used alone or in emulsions), bone marrow, meat broth, milk products, and butter. They furthermore include fat in the yolk from sea birds eggs as well as fatty substances from fish and marine mammals, such as fish roe, fish liver, and seal blubber (Pallas, [1768-1774], 1973:178; Tungus culture in Georgi, 1775:261; Erman, 1838:343; Dobell, [1830] 1970:80; Bush, [1871], 1970:390; Fors & Enoksen, 1991:71; Krasheninnikov, [1735-41], 1972:221; Middendorff, 1953:122; Prokofyeva, 1956:595; Popov, 1964:575; Bogoras, 1909:219; Vasilevich & Smolyak, 1956:636; Sámi culture in Delaporte, 2004:269).

Products made from milk have been used and are still used in skin processing (Tungus (Evenk) and Buryat culture in Georgi, 1775:261; Hatt, 1914:28-29). Milk contains from 16 g/l (horse) to 105 g/l (deer) fat (Padley *et al.,* 1994:195) dispersed in an aqueous phase that will evenly coat the fibres in skin material. Butter contains more fat than milk but will still give the same effect to the skin as milk does (Reed, 1972:66). Eggs from sea birds have been used as fat liquoring (Hatt, 1914:26; Bogoras, 1909:219); the yolks contain phospholipids which form an emulsion in combination with water and when applied render the skin more waterproof. In an emulsion the egg yolks coat the fibres and prevent the fibres from sticking together and as a consequence provide a more flexible skin (Reed, 1972:66). Another marine source apart from fish liver oil is fish roe which is used raw, boiled

or fermented and applied to the flesh side of the skin. Fish roe is also often used in a mixture with fat from fish intestines (Hatt, 1914:26; Bogoras, 1909:219).

Mammal liver contains a combination of storage lipids, such as triacylglycerols, and membrane lipids, such as phospholipid (Padley *et al.*, 1994:198). The amount of fat in the mammal liver is, however, low compared to mammal adipose tissue (Hilditch & Williams, 1964:80). Mammal liver is often used in combinations with other tanning substances such as brain substance and various other fats or vegetable tannins (Hatt, 1914:26). Brain substance may also be applied raw, boiled or in a fermented state mixed with water (Popov, 1966:88). Gudmund Hatt proposes that a reason for using mammal liver is that the gall content of liver dissolves the fat in, for example, brain substance and leads to an easier penetration of the fat in the skin (Hatt, 1914:26). One of the few descriptions of the use of reindeer liver as a tanning agent is from the Nganasan culture in western Siberia, in the northern part of Taymyr region. Boiled mashed reindeer liver is smeared on the flesh side of fur skin and left approximately half a day before the surplus is scraped off. Here the boiled reindeer liver appears to have been used as a lubricant. The same substance is used in the process of producing depilated skin where the liver substance is left in a rolled up skin for approximately two days to ease the removal of hairs (Popov, 1966:87-88).

Fats and oils may generally be divided into saturated and unsaturated fats. Saturated fats are solid at room temperature and hold all the hydrogen atoms they can as opposed to unsaturated fats which are liquid at room temperature and have space for more hydrogen atoms in their molecular structure (Microsoft® Encarta®Online Encyclopaedia, 2004). This opens up for modification of the fat through, for example, hydrogenation, which lowers the unsaturation degree of the fat, rendering it more stable.

Fats or oils used in skin processing may consist of a single type of fat/oil, such as cod liver oil or of mixtures of various fats and oils both naturally occurring, modified though the production process or as a mixture of both natural and synthetically produced oils. However, the traditionally used fats and oils obtained from natural sources have not been manipulated through, for example, hydrogenation or sulphation. Such highly manipulated oils have emerged through trade and as a result of less time spent on producing fatty substances and but as a result of reduced access to natural sources of oils and fats.

Certain properties of fats and oils may affect the reaction, performance and deterioration of collagen in skin material. These properties include the degree of saturation or unsaturation, the melting point and the lubricating effect of the substance. The degree of saturation or unsaturation can be used as a measure of the stability of the fat. A high level of unsaturation indicates that the fat is more reactive, it may oxidise more easily, and it becomes yellow or darkens over time.

There are differences in the effect of using a highly unsaturated fat that may oxidize to form insoluble compounds in the fibre structure (for example cod liver oil) and the use of more stable fats, such as brain substance or other terrestrial mammal fats which generally are high in saturated fats. Neither of them however, seem to form strong bonds in the collagen structure. Gansser (1950:2950) suggests that the strong emulsifying effect of the brain substance increases the surface of the fat so that the air has a greater oxidising effect. Emulsifying fats such as brain substance and for example egg yolk lipids will also penetrate the skin more easily. The composition of fats and oils will be further described in chapter 5.

3.1.5.4 Smoking the skin

The smoking of skin is a method used to protect the skin from decay by making the skin less susceptible to water; in addition it gives a yellow/brown colour to the skin (Hatt, 1914; Guldbeck, 1969:4). It is not known when this method developed into an intentionally used method for providing skin with its special properties. Inden, a deer skin leather, characterised as a strong and soft material, is an example of fat and smoke tanned leather with a long tradition. It is believed to have originated in India, and may have been performed as a craft in Japan as early as in the Warring States period (1467-1568) (Yorozu, 2005). The fat used is brain and spinal cord substance which is mechanically worked into the skin with a subsequent exposure to smoke from straw and pine, creating an aldehydes tanning effect (Kuntzel, 1958:434). Smoke tanning is and was used extensively by indigenous cultures in the circumpolar area, but not by all. According to Hatt the method is confined to indigenous cultures in central Siberian areas and to most Indian cultures in North America (Hatt, 1914:38). Smoked skin has water repellent properties and is used in damp or wet environments and is therefore especially used in the manufacture of tents and boots (Georgi: 1775:261; Bush, [1871] 1970:390); Dobell, [1830], 1970:127); Hatt, 1914:38; Krasheninnikov, [1735-41], 1972:221;

Prokofyeva *et al*., 1964:528; Antropova, 1964:857; Vasilevich and Smolyak, 1964:636). The smoke is created by burning decomposed wood, wood and/or moss with the aim of creating a substantial amount of smoke but not too much heat. Other materials such as pine cones and dry dung have also been used (Georgi, 1775:309). In the slow burning of these vegetable materials tarry products and aldehydes are formed, which cause a slight tanning effect on the skin material (Gansser, 1950:2951). One might say that the smoking of skins is an aldehyde tanning procedure even though the effect is less significant than the industrial process. There are several components in smoke that easily react to the collagen substance, such as aldehydes, ketones and reactive substances such as epoxides, peroxides, and free radicals (Larsen & Rahme, 1999:53).

3.1.5.5 Combination tanning and methods of application

There are many ways of combining tanning and procedures to obtain the qualities that are desired and needed in skin materials. These combinations are based on variations and combination of traditions of indigenous cultures, and on local environment and climate. Most of these combinations are intentional processes, although the smoking of skin can also be an unintentional process in some cultures where clothing items are kept or dried in tents/houses over an open fire. Succession of substance-application and processes in combination-tanning seem to follow a set pattern where vegetable tanning often is the first step in the tanning process, and application of fatty substances follows, most often as a lubricant. Another frequent combination is the combination of fatty substances and smoking, where the application of fats may be the first step, followed by smoking. This could be seen as a fat tanning process, even though the heating required to fulfil the process is avoided. The description that "it is important to create a lot of smoke, but that the smoke should be as cold as possible", implies that an actual fat tanning process is not taking place.

3.1.5.6 Other substances used in skin processing

Blood has also been used in skin processing technology. Leaving the blood in the fresh skin for a specific period of time is supposed to render the skin softer (Hatt, 1914:33). This is in contrast to most of the informants' statements, both in Finnmark and in Siberia; they emphasize the importance of removing as much blood as possible from fresh skins.

It has been shown that the enzymatic or bacterial action caused by dung/manure as well as urine, renders the skin soft (Gansser, 1950:2944). Dung has been used in the bating (dog manure) and puering (fowl droppings) process as a preparation for the tanning process, and the procedure goes back a long time. The enzymatic action removes unwanted protein substances in the skin's structure and weakens the fibre structure, preparing the skin's structure for the diffusion of tanning substances into the skin (Sharphouse, 1995:131). In the Chukchi culture, reindeer dung combined with urine has been used as a pre-tanning process. Urine was also used, mixed with alder bark, in the subsequent tanning process of reindeer skin. Alder bark was heated up in urine and the solution was applied to the flesh side of the skin. The process was repeated several times, and each time the skin was left overnight (Bogoras, 1909:219).

This process is similar to the processing of fish skin and marine mammal skin, where urine is used to remove unwanted or excess substances, especially fat, and to prepare the skin for tanning or mechanical processing (Hatt, 1914:33-35; Oakes, 1993, pers. comm.).

Soap may be added to an aqueous solution in skin processing. The solution may also contain fats, and the soap will act as a useful emulsifier for the fat (Thorstensen, 1976:193).

Yeast is used in skin processing as a preparatory process. Skins with hairs attached are left in a mixture of water and yeast for a couple of days before they are scraped (Vasilevich and Smolyak, 1956:636). This would probably function as a depilation method and as the enzymatic action of manure, remove unwanted proteins and open up the fibre structure for the subsequent tanning method. Yeast is a fungus, and in skin processing the yeast type is the same as that used for baking (baker's yeast, most often *Saccharomyces cerevisiae*). The fermentation is caused by enzymatic action where carbon dioxide and alcohol are formed (less alcohol in baking yeast) in the process (Stær, 1952:453).

Bile extracted from the gall bladder and from the liver of fish is applied to depilated skin (Prokofyeva, 1956:595). The effect on the skin material is not known, but as Hatt (1914:26) proposed it may have an effect on the penetration of fat into the skin's fibre structure.

Flour (wheat flour) is used in the tawing of fur skins as a filling substance (Sharphouse, 1995:204). Flour has a binding effect on the fat and makes the skin fuller (Larsen & Rahme, 1999:39). It is used in the tan-

ning or rather, tawing of fur skins in the Sámi culture also today (Hætta, 1993:36).

Tar (wood tar) is used in a mixture with cod liver oil in the Sámi culture to make depilated skin shoes, leggings and trousers water repellent (Demant-Hatt, 1913:22).

3.1.6 Colouring substances

Vegetable tannins were primarily used as colouring agents and, secondly, as a tanning agent. Nesheim (1964:207) suggests this based on linguistic research in the Sámi culture where terminology of vegetable tannins used on depilated skins seems to be composed of loan words from other neighbouring cultures. Hatt (1914:29) touches on the same subject but argues that available research does not give enough reason to believe that vegetable tannins are not original in indigenous cultures. This is acknowledged in Drake's thesis (1918:196), where she discusses the use of vegetable tannins both as colouring and tanning agents. Linné's description from 1732 also testifies to their tanning purposes. By studying the literature and the information given through interviews, it seems that vegetable tanning methods developed over time in the various indigenous cultures. These developments include impulses from neighbouring cultures as well as a thorough knowledge of the natural resources that were available in the local environment.

Fig. 3.16. Historic photo of a Sámi woman and her child. Photo by E. Wessel. Historic photo. ©KHM.

Alder bark, chewed or boiled (in water or urine), is the vegetable tannin that yields the strongest colour. It may be applied as a regular tanning agent, or it may be painted onto the surface as a decorative element. Alder bark extract mixed with water containing iron (from the grindstone) yields a black colour (Hatt, 1914:29-30; Drake, 1918:205; von Düben, 1873:133). Ashes are used in a mixture with other substances to achieve certain effects, as enhancing the colour of alder bark tannins (Hatt, 1914:30, 36). Soot and ochre are used as a colouring substance and most likely as decorative elements. Bogoras (1909:40) mentions that the Chukchi culture curried and dyed skins with ochre. Ochre used for dying depilated skin is also mentioned in the Nganasan culture, but not how it is processed or applied (Popov, 1964:576). Mineral substances such as ochre and clay are mixed with fish glue or larch gum (arabinogalactans) and used as decoration on skin garments (Georgi, 1775:263).

Smoking the skin also gives the skin yellow/brown colour and is continued until the desired colour is obtained. Georgi observes on his travels in Siberia that the skin is smoked until it is brown as liver (Georgi, 1775:261). To produce an intense red colour Krasheninnikov ([1735-41] 1972:221) describes in 1735-41 how cowberries are boiled with alder bark, alum, and a mineral oil, and applied to the skin as a colouring substance.

3.2 Materials, tools and methods in Sámi and Evenk culture

This study is based on information from Sámi reindeer pastoralists and residents in three localities in Finnmark, and from Evenk families in five locations in Siberia. The geographic locations, the garments and the informants are presented in chapter 1.

The information presented here is a summary of the information given during interviews in Siberia and Finnmark during 1998 to 2004. Most certainly there are methods from other areas that deviate from the methods described here, as the methodology varies from region to region. The use and processing of three reindeer skin material types will be described in this

Fig. 3.17. Konstantinov Svetoslav Dmitrievich (right) in his new winter clothing for hunting in temperatures down to minus 50-60 °C. His wife Konstantinova Rosalia Prokofievna (second from left) in a coat decorated with appliqué. Aiana (left) and Mischa (middle) in thigh high leg skin boots with toe-fur soles and coats made from square patches of reindeer skin. Kharyyalach, Sakha Republic, Russia, 2004.

section (3.2). Whole reindeer skin with hairs attached (SWH) is used mainly for coats or trousers. Leg skin (LS) is used for footwear, winter leggings, trousers, bags, and mittens, and depilated skin (DS) is used for summer leggings and footwear, bags, purses, rope, and harness.

3.2.1 Materials used for clothing purposes

The knowledge of which skins to use or which parts of skins are used for which garment or part of garment is significant in both the Sámi and Evenk culture. Knowledge is passed down through generations, mainly through the female side of the family, but is rapidly losing its importance to an altered way of life and the availability of modern materials. Winter outdoor clothing for work and leisure is, however, still based on skin material and regarded as being the warmest and most appropriate material for very low temperatures. Climate and occupational activities in the arctic and sub arctic require a material with excellent insulating properties such as reindeer skins. E.g. as snowmobiles were introduced as an integrated part of reindeer herding and hunting, and physical activity decreased, the need for thicker reindeer skin anoraks emerged (interviews Finnmark 2004/Siberia 2001, 2004).

The reindeer (*Rangifer tarandus tarandus*) is the main source of skin clothing material in the Sámi culture (Tyler & Røed, 1993:4). Reindeer skins are used with hair (SWH and LS) or depilated (DS). The depilated skins have a full grain. Other skins that have been used as skin for clothing or parts of clothing and footwear, such as trimming and lining, are bear, sheep, wolverine, wolf, fox, dog, lynx, squirrel, and ermine. The skin of seal, predominantly *Erignatus barbatus* and the skin of cattle was used especially for summer footwear (Interviews Finnmark 2004).

In the Sámi culture reindeer skin (SWH) used for coats and footwear are from calves slaughtered from July to early September when the skin of the reindeer calves is lightweight and of good quality. These skins are especially utilized for the festive and lightweight clothing and footwear (Demant-Hatt, 1913:37-38; von Düben, 1873:156-157; Collinder, 1953:87; Porsbo & Nordenhem, 1988:25; Vorren, 1951:93; Interviews Finnmark 2004). For slightly thicker skins, one to one and a half year old calves are slaughtered (Fig. 3.16). The number of animals slaughtered depends on how many skins are needed for making clothing and footwear. If it was not possible to slaughter all the animals you needed for clothing, barter or trade was also an option (Porsbo & Nordenhem, 1988:26). Today, it is possible to buy skins from the slaughterhouse, even though the shape of the skin is not as it should be. The number of slaughtered animals furthermore depends on how many animals the reindeer herder could afford to slaughter (Sara, 2001:59) in order to keep the size of the herds intact. In addition, present government regulation on the size of reindeer herds also plays a part in deciding the number of animals each herder is required to slaughter.

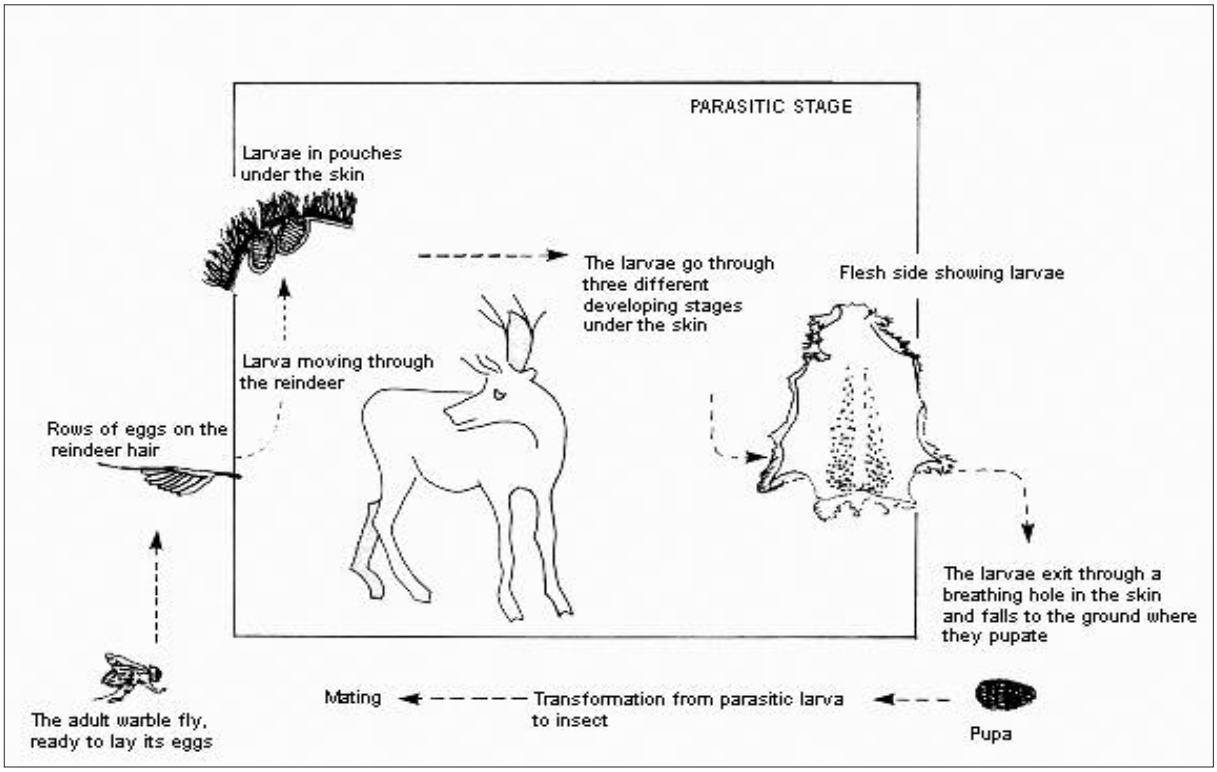


Fig. 3.18. The stages in development of the reindeer oestrid fly (*Hypoderma tarandi*). From Folstad, 1986:38 translated with permission from the author.

Skin clothing and footwear in the Evenk culture, in the northern Transbaikal region and in the northern Sakha Republic, is and was mainly made from wild reindeer (*Rangifer tarandus tarandus or R. t. fennicus*) (Tyler and Røed, 1993:4), red deer, roe deer and elk. Brown bear and also smaller animals such as Siberian musk deer (*Moschus moschiferus*), wolverine, wolf, lynx, dog, marmot, pine marten, sable, mink, squirrel, and ermine have been used either as the main part or as decorative elements in clothing, foot wear and accessories. Skin and fur used for lining, trimmings and decoration might vary according to the accessibility of various animals in the area, seasonal variations, and may be gathered over a period of time for a specific purpose. This applies for example to the collecting of white belly skin from squirrel for lining or clothing for young children (interview Siberia 1999-2004). Reindeer skins are used with hair (SWH and LS) or depilated (DS). Unlike Sámi culture, where the grain of the depilated skin is intact, the depilated skin manufactured and used in the Evenk culture is suede. As in the Sámi culture the skins are processed according to their specific use. For example, skin materials for use on moist grounds are most often smoked and treated with fats, whereas skin material for use on more arid land does not require the same waterproofing qualities and are not necessarily smoked or treated with fats.

Today summer clothing is mainly Russian style, although summer boots made from depilated reindeer skin, where the grain is removed, are still being used but primarily by older people (interview Siberia 1999-2004).

In the Siberian arctic and sub arctic reindeer are slaughtered around September, depending on location (interviews Siberia 2004). For clothing, footwear and accessories the skin from calves of reindeer, red deer and elk are primarily used (Fig. 3.17). For thicker and warmer reindeer herder's coats, the skins of older reindeer calves are used (one to one and a half years old). If the size of the animal is too large, the skin is heavy and thick, and therefore difficult to process and also too heavy to wear. An exception may be the manufacture of soles for water-repellent footwear, where depilated skin of elk may be used (interviews Siberia 1999).

The technique of splitting depilated skins has been performed when the skin is thick (Turov, 2005, pers. comm.). Skin from reindeer fawns is thin and soft but not very durable and is primarily used for clothing for small children.

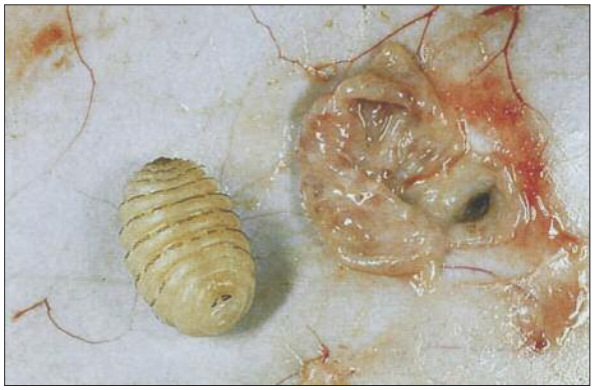


Fig. 3.19. Larvae and larvae hole on the flesh side of a reindeer skin. Photo: A. Nilssen (Folstad, 1986:44).

In the early autumn the reindeers have recovered from the presence of the larvae that have plagued them through the winter and into the late spring. The reindeer oestrid fly (*Hypoderma tarandi*) lays its eggs in rows in the fur of the reindeer. When the eggs hatch the larvae go through the reindeer's skin and eventually position themselves (autumn) under the skin's surface in a pouch with sufficient access to oxygen through a hole in the skin. In late spring (May-June) the larvae is fully developed (2.5-3 cm long). It then works its way out through the breathing hole and falls to the ground where it pupates (Fig. 3.18, 3.19). The breathing hole in the skin heals through the summer (Folstad, 1986:38; Josefsen *et al*., 2006:32). Because of these often numerous breathing holes in the skin, summer skins are rarely used for clothing purposes (Interviews Siberia and Finnmark 1999-2004. Drake, 1918:194).

3.2.2 Pre processing stages of skin processing

3.2.2.1 Aspects of skinning animals for clothing purposes

In the Sámi culture, if the skin is to be used for clothing items, great care has to be taken during the slaughtering process. All the informants in Finnmark emphasize the importance of skinning the reindeer correctly. For working coats the cut of the pelt is not quite as important as for the festive anoraks. If you buy the reindeer skin from the slaughterhouse it is difficult to get skins that are cut properly for making especially festive coats. For this coat you need the neck skin and parts of the head skin attached to the whole skin (Fig. 4.4). Special care also has to be taken when skinning the legs and the head skin from the reindeer. It is equally difficult to obtain leg skins that have been properly cut, both in length and closely around the hooves for making boots. This is only achieved if the legs are flayed by hand.

According to most informants in Siberia and Finnmark, the spilling of blood on the skin in the slaughtering process affects the properties of the skin in the continuing process.

The spilling of blood on the flesh side of the skin makes the skin harder and more difficult to process. If the blood is only superficial it may be washed in cold water or removed by rubbing the skins flesh side against the snow whilst the skin is fresh. The remaining residues will most probably be removed in the initial scraping process. If the blood has penetrated the skin, or if it is impossible to sufficiently remove a bloodstain, the skin may be used for base covers in sledges or the like, but not for clothing. The initial cleaning of fat, blood and other remains on the flesh side surface and cleaning raw sinew is done with a knife (Fig. 3.20).

3.2.2.2 Drying the skin

In the Sámi culture large skins are dried flat on the ground with the hair side down. Stones are placed around the edge to hold the skin in place or they may be pegged down with wooden sticks to the ground. According to the informants skins for coats should not be stretched during drying, as they will be more difficult to soften later in the process. In rainy weather it is possible to dry the skin inside the tent, where the skin is kept in place between the tent poles and the tent cover or inside a house, although it should not be allowed to dry too fast.

In good weather it takes approximately a day to dry a skin in the open air, depending on the thickness of the skin. Keeping it out of the sun is very important, as

Fig.3.20. The characteristic multi-purpose Sámi knife, which is made in a variety of sizes.

Fig. 3.21. Leg skin dried with wood shavings. Sámi culture. Stabbursnes, Finnmark, 2004.

the heat will *burn* the skin (making it more fragile). Whole skins may also, in some cases, be dried by sticking them to the tent cover with the flesh side facing the cover. These skins may take a little longer to dry and a fire is built up in the tent to speed up the drying process.

Leg skins can be dried with wooden shavings or strips of thick paper attached to the flesh side of the skin (Fig. 3.21). They may also be stuck to the tent cover with the flesh side against the cover. Head skin is dried with sticks placed vertically and horizontally on the skin, or it may be nailed to a wall. Nailing skins (all types) to the wall of a house, with the flesh side out, is a common drying method. This method seems to be more predominant now than earlier (Fig. 3.22). A dry skin should not immediately be used or rolled up. The skin needs to be placed in an outhouse, or similar structure to be allowed to *relax* after drying.

In the Evenk culture there are also variations in how skins are dried. In the summer period larger skins can be dried in a frame consisting of two rooted trees that are in a suitable distance from each other, upon which two poles are placed horizontally to create a drying frame. The skin is sewn to this frame using a string/rope. A method mainly used in winter follows the same principle. The only difference is that the two vertical trunks are not rooted. The frame with the drying skin is leaned against surrounding trees or any suitable structure (Fig. 3.23). Another method for drying larger skins is to place the skin on the ground flesh side up. Wooden pegs are stuck through the edges of the skin into the ground, leaving some space between the skin and the ground for the air to be able to move freely. Skins are also hung lengthwise on a pole (fur side inwards) and wooden sticks are attached to the edges of the flesh side to prevent the edges from curling up (Fig. 3.24). When the skin is dry the sticks will fall off or can be easily removed. As in the Sámi culture skins are also nailed to the wall of a house with the fur side facing the wall. Leg skins and smaller parts of skin are dried by sticking wooden sticks from edge to edge on

Fig. 3.22. Whole skins (left) and head skins (right) are nailed to a wall for drying. Sámi culture. Finnmark, 2004.

Fig. 3.23. Although this is an elk skin and not a reindeer skin, the method of stretching the skin in a frame for drying is often used for deer skins. Evenk culture. By the River Ternakanovskaja Umotka, Irkutsk County, Russia, 2004. Photo: O. Grøn.

Fig. 3.24. Whole skins can be placed lengthwise over a pole, and small sticks are adhered to the edge, to prevent the skin from curling. Evenk culture. Kharyyalach, Sakha Republic, Russia, 2004.

the flesh side of the skin (Fig. 3.25, 3.26). According to informants in Siberia the skin must not be dried in the hot sun where as it will *burn* and become stiff and more difficult to process. Raw skins can also be stored frozen until drying is more convenient (from October/November and dried in March/April).

Fig. 3.25. Konstantinov Svetoslav Dmitrievich (left) and a friend standing in front of strings where leg skins are being dried with sticks. Evenk culture. Kharyyalach, Sakha Republic, Russia. Photographer unknown. Year unknown.

Fig. 3.26. Leg skin dried with wooden sticks. In the house of Malchakitova Ludmila Vasilievna, Chapo Ologo, Evenk culture. Chita County, Russia, 1998.

3.2.2.3 Salt as a preservation method

Some of the informants in Finnmark use salt as a way of preserving the skin, until it is time to process the skins. This also applies to most skins which are bought from the slaughterhouse. Different experiences among the informants propose that the salted skins seem to become thicker; they are easier to scrape and to work with, but they also seem to be heavier, and the boots or coats may feel damp and become wetter when in use (Fig. 3.27). Some of the informants indicate that they would never use salted skins for clothing items and especially not in boots, as they do not keep their shape well. A salted skin means in some cases that a mixture of salt (NaCl) and alum ($KAl(SO_4)_2 \bullet 12H_2O$, Merck) is used. The ratio of salt and alum varies. As the salted skins and leg skins in particular are tanned it is more common to use birch bark, as it renders the skin firmer and in that way compensates for the increased looseness of the salted skins.

Salt or salt mixed with alum does not seem to be used in skin processing in the Evenk culture.

3.2.2.4 Depilation

In the Sámi culture the depilation of the skin is accomplished in a number of ways. Dry skins are placed in a stream, lake, or the sea, floating with the hair side up. Removing the hairs by floating in water may take

Fig. 3.27. Reindeer leg skin which has been salted in a mixture of NaCl and alum. This makes the skin easier to scrape. Sámi culture. Finnmark, Norway, 2004.

one to two weeks or more, depending upon the outdoor temperature, and the skins must be well looked after, to make sure they stay floating with the hair side up and to keep birds, for example, from damaging the skins. Burying skins under the snow for a longer period of time, wetting with water (only on the flesh side) or wetting with water and soap and then folding and placing in a plastic bag (the plastic bag should be placed where it is not too hot), are all methods based on 'sweating': a beginning putrefaction of the skin, which preserves the grain layer. Using a plastic bag requires repeated wetting, to ensure that the skins do not dry up, and repetitious washing after the depilation process to remove the strong smell of rotting skin and to clean the skin before the next stage in the process. Some informants use soap in the washing process to further eliminate this smell. It is important to prevent the depilation process from going too far; it will damage the grain layer. An uneven depilation will appear as flaws in the finished skin (Fig. 4.6, 4.7). Flaws from an uneven depilation process can be observed as suede areas on the surface, where the grain layer has loosened and is peeling off. It may also be observed as hair and epidermis still left on the skin's surface. These patches of the remaining epidermis will not absorb tannin as properly depilated skin does, and will leave lighter coloured patches on the skin's surface (Fig. 4.8).

In the Evenk culture the removing of hairs from fresh skins is achieved by cutting the hairs off with a sharp knife. Leaving the skins in water for approximately one to two days (depending upon the skin's thickness) will ease the process. Household soap has been added to a water/yeast mixture, and the skins (where the hairs have been cut off) are soaked in this mixture for approximately one day to ease the process of removing the remnants of hairs from the surface. This is achieved with a sharp two handed scraper on a scraping board (Anatolievna, 2000, pers. comm.). Dry skin is depilated by cutting the hairs off with a sharp knife (cutting with the hairs) and remaining hairs are removed with a sharp scraper. The grain layer is removed in this scraping process, and a skin with a suede surface is created. Skins from elk or red deer that are intended for boot soles (quite thick skin) have their hairs carefully cut without damaging the surface and must not be soaked in water previous to the cutting of the hairs, for this would make the skins less waterproof.

3.2.2.5 Cleaning, softening and stretching

For dried skins, where the hairs have not been removed (SWH), scraping is performed on the flesh side to remove the dry subcutaneous layer. This also applies to skins where the hairs have been removed. The subcutaneous layer acts as a non diffusion layer and may prevent the succeeding tanning substances from penetrating the surface.

The main tools used in the scraping processes in the Sámi culture are the two-handed scraper with an s-shaped metal blade, called jiehkku, and the scraping board, called neaskinfiellu (Fig. 3.27, 3.30 and 3.34). This s-shaped scraper is used all over Sápmi as well as in the Nganasan's and Nenet's cultures in western

Fig. 3.28. The skin processing tools of Nikolaeva Maria Vladimirovna. From top to bottom; the two-handed scraper with a serrated edge, the scraping board, one handed scraper with serrated edge and extra long handle, and the sharp one handed scraper. Evenk culture. Kharyyalach, Sakha Republic, Russia, 2004.

Fig 3.29. Kombagir Ludmila Afanasievna removing the subcutaneous layer from leg skin with the one-handed sharp scraper. Evenk culture. Kharyyalach, Sakha Republic, Russia, 2004.

Fig. 3.30. Karen Marie Eira Buljo removing the subcutaneous layer from leg skin using the two handed scraper with the s-shaped blade and the scraping board. Sámi culture. Kautokeino, Norway. March 2004.

Siberia (Fig. 3.7, 3.11) (Middendorff, 1953:121; Popov, 1964:574; Sirelius, 1983:287; Nesheim, 1964:205). The wooden scraping board, which is slightly rounded, serves as a support when scraping the skins. When thin and fragile skins are being scraped a depilated skin is used as a lining on the scraping board to protect the skin from physical damage. The board is leaned towards the waist and supported against a wall or another fixed point. The scraping is performed in different directions and does not seem to follow a set pattern, but it is performed evenly across the skin. This process also stretches the skin, and it is especially important to smooth out the slightly thicker edges of the skin.

In the Evenk culture there are mainly three scrapers used for various stages in skin processing, as well as a scraping board (Fig. 3.28, 3.38). The end scraper with a short handle, sharpened, but not as sharp as a knife, is the initial scraper used. Its main purpose is to clean the surface of the flesh side of the skin and to remove the subcutaneous layer of the dry skin (Fig. 3. 29). A rounded wooden board, a scraping board, leaning against the waist and supported against a fixed point/wall is often used for the different scraping stages in the process. The skin rests on the rounded side of the board and is held in place between the waist and the board (Fig. 3.37). Scraping also takes place without the scraping board, on the floor of the house or on the ground outside. Another form of scraping board is the tripod or a *goat*. The tripod is made from wood and has two legs of the same length, vertically placed, whereas the third leg is longer and stretches at an angle to the ground. The skin is secured on the third leg as it would be on a scraping board (Fig. 3.43).

3.2.3 Tanning

3.2.3.1 Vegetable tanning

In the Sámi culture willow, birch and alder bark are the main vegetable tanning substances. Bark tannin extracts are made from fresh or dried bark depending on the effect required. Fresh willow bark is removed from the branch or twig using a knife or a small debarking tool (Fig. 3.31).

Fig. 3.31. Ellen Sara M. Sara, removing bark from a willow twig, using a bent knife as a debarking tool. Suotnju, Norway. March 2004.

Fig 3.32. Boiled willow bark in lukewarm suspension.

The bark is either dried for later use or extracted immediately in boiling water for approximately half an hour. Dry bark yields a darker colour than fresh bark. For softer and lighter (in colour) skin, the bark from thin willow twigs is used. It is also said that bark from trees that grow close to water provide a better quality extract than those growing far away from water. Willow bark extract yields, according to the informants, a lighter and softer skin than either birch inner bark or alder bark.

A darker colour and a firmer more solid skin is obtained by using birch bark. Birch bark is retrieved from the powdered inner bark and is mixed with water. Combinations of willow bark and birch bark may also be used if a slightly more firm skin is required. Alder bark yields a redder colour than both willow and birch and seems to be used when this specific colour is required. It is also said to yield a skin with higher stretch-

Fig. 3.33. Lilly Guttorm is applying willow extract on leg skin. Sousjavre, Norway, 2004.

Fig. 3.34. Collection of tools and materials for the process of making short winter boots. From left to right: Scraping board, with a short boot lying on its side. Next to this, dried leg skins with remnants of paper attached to the flesh side and tanned leg skins. Above these leg skins there is a scraper with s-shaped blade. In the right upper corner a paper bag filled with willow bark scrapings and in the cooking pot next to it, boiled willow bark in water, ready to be used. In the house of Inga Guttorm, Karasjok, Norway, 2004.

Fig. 3.36. (Above) Close-up of the application of brown rotted larch wood leg on skin in Kharyyalach, Sakha Republic, Russia, 2001.

Fig. 3.35. (Left) Afanasieva Tatiana Stepanovna applying brown rotted larch wood to the flesh side of a leg skin in a settlement north of Kharyyalach, Sakha Republic, Russia, 2001.

ing properties. Table salt (NaCl) is added to vegetable tannin extract, most often in the last tannin bath, as it enhances the tannin penetration (Kay, 1958:182).

Anne Kirsten Kemi Eira describes how some thin and structurally loose skins are made more firm and functional by using birch bark instead of, or in a mixture with willow bark extract in the tanning process.

Today, ready made powdered tannins can be acquired for usage in the skin processing technology. It is possible to buy a brown powder (possibly birch), quebracho and mimosa powder in 500 gram bags to be mixed with lukewarm water. Most informants who have tried powdered tannins claim they are not as good as the tanning extraction they make themselves from fresh or dried bark.

Depilated skins are immersed into the tanning extraction in a container suitable for the amount of skin to be tanned, and the skins are agitated regularly. The skins remain in the extract over night and the extract is renewed two to three times according to the desired result. A washing machine may be used if many skins are tanned at the same time (preferably a top loading machine with a drum agitator).

Skins with hairs attached are not immersed in the tannin extraction. Rather, the extraction is applied using the bark in the solution; after application the leg skins are folded flesh side against flesh side and left

Fig. 3.37. Konstantinova Rosalia Prokopievna scraping a leg skin with a two handed scraper, to remove surplus tanning substance. Kharyyalach, Sakha Republic, Russia, 2004.

Fig. 3.38. Collection of tools and materials used in skin processing technology. From left to right, placed on a tanned reindeer skin are two white leg skins, tanned with brown rotted larch wood and boiled reindeer liver. Next to these are placed two lumps of brown rotted larch wood and above these, thin wooden sticks for drying whole skins. The typical tools; a sharp end scraper, an end scraper with a serrated edge and an extended handle, and a two-handed scraper with a smooth but not sharp blade is observed next to the scraping board. Presented by: Tomskaya Rosalia Ivanovna, Egerova Maria Ivanovna, and Stepanova Valentina Vasilievna, in Kharyyalach, Sakha Republic, Russia, 2004.

overnight (or as long as it takes). This procedure is repeated until the desired result and colour are achieved (Fig. 3.32, 3.33).

In the Evenk culture, in the northern Sakha Republic, brown rotted larch wood is collected and crushed into a powder. This powdered wood is mixed with lukewarm water and applied directly onto the flesh side of the skin using hands, cloths, and moss or grass balls. The tannin may be chewed and sprayed from the mouth onto the skin or rubbed dry into the surface while at the same time spraying water from the mouth onto the surface (Kirillovna, 2001, pers. comm.). The skins are left overnight and excessive residues are scraped off the next day. This method applies to whole skins with hairs attached. Leg skins are not left overnight unless the skins are very thick. Here the powdered wood and water mixture is applied and only left for a few hours on the skin before it is removed with a two-handed scraper. Leaving the tanning substance on the skin too long may lead to a complete penetration of the tannin and discolour the hairs of the leg skin. This powdered tannin/water mixture may also be combined with boiled mashed reindeer liver before application if the skin is very thick. The liver is supposed to make the skin softer, and it makes thicker skins easier to manipulate manually.

Alder bark, which is scraped off the branches and boiled in water, is also used in the tanning process. But according to informants it is used mainly as a colouring matter on both depilated skins and skins with hairs attached.

Tea has also been used to give a tanning effect as well as to add colour to the skin's surface. Strong tea is applied to the flesh side of skins with a rag. The skins are folded flesh side to flesh side and left for some hours. The skin is then scraped and the process is repeated until the desired colour and quality has been achieved.

In this process either the end scraper or the two-handed scraper with a serrated edge is used. The end scraper has a serrated semi-lunar edge, and the two-handed scraper may have a serrated edge, a smooth edge or a combination of the two (Fig. 3.28, 3.38). In the application of tannin substance the end scraper is

Fig 3.39. Nikolaeva Maria Vladimirovna using an end scraper with a serrated edge and an extended handle. The scraper is stuck up her sleeve, as she is working the tanning substance into the skin. The skin is placed in the scraping rack for support. Settlement north of Kharyyalach, Sakha Republic, Russia, 2001.

used to manipulate the tanning substance into the skin, but also to remove superfluous tanning matter from the surface. In Olenek and Kharyyalach the handle of the end scraper is longer, and its practical use is different from that in Chapo Ologo, Sredniy Kalar and Nichatka. To obtain better support, the handle is stuck inside the sleeve, and the whole arm is shifted as the skin is scraped and the tannin substance is worked well into the flesh side of the skin (Fig. 3.39).

These uses of scrapers also aim to stretch and soften the skins. According to Kristoforova Fedora Prokopievna (age 85 in 2004) there used to be several varieties of two-handed scrapers, of different sizes and for various purposes.

Fig. 3.40. Implements for assisting in skin processing: 1: Large softening-chair, 2: Small softening-chair. 3. Scraping rack and 4: Skin press for large and heavy skins. In the yard of Ambrosieva Vera Aleksandrovna and Ambrosiev Stephan Ivanovich, Olenek, Sakha Republic, Russia, 2004. Photo: O. Grøn.

Fig. 3.41. Nikolaeva Maria Vladimirovna using the softening-chair on a leg skin. The flesh side of the leg skin faces the iron blade, and the skin is pulled back and forth over the blade. Settlement north of Kharyyalach, Sakha Republic, Russia, 2001.

There are several other implements used in northern Sakha Republic area, which assist the user during the different stages of skin processing (Fig. 3.39, 3.40, 3.41). The most standard implement seems to be a scraping rack, which holds the skin in place while the end scraper with serrated edges is being used.

3.2.3.2 Fat tanning and lubrication

The main fats used in the Sámi culture were oils from fish liver and, in particular, cod liver (*Gadus sp.)*. To collect the oil the liver is either hung in a cloth bag where the oil is allowed to drip into a container, or it is placed in a jar, and the fat is eventually skimmed off the surface. This oil does not have to be fresh, and some informants say that it is even better as it ages. The oil is mixed with salt and flour (wheat or rye) into a pancake-thick batter and applied in this state to the flesh side of the skin. The whole fish liver, particularly halibut liver (*Hippoglossus sp.)*, is also used, preferably in a fresh state. It is crushed and applied to the skin, either by itself or mixed with flour and a pinch of salt. The smell from skins tanned with fish liver oil seems to be the main reason why only a few people use this oil today.

Fat skimmed from the surface of boiling meat may also be used as a tanning or lubrication agent. It is purified, through repetitious heating where residues are skimmed off, and applied to the skins in a lukewarm state. As fermented cow milk became a regular commodity in the 1950 it was also added to the fat tanning batter. Sometimes the fish liver oil was omitted, and the fermented cow milk was used as a substitute, especially for festive coats, where the smell from fish liver oil was not desired. Reindeer brain substance has been used as a tanning agent and lubricant in the Sámi culture. Only a few informants remember this method and it is not widely used today. The brain would be used raw, crushed and smeared onto the flesh side of the skin. In the Sámi culture today the most common fat used is the oil that is bought in special craft shops. The composition of the fat is not defined, and it comes in various colours, whitish pink, brown/yellow, and almost clear. Several informants have better experiences with the whitish pink emulsion than with the clear or brown/yellow oils. Oils are often applied to the skin in a mixture with a stuffing medium, such as flour or in the last extraction bath of vegetable tannins.

In the Evenk culture, a variety of fats has been used and is used today. These include oils and fats bought from the local shop, as well as bear fat, marmot fat, reindeer brain and reindeer liver. Bear and marmot fats are not easily available today. Malchakitova Ludmila Vasilievna remembered a mixture used by her mother which consisted of reindeer brain substance, preferably mixed with bear fat or the fat from marmot (tarbagan). This mixture of brain and fat are melted together in a pot and will, upon cooling, separate into two layers, of which the top layer is used for food and medicinal purposes, and the bottom layer is used as a tanning substance.

Raw bone marrow is also used, mixed with reindeer brain substance or with reindeer liver. Vegetable oils have been used in the 20th and 21st century, either

Fig. 3.42. Smoked depilated reindeer skin is soaking in a water mixture of, yeast, a pinch of salt, and oil, prior to scraping and softening. The skin will be used for the palm part of mittens. Nichatka, Chita County, Russia, 2001.

Fig. 3.43. Kuzmina Julia Anatolievna is scraping depilated reindeer skin, on a tripod, using a two-handed scraper with a dual edge. Here using the non-serrated edge. Nichatka, Chita County, Russia, 2000.

alone or in combinations with other fats. This can be soy, olive, sunflower, linseed or any vegetable oil that is commercially sold in the local community.

The fats or mixtures of fats are applied to both sides of depilated skins with the hands or a rag in a circular movement. If the depilated skin is thick and heavy, the process is repeated. One informant explained how some women would spray the fat onto the skin from their mouths. In Sredniy Kalar, an informant remembers how the fat was applied with grass balls. The fat may also be added to water and the skin soaked in this solution for a period of time, depending on the skins thickness. This would however only apply to depilated skins (Fig. 3.42). In fat tanning the hydroxy fatty acids form insoluble bonds with the skin substance. It is these fatty acids, which create the tanning effect. Mixing the fat with brain substance creates an emulsion, which penetrates the surface more easily and gives a better tanning of the skin (Gansser, 1950:2950). Reindeer liver is also used as a lubricant in the Evenk culture. When questioned as to what affect the boiled and crushed liver has on the skin, most informants state that it makes the skin stronger and more pliable.

3.2.3.3 Smoking the skin

Smoke tanning is not used intentionally in the Sámi culture. A non deliberate smoking effect on clothing and footwear may however be gained over time as clothing is dried in a tent with an open fire. Even though smoking is not part of the skin processing, the skin items may eventually be slightly smoked. This is supported by the fact that some Sámi informants confirmed that they had noticed an increase in the durability of, especially, footwear after a period of use.

In the Evenk culture smoke tanning is a standard method in skin processing. At least it used to be so. The main purpose of smoking the skin is to make it waterproof or at least more water repellent. Another purpose of smoking is to give colour to the skin. In northern Transbaikal, most informants state that not all skins are smoked, but it is not far from the case.

Fig. 3.44. A larch bark covered construction for smoking fish and meat, but also for smoking skins. The fire is made in the small iron oven, and the smoke is led through the pipe to cool off before entering the construction. Terteia, Katanga Region, Irkutsk County, 2002. Photo: O. Grøn.

Skins used for the soles of boots are in particular smoked, as well as depilated skins and sometimes leg skins and whole skins with hairs attached. In the northern Sakha Republic all depilated skins are smoked, but today mainly for the colouring effect.

Skins are smoked in specially constructed smoking structures, which vary according to accessibility of construction materials and location. A smoking structure should be located some distance from the settlement area and is often placed near a river or lake. The objective is to create cold smoke, and the smoking structures are often placed well away from the source of fire itself. The smoke is led through a pipe to the covered smoking structures (Fig. 3.44). To create a lot of smoke, moss and decomposed wood is often added to the fire. Smoking is performed until the skins have obtained the 'right' colour. This may take hours or days. As with other different parts of the skin processing technology, the experience of the tradition bearer determines the result of the process, and this experience is often difficult to explain to a non expert. When asking how long the skins should be smoked, most informants stated; "Until the colour is right", or "Until it is finished".

Temporary smoking structures are also used (Fig. 3.45, 3.46). Malchakitova Ludmila Vasilievna describes one temporary structure like this:

« You need a lot of willow twigs. Then you dig a hole in the ground, and above this hole you build the smoking construction. At some distance from the hole you put two willow twigs in the ground opposite each other, and then you connect the ends of the twigs above the hole. The hole should be quite deep. Then you surround the hole with twigs in the same way. It is in the shape of a cupola. The twig construction should be quite tall, to make space for a lot of smoke.

Fig. 3.45 Willow twigs organised in a cupola shape, used for smoking skins. Chapo Ologo, Chita County, Russia, 1999.

Then you put 'kamus' (leg skin) on the twig construction (on the outside of it). Then you cover the whole cupola with 'nechuksa' and 'najaksa' (depilated skin). There should not be any open space between the skins.

Fig. 3.46. The inside of a smoking tent. The tent poles are covered with skins and also cloth to prevent the smoke from leaking. Sredniy Kalar, Kalar District, Chita County. Russia, 2001. Photo: O. Grøn.

Then you take 'sejavaksa', which is an old dry larch tree. It must dry on the root (it has a white colour). Then you collect moss – 'yalbuka'. To make the fire you take 'sejavaksa' and cover it with 'yalbuka'. The smoke from the fire will smoke the skins. You keep the skins on the construction until they are finished. The process should not take place when the weather is too hot. Spring or fall is good.» Chapo Ologo, Chita County, Russia, 1999.

3.2.3.4 Finishing

In the finishing stages of skin processing the aim is to dry, soften and to stretch the skin to its final shape. In the Sámi culture this is again achieved with the two-handed scraper with the s-shaped blade, performed on the scraping board. In addition, and maybe more important, the hands are used to pull the skin in different directions and to wring the skin until it is considered finished.

In the Evenk culture the final stages of the process are performed with the serrated edge scrapers and with

Fig. 3.47. Kuzmina Julia Anatolievna is using her hands to soften and at the same time to dry the skin. Nichatka, Chita County, Russia, 2000.

Fig. 3.48. Kuzmina Julia Anatolievna is scraping the skin with an end scraper with serrated edge, to soften the skin. Nichatka, Chita County, Russia, 2000.

Fig. 3.49. A newly built skin press (talki), used to soften larger skins. Nichatka, Chita County, Russia, 2000.

Fig. 3.50. Malchakitova Ludmila Vasilievna softening a leg skin in a small skin-press (talki). Chapo Ologo, Chita County, Russia, 1999.

the hands (Fig. 3.47, 3.48). In addition to various end scrapers and two-handed scrapers, a small skin press (talki) is sometimes used for softening smaller pieces of skin, especially leg skin, and a larger skin press is used for whole (or half), depilated larger skins. The skin press is made from a hollowed trunk, which has been divided longitudinally. The handle consists of a wooden stick cut to resemble teeth whose thickness fits the inner diameter of the hollowed trunk. When the skin press is used, the handle is moved up and down and will press together and thereby soften whatever skin material is placed between the trunk and the handle (Fig. 3.49, 3.50).

3.2.4 Colouring substances

The bark of the alder tree is used as a colouring substance in both the Sámi and Evenk culture. The alder bark is boiled in water for some time, and the colouring solution may be added to the tanning solution or rubbed into the skin. This yields a redder colour than both willow and birch bark. In the Evenk culture, in the northern Transbaikal area, cowberry extract is also added to the tanning solution and gives a stronger red colour to the skin. The cowberry extract may also be applied as line decorations, using sticks.

Soot mixed with fat is used as a black colouring and is applied with small sticks or fingers. In the Evenk culture, skin artefacts that have been examined show a mat, dark red surface colouring that resembles earth

Fig. 3.51. Boots decorated with beads and partly coloured with unknown red substance, see arrows. Museum number: VK-435-2, Museum of Cultures, Helsinki, Finland, 2004.

Fig. 3.52. Short trousers, evenly coloured (probably) with grey unknown substance. Museum number: MAE-2864-3. The Russian Museum of Ethnography, St. Petersburg, Russia, 2005.

pigments (possibly ochre) mixed with a medium that attaches to the skin.

As earlier stated, smoking of the skin serves several purposes, where giving colour to the skin is one of them. The informants who state that the skin should be smoked until it has the right colour also confirm this. When it became possible to buy, for example, watercolours in the shops, these would also be used for decorating skin items.

Examples of colouring are shown in figure 3.51 and 3.52. As Georgi described from his travels in Siberia in 1772-74 (1775:263), ochre pigments were mixed with fish glue or larch gum. The substance used for this boot (VK-435-2) is not known.

3.3 Storage, maintenance, and repair of skin artefacts

The principles of storing clothing items and other skin articles are identical in the Sámi and Evenk cultures. They should be stored in an outhouse or a loft, airy, cool and away from insects and mice (Fig. 3.53, 3.54). It is however important that skins are not stored too long (many years), as they will be destroyed. This may be connected to what is generally called freeze burns, known in the meat industry, where the frozen material over time loses water and becomes dry, discoloured, and brittle.

There is a difference in opinion among the informants in the Sámi culture about whether it is acceptable to store the skin clothing items in a plastic bag or in a bag made from burlap or cotton cloth. Some say plastic bags are acceptable as long as they are monitored regularly, and others say that plastic bags cannot be used for storing skin clothing items, as the hairs may loosen, and this may lead to the growth of micro organisms. Depilated skins can be stored in a freezer, preferably before they are completely dry, and may be stored there until they are to be used.

In the Sámi culture the coats are turned inside out before storage. This is supposed to prevent mould formation. If mould is present, it may be removed using willow bark extraction rubbed into the skin with a subsequent light scraping and rubbing. This may also be the case if the item has lost its flexibility.

Coats and other clothing items are normally softened by absorption of humid air as fall turns to winter. Informants state that before using the coat it should be allowed to hang outside and "soak" humid-

Fig. 3.53. Storing fur items. Typically in an outhouse, where garments and footwear are hung from the ceiling. Finnmark, Norway, 2004.

Fig. 3.54. Storage platform (left) on the site where Tatiana Stepanovna lives. Kharyyalach, Sakha Republic, Russia, 2004.

ity and then be stretched to regain its form and flexibility. If this is not sufficient, willow bark extraction, spraying water or adding fat may be used with a subsequent light scraping and/or rubbing between the hands. As houses became electrically heated, stiff and hard clothing items became more of a problem.

Insects are not generally a massive problem in the arctic and sub arctic, but they are present when temperatures rise, and especially in museum collections. Both moth (*Tineola bisseliella*) and Dermistae are known to most of the Sámi and Evenk informants. In the Evenk culture insect repellent material is used, such as Juniper twigs (*Juniperus communis L.*) and twigs from Labrador-tea (*Ledum palustre L*). Fresh twigs are placed among the clothing items to keep insects away. The twigs must be replaced regularly.

3.4 Summary

The preferred material for winter clothing both in the Sámi and Evenk culture is reindeer skin. In the Evenk culture there is, however, a more extensive use of red deer skin, elk skin, musk deer skin and smaller fur skins. These variations may be seen in areas where reindeer is not the principal animal for hunting or herding. In the winter clothing items are supposed to keep the bearer warm and they should be lightweight. Reindeer skin fills these criteria and is therefore the primary material used in winter coats. Adjustment of insulation and weight are regulated by the animals' size and age, which reflects in the choice of materials when garments are made. Festive coats are made from thinner skins of young animals, and winter herding or hunting coats are made from more mature, larger animals. Depilated skin has in both cultures decreased in use for clothing items and shoes, as other materials made from wool, vegetable and synthetic fibres are available for purchase. This change seems more recent in the Evenk culture than in the Sámi culture even though the use of cloth is described in the 18th century and probably was also used earlier in both cultures. The depilated skin garments and footwear that are in use today are primarily used by elderly people. The skins are also currently utilized for accessories such as purses, belts, and bags. It also seems that the further away from the local town a group of people lives, the more they have to rely on the natural resources in the surrounding area. Variations in the use of materials may of course also be regulated by other criteria, such as economy, ability to travel and family relations.

In the following the focus will be on reindeer skin, both with hairs attached and depilated.

In the slaughtering process both cultures argue the importance of keeping blood off the skin. If allowed to penetrate the skin the blood will render the skin discoloured and more difficult to soften. It is however not crucial for all uses of skins that they are free of blood, as skins for sitting on in sledges, snowmobiles, and in the tents may have these stains without losing their value.

There is in the Sámi culture a strong sense of form, which determines how the skin should be removed from the carcass. If these principles are not followed the sewing of the coat will be complicated and the final shape not in accordance to tradition. Informants state that it is, of course, possible to make a coat even if the skin is not properly removed, but it will require patching, and the final shape may not be as good as it could have been. There seems to be a closer connection between the full shape of the skin and the shape of the coat in the Sámi culture than in the Evenk culture, where the skin's shape is not to the same degree reflected in the shape of the coat. This is also seen in the making of short boots, where the removal of the skin from the reindeer's legs, in the Sámi culture is very important for the shape and comfort of the finished boots.

Drying of skins has many similarities both in principles and in practical methodology. The principles are that the skins should be dried outside and not in strong sunshine. Strong sunshine (excess heat) will "burn" the skin. Drying in frosty weather makes the skin softer and this applies especially to depilated skin. Skins with hairs attached should not be stretched too much during the drying process if they are to be used for clothing purposes, as this will make the skins stiffer and more difficult to process. The methods of drying skins are very similar in both cultures. There is some variation as to methods used, but the purpose is the same: to dry the skin not too fast and not too slow with the aid of various practical implements available in the local area.

Salting of skins seems only to be used in the Sámi culture. This may be related to the increasing industrialisation of the

Table 3.2. Schematic presentation of similarities and dissimilarities in Sámi and Evenk skin processing technology. The table displays a general outline of materials and does not demonstrate the diversity within each skin type.

Sámi and Evenk skin processing technology

Sámi		Evenk	
Skin type:	**Depilated – full grain**	**Skin type:**	**Depilated – suede (grain removed)**
Salted skin	Used by some	**Salted skin**	Not used
Vegetable tanning agents	Salix, Alnus, Betula	**Vegetable tanning agents**	Larix and Alnus mainly for colouring purposes
Fat tanning agents or lubricants	Cod liver oil, brain substance, fermented milk, household oils, commercial leather oil	**Fat tanning agents or lubricants**	Animal fat – bear fat, marmot fat, bone marrow, brain substance, reindeer liver, household oils
Smoking	Not used	**Smoking**	Used
Skin type:	**Whole skin with hair**	**Skin type:**	**Whole skin with hair**
Salted skin	Used by some	**Salted skin**	Not used
Vegetable tanning agents	Salix, although very little and not used by all	**Vegetable tanning agents**	None or Larix
Fat tanning agents or lubricants	Cod liver oil and /or fermented milk mixed with flour and salt, household oils, commercial leather oil	**Fat tanning agents or lubricants**	Animal fat – bear fat, marmot fat, bone marrow, brain substance, reindeer liver, household oils
Smoking	Not used	**Smoking**	Used, but more in earlier times than today
Skin type:	**Leg skin**	**Skin type:**	**Leg skin**
Salted skin	Used by some	**Salted skin**	Not used
Vegetable tanning agents	Salix, Betula	**Vegetable tanning agents**	None or Larix
Fat tanning agents or lubricants	Seldom	**Fat tanning agents or lubricants**	Not always used. Animal fat – bear fat, marmot fat, bone marrow, brain substance, reindeer liver, household oils
Smoking	Not used	**Smoking**	Used, but more in earlier times than today

slaughtering process in the Sámi communities and the decreasing availability of fresh skins. Salted skins have also gained some recognition in parts of the Sámi community, as it makes the skins easier to scrape.

Mechanical processes such as scraping and stretching in various stages of the process are based on the same principle; to shape, stretch, soften, and to work tanning substances into the skin, as well as to remove superfluous tanning material. These principles are the same in both cultures, although the tools and implements used in these processes vary in shape and number. All Sámi and Evenk informants confirm that stretching the skin in various parts of the process is imperative. This is done through various scraping processes but also through pulling or stretching the skin in all directions. The hands are an important tool in these processes along with scrapers of various styles. In the Evenk cultures the scrapers differ according to which step in the process one has reached: sharper scrapers in the initial stages and less sharp scrapers as the process moves forward, and scrapers with serrated edges to work tanning substances into the skin. Both two-handed and one-handed scrapers are used, and according to some informants there used to be an even a larger variety of scrapers in earlier times. The two handed scraper with the s-shaped iron blade is today the only major tool in Sámi culture skin processing technology. The s-shaped blade with its characteristic two blade shape; one side of the blade sharp and the other often serrated, is sufficient for most of the steps in skin processing. In the scraping process, both cultures scrape the skin on scraping boards or tripods. Implements to aid in the processing process, as well as scrapers, seem to be more numerous in the Evenk culture, such as for example the softening-chair, the skin press and the scraping rack.

The major difference between Sámi and Evenk skin processing methodology relates to depilated skin. In the Evenk culture the grain of the skin is not preserved in the depilation process, while in the Sámi culture a full grain is always preserved. In the Evenk culture the hairs are first cut from skin, and then remaining hairs are scraped off; in the Sámi culture the hairs are removed by 'sweating', where the hair is loosened from the hair follicle by an initial rotting process. The latter process may be more complicated to control and therefore potentially more damaging to the skin. If damage has occurred it may not reveal itself until later in the process.

Furthermore, it seems as if depilated skin clothing in the Sámi culture is primarily worn with the full grain side as the exterior surface. This also applies to bags, purses, and boots when depilated skin is used. It has not been possible to find any information on the use of suede skin material in the Sámi culture. In the Evenk culture examples have been found which imply that mainly the flesh side is used as the exterior of clothing items (MAE-376-59 and IMRS-625-2). This may also be the reason why recovered larvae holes are often highly visible on the exterior surface of the depilated skin items from the Evenk culture.

Another major distinction is whether the skins are smoked or not. In the Evenk culture most skins are smoked, or at least they used to be smoked. Smoking is an important part of the skin processing technology, and it is applied to provide water repellence properties to skin materials. Today, as waterproof materials may be bought, this method is used mainly as a colouring process. Smoking of skins has not been used and is not used today in the Sámi culture, although most informants have heard about its use in other indigenous cultures. Gudmund Hatt's information (1914:38) on the distribution of smoking as an important tanning method in arctic and sub arctic indigenous cultures seems to coincide with the observations made in this research.

Vegetable tannins are used in both cultures. The only parallel in the use of tannins appears to be alder bark extract, which is used as a tanning agent, but, in the Evenk culture, its colouring qualities are just as or perhaps more important. The vegetable tannins are all confined to the condensed tannin group and include birch inner bark, willow bark, alder bark, and brown rotted larch wood. Each of the tannins has specific characteristics apart from the colouring properties. Birch bark yields a firmer, stiffer skin and appears to be used mainly on heavier skins or skins whose structure is very loose. Willow bark yields a lighter and softer skin, while alder gives a darker coloured skin with high stretching properties. In the Evenk culture no such characteristic description is given for the properties of brown rotted larch wood.

High vegetable tannin penetration does not seem to be a major purpose of the tanning procedure in either culture. In the Sámi culture, especially in the tanning of skin material for footwear, a skin with a raw streak is desirable. The raw streak in the skin material is obtained through the method of tannin application. This in particular is recognized in the processing of leg skins for boots, where the tannin is applied to the flesh side using the bark in the extract. Some informants state that it is possible to use a washing machine in the tanning of leg skins, but the outcome is not as good as for manually tanned leg skins.

Boots made from leg skin tanned in this way are more difficult to shape and they do not maintain their shape as well as the manually tanned leg skin boots. This might imply that the raw streak is less developed in leg skins where tanning is carried out in a washing machine. The development of a raw streak furthermore applies to other clothing items or accessories where water repellence qualities are important. This aspect is not commonly expressed in the Evenk culture, even though it is known and used.

The common denominator in fat liquoring and lubrication is that most fats can be used if they produce the desired qualities in the skin material. This research shows that even though different fats have been used and still are in use, these fats have mainly been applied to soften and create skins with water repellence properties. A general feature in both cultures is that thick, heavy skins are fat liquored more often than thinner skins and that the application of fats is repeated several times. This also confirms the impression that fats are mainly applied to produce a pliable skin. The tanning affect of oxidizing fats, such as cod liver oil, does not seem to be the main objective of applying fat substances, apart from the fact that it has yielded a good quality skin with certain desirable properties. The choice of fats has changed from fats available in the household to fats obtainable in the local community and the availability of commercial fats. This can be explained in a number of ways, but it appears to be mainly dependent on a changing way of life in the indigenous cultures.

4 PHYSICAL CHARACTERISATION AND IDENTIFICATION OF TANNED AND SEMI TANNED COLLAGEN FIBRE MATERIAL

When examining an artefact for the first time in a museum setting, specific observations should be recorded, and this information should consequently follow the artefact through the successive stages of its investigation and treatment. This includes information on artefact type, provenance, material composition and age and provides the basis for more in depth exploration. This is the first set of questions which were applied in the study of the historic artefacts, made from reindeer skin and fur, for this research. The next set of questions encompassed features which are visible in the artefact material, and which possibly provide information concerning the technology used in the forming of the artefact, such as indicators of slaughtering, depilation, tanning, and mechanical action and, finally, the condition of the artefact. This included questions such as visible surface features, colour characteristics, wear and tear, and general appearance.

Information on materials and methods is initially sought through available literature, through the study of climatic conditions, flora and fauna, and not least through tradition bearers to identify possible and available tanning materials at a specific geographic location. For example: suggesting at this point in an investigation of depilated reindeer boots that the skin is waterproofed, either with fats or by smoking, may be difficult. However, if the artefact is of Sámi culture origin, smoking may be ruled out, as the Sámi do not intentionally smoke skin materials. Consequently, the investigation would lead to the exploration of the use of potential fats in the skin material. Therefore, the investigation of the artefact may, to begin with, start with a simple elimination process but the increasing complexity of features and observations will indicate that other methods of identification must be pursued. A successful interpretation of the various visual characteristics could, for example, benefit from an established catalogue of reference material images. This reference catalogue should be based on experienced observations and be continuously updated.

This chapter will describe indicators in the skin material at each production stage in the processing of skin clothing, footwear, and accessories. The examination will focus on characterisation and identification of material and substances, but as certain features have evolved from stages in the skin processing technology as well as from the changes that have taken place as the artefact is used, collected, exhibited and stored, the condition of the artefacts based on observable features will also be included.

4.1 Pre-slaughtering and slaughtering indicators

Pre-slaughtering indicators include an animal's skin characteristics and the various influences on skin quality which take place prior to slaughtering. This includes seasonal variations such as density of hairs (the number of hairs pr cm^2), hair coat thickness (hair length), hair colour, but also features such as age at the time of slaughter, the thickness of the dermis, and the structural firmness of the dermis. It also includes certain characteristics specifically visible on the flesh side of the skin, such as scar tissue from holes of the warble fly (*Hypoderma tarandi*). Slaughtering indicators are connected to the processes and actions during the slaughtering and immediate after the slaughtering process. This includes the spilling of blood and stomach content, knife cuts, the shape and extent of the hide as it is removed from the carcass, as well as the amount of fat and other tissue left on the flesh side.

By examining skins with hairs attached (SWH) one can determine if the hair coat is from a winter, spring, summer, or fall skin. For a winter skin the hair coat is generally thicker and the hair density is higher than for summer and fall skins. Although the colour varies from animal to animal and between subspecies, there are generally more grey/white hairs in a winter skin than in a summer or fall skin (Fig 4.2, 4.3). The hair coat of winter skins is more easily damaged than the hair coat of summer or fall skins, as the hairs are more fragile (brittle) and break more easily. Spring skins are typically characterised by patches of mixed hairs (winter and summer) and thereby a greater number of loose hairs.

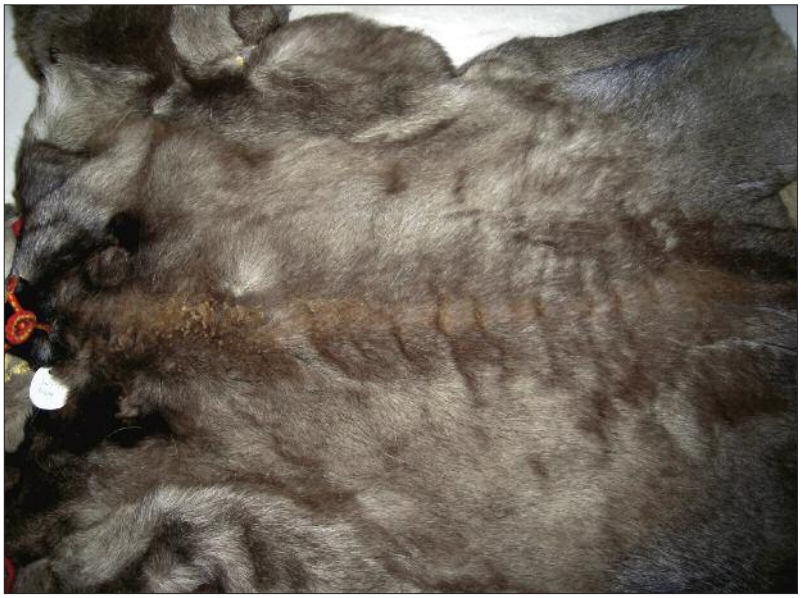


Fig. 4.1. Sámi coat for a small child. The skin is from a reindeer fawn, illustrated by the curly hair in the upper back area of the skin. Museum number: SVD-3604. Samiid Vuorká-Dávvirat. Karasjok, Norway. 2004.

The approximate age of the animal can to a certain degree be indicated, based on the characteristics of the hair coat. Other features, such as the presence or absence of scar tissue, the thickness of the dermis, and possible skin splitting marks, may also be included in the identification. The hair coat of a reindeer fawn is in part curly (Fig.4.1) and the dermis is thin (0.3-0.5 mm). As the reindeer grows the hairs straighten and the dermis thickens, but it will still appear as a fairly thin skin (0.5-0.8 mm) when four-to-five-month-old calves are slaughtered by early August or September (Fig. 4.2).

Another feature which may be recognized in the pre-slaughtering of the animal is the yellowing of male deer leg skin. This is the result of the males regularly depositing urine in the rutting period and thereby miscolouring the hairs on the legs. These skins are rarely used, due to the miscolouring and the odour of the skin (Interview, Finnmark, 2004).

In the slaughtering process certain actions can have an effect on the subsequent quality of the skin. These

Fig. 4.2. Sámi culture coat. Hair coat characteristic of reindeer calf skin. From a calf approximately four to five months old. Museum number: SVD-3073. Samiid Vuorká-Dávvirat. Karasjok, Norway. 2004.

Fig. 4.3. Evenk culture winter coat. Late fall or winter hair coat characteristic of reindeer skin. Museum number: REM-11121-54. The Russian Museum of Ethnography, St. Petersburg. Russia. 2005.

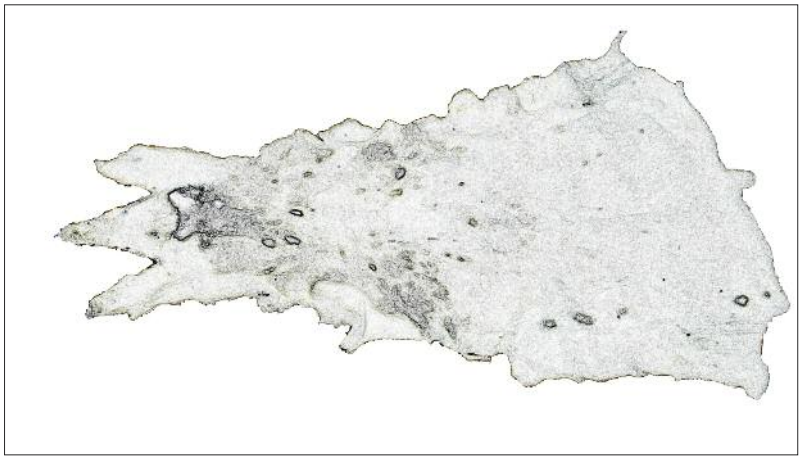


Fig. 4.4. Outline of a reindeer skin from a four to five month old calf. The head skin is attached to the whole skin, which is important for the shape and design of the Sámi coat. Karasjok, Norway 2004.

include knife cuts, spilling of blood and manure, spilling of stomach content and subsequent insufficient removal of fat from the flesh side. In the Sámi culture the skin is removed from the carcass to obtain a maximum size and correct outline for the design of coats and boots. This involves removing the head, body and leg skin from the reindeer as one piece (Fig. 4. 4). The leg skins, including the hooves, are not immediately removed from the skin, as this must be done with particular accuracy to obtain the correct shape for manufacturing boots. The leg skin is, however, cut from the skin before the whole skins are dried.

The spilling of blood will leave bloodstains that can be observed as darker patches on the flesh side of the dried skins. Blood spilling can also result in patches of the skin that are less flexible than the surrounding skin. Stomach content can also stain the skin and is, moreover, regarded as a biologically active substance, which some times is used in the depilation process. It is therefore not a desired substance to spill on fresh skins. Leaving too much fat on the flesh side, in the cleaning process, will slow down the drying process and can cause hair loss.

Another characteristic of fawn skins is the absence of larvae holes and visible scar tissue from larvae holes. Larvae holes and scars usually appear on skins from one-year-old animals and onwards in age. The scarring of reindeer skin, due to the larva infestation, is easily observed on the flesh side and often causes an uneven colouring of the scarred over holes (Fig. 4.5). The scarred-over larvae holes can sometimes also be observed on the hair side of the skin. The hairs that have re-grown on the scarred surface often have a different colour or stand out from those of the surrounding hair coat.

As the animal matures, age is more difficult to determine. However, in depilated skins follicle pattern can be used to indicate the age of an animal. This is observed by the coarseness of the follicle pattern, which increases as the animal ages. The thickness and the structural firmness of the skin are determined by factors other than age and size, such as dietary factors. A good grazing season for the reindeer yields a thicker, fatter, and structurally firmer skin than a meagre grazing season. If, however, the skin is too fat the structure again will become less firm (Tancous, 1969:7).

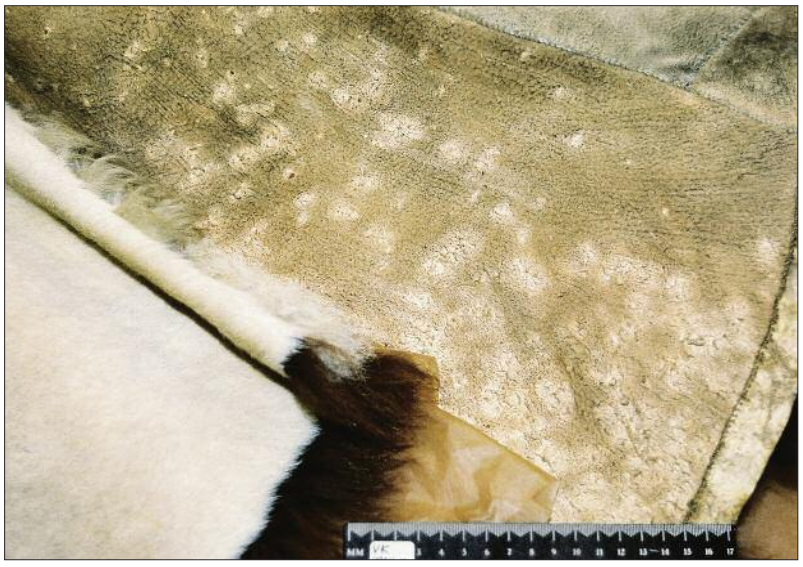


Fig. 4.5. Scar tissue from holes made by the reindeer warble fly (*Hypoderma tarandi*) visible as lighter patches on the flesh side. Museum number VK-4934:170. Evenk culture coat from Museum of Cultures, Helsinki, Finland. 2004.

4.2 Indicators of the skin processing method

Methods to dry skins have an impact on the skin's properties and future usage. If a skin dries too quickly it can become very stiff and hard. Such skins are difficult to re-hydrate and process further. Rapid drying can also lead to hair loss, as the subcutaneous tissue of the flesh side dries and inhibits adequate evaporation of humidity, which leads to initial putrefaction. Excessive heat impact during the drying process induces dehydration of the surface and possibly gelatinisation of collagen in central parts of the dermis. This can in the further processing cause the skin to split. The phenomenon is called 'blisters' and is particularly obvious after the tanning has been completed (Tancous, 1969:129; Guttorm, 2004, pers. comm.). Using salt in skin preservation prior to processing the skin may lead to a skin which does not keep its shape properly. It is also said that salted skins become heavier and absorb humidity more easily than skins that have not been salted (Interviews, Finnmark, 2004).

Fig. 4.6. The loosening of the grain's surface is seen as lighter patches where the grain is peeled off. Karasjok, Norway 2004.

Fig. 4.7. Incomplete depilation of reindeer skin summer leggings from the Sámi culture (grain surface). Museum number TM-0710 a-b. Tromsø Museum, University of Tromsø, Tromsø, Norway. 2004.

The depilation process can give rise to a number of characteristic features visible on the skins surface. This is particularly evident in the Sámi culture, where "sweating" is used as a depilation method and which results in a skin with a full grain layer (see chapter 3). If the process goes too far, part of the grain layer may loosen (Fig. 4.6), and if not performed long enough remnants of epidermis and hairs are left on the surface (Fig.4. 7). In the depilation process the starting point is either dried skins or fresh skins. If a fresh skin has dried in patches before depilation, it is more difficult to remove the hairs evenly, and patches of epidermis and hairs may remain on the surface. The peeling of the grain's surface may not be discovered until late in the tanning process.

In the leather industry there are a number of terms for these phenomenons, such as grain slip, grain peeling, and blistering. They are often a combination of factors which have taken place during the pre-processing or processing of skin materials. The grain damage in figure 4.6 may have been caused by excessive heat exposure in the drying process, by a depilation process gone too far, or a combination of both.

There is less visible damage or characteristic features in the depilation of skin in the Evenk culture material. This is due to the fact that the full grain is not preserved in depilated skins. There may be insufficient removal of hairs by the knife, but this is not often significant as the surface is subsequently and repeatedly

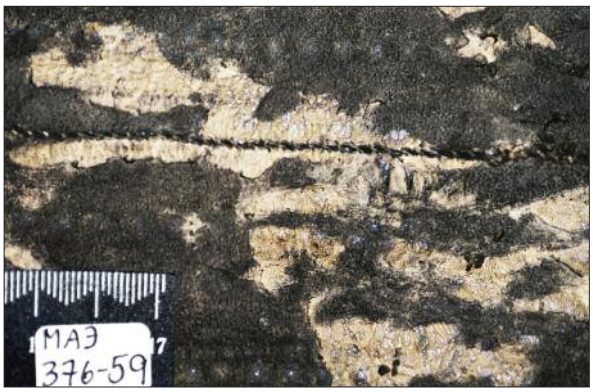


Fig. 4.8. Remaining parts of the subcutaneous tissue on the flesh side, observed as light patches where tannins or dirt have not penetrated the surface. Artefact number MAE-0376-59 (SWH). Peter the Great's Museum of Anthropology and Ethnography (Kunstkammer), the Russian Academy of Sciences. St. Petersburg, Russia. March 2005.

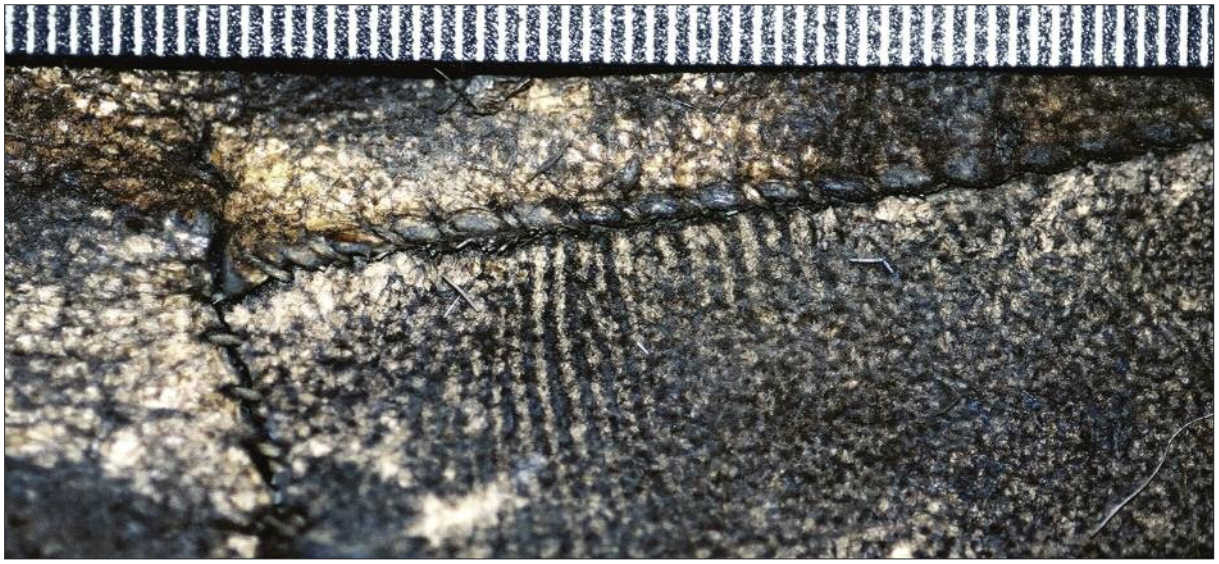


Fig. 4.9. Tool marks on the flesh side of an Evenk culture coat, probably from the use of a scraper with serrated edge. Notice the narrow parallel lines. Museum number VK-4934:180. Museum of Cultures, Helsinki, Finland. November 2004.

scraped on both sides during the different stages in the process.

Remaining parts of the subcutaneous tissue on the flesh side surface can be observed in artefact number MAE 376-59 (SWH) coat from the Evenk culture. Both residues of epidermis and subcutaneous tissue inhibit the tanning or the colouring of the skin (Fig. 4.8).

Enlarged hair follicles are another feature which may characterise skin. This feature however, requires a full grain and considerable experience in studying skin materials. Informants in the Sámi culture have pointed out that chemical (in the meaning industrial) removal of hairs renders the hair follicles open, enlarged, and unable to retract adequately. In home tanned skin the hair follicles retract and thereby produce a less permeable skin. This characteristic inhibits the use of industrially tanned reindeer skins for certain purposes, such as, for example, the rucksack used for food. Food kept in home tanned skin rucksacks will not freeze to the same degree as food kept in a rucksack made from industrially tanned skin (Labba, 2005).

Tool marks are observed on the surface of many artefacts. These are mainly seen as parallel lines, with varying width originating from various scrapers used in the different stages of processing. In the Sámi culture, the s-shaped scraper only recently (in the 1950) acquired a serrated edge on one of the blade edges (Fig 4.11). This serrated edge may be quite aggressive on the skin's surface and is mostly used when the subcutaneous tissue is removed from dried skin. It is not used unduly in the finishing stages of skin processing, as it may damage the skin. In Evenk culture skin processing the one-handed and two-handed scrapers, with a serrated edge, are used in several stages of the process. They are used both as a softening and stretching tool and as a tool to work tanning agents into the skin (Fig. 4.9, 4.10). Tool marks are therefore more visible in the Evenk culture artefacts than in the Sámi culture artefacts included in this study (Fig. 4.12). This is supported by observations and interviews.

Fig. 4.10. Tool marks on the flesh side of an Evenk culture coat, probably from the use of a scraper with serrated edge. Notice the various directions of the parallel lines. MAE-1524-3. Peter the Great's Museum of Anthropology and Ethnography (Kunstkammer), the Russian Academy of Sciences. St. Petersburg, Russia. March 2005.

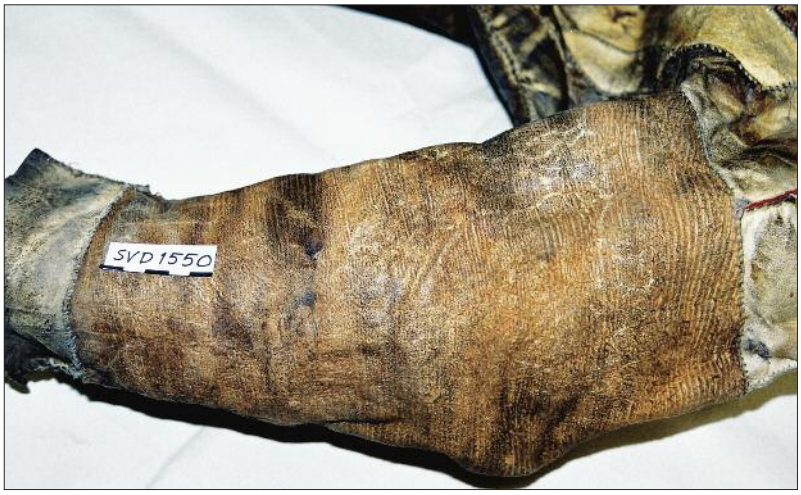


Fig. 4.11. Tool marks on the flesh side of a Sámi culture coat, probably from the use of an s-shaped scraper with serrated edge. Museum number SVD-1550. Samiid Vuorká-Dávvirat. Karasjok, Norway. 2005.

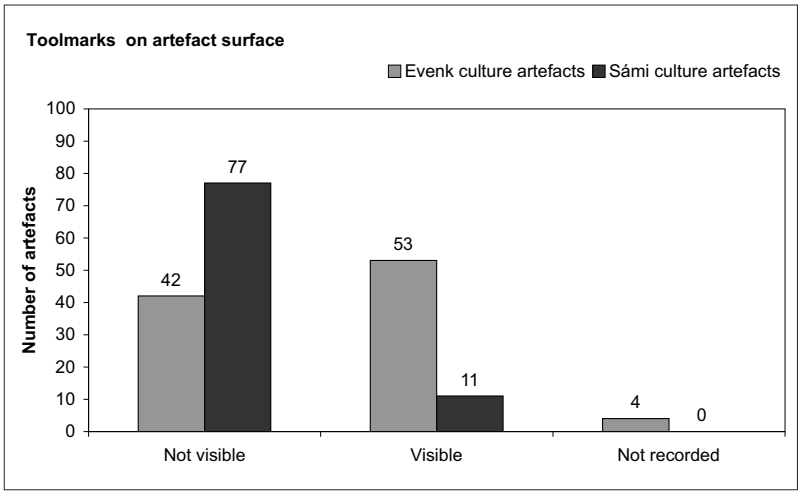


Fig. 4.12. Tool marks registered for the Evenk and Sámi culture artefacts included in the study.

The only tool mark, other than scraping marks observed in the historic artefact study is possible slicing marks from the horizontal splitting of skins. Splitting of skins is used in the Evenk culture, at least in some areas (Turov, 2004, pers. comm.), but it is not used in the Sámi culture (Kemi Eira, 2006, pers. comm.). It is possible to observe slicing marks on the surface of the split skins, although the subsequent scraping of the skin may weaken the marks (Fig. 4.13). Splitting is performed on especially thick skin, such as thick reindeer, red deer and elk skin to produce lighter and more usable skins.

The colour profile for an artefact varies in colour, nuance, and saturation. Plant polyphenols often yield a specific colour, but the method of application, the experience and preference of the manufacturer, and the age and condition of the tannin substance itself, will affect colour of the skin. In addition, the history of the artefact concerning use and maintenance, conditions related to exhibition, storage, and handling also has an effect on the colour as it is perceived today.

The colour most often varies throughout the artefact, both the colour range and the saturation of the colour. Dirt from use and museum dust and dirt often camouflage the 'original' colour, making it difficult to suggest both colour range and variation. For these reasons the colour itself can not identify the plant polyphenol used in the skin material. It may only be

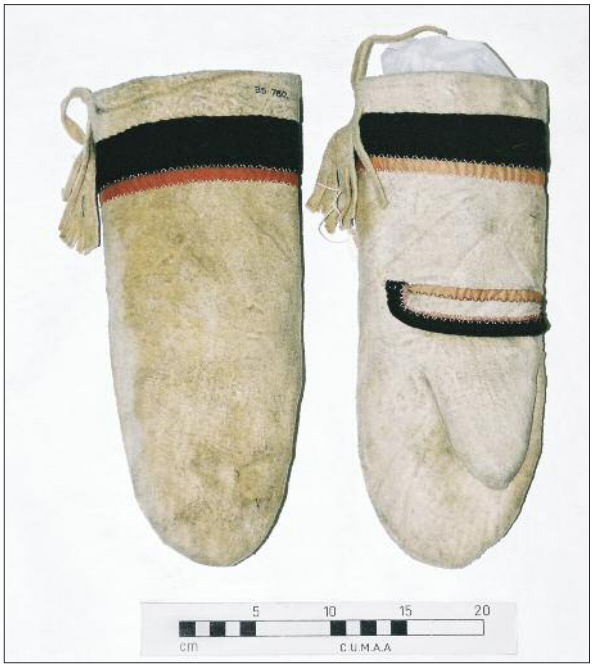


Fig. 4.13. Possible slicing marks on the suede surface. CUMAA-1935-780. Museum of Archaeology and Anthropology, University of Cambridge. United Kingdom. July 2005.

Skin type – Sámi culture	Munsell® soil colour chart - Hue	Colour description and range
SWH	2.5Y	pale yellow
SWH	10YR	very pale brown
LS	7.5YR	light brown/brown/strong brown
LS	10YR	very pale brown/brownish yellow/yellowish brown
DS	7.5YR	light brown/brown/strong brown
DS	5YR	reddish brown/yellowish red/dark reddish brown
Skin type – Evenk culture	**Munsell® soil colour chart - Hue**	**Colour description.**
SWH	2.5Y	pale yellow/yellow
SWH	10YR	very pale brown
LS	2.5Y	pale yellow/yellow
LS	10YR	very pale brown
DS	2.5Y	pale yellow/light yellowish brown/olive brown
DS	10YR	light yellowish brown/brownish yellow/yellowish brown

Table 4.1. General colour profile for the artefacts encompassed in the study.

used as an indicator of the presence of tannins in the material. There are, however, exceptions. The characteristic presence of the deterioration feature 'red rot' will indicate the use of condensed plant polyphenols. Until now very few artefacts seem to be affected by 'red rot', but one of them, a rucksack, museum number SVD 1171 (Fig. 4.15), shows possible signs of this feature.

In the artefacts study the colour profile of the artefacts, where recorded, and the main tendencies are seen in table 4.1. The colour charts used to indicate the colour profile of the artefacts are Munsell® soil colour charts.

The colour profile chart (Fig. 4.14) demonstrates, based on the colour profile registered for the examined artefacts, that Evenk culture skin processing for the three types of skin investigated is similar rather than different. The colour profile mainly falls into two colour series; the 2,5Y series and the 10YR series. In the Evenk culture, in the areas where interviews have been made, the chosen methods are used more or less on all skin types. This is supported by the interviews. The colour profile chart also demonstrates that Sámi culture skin processing shows a larger variation in colour profile for the three types of skin, which indicates a less uniform skin processing technology.

Tannin penetration, judged by the observable colouring of the dermis' cross-section, can not be determined for all material types from the Evenk culture historic artefacts. Nor is the tannin penetration easy to ascertain, as the colour difference between skin's colour observed on the flesh side of a scraped skin and tanned skin colour is small. In cases where the colour difference in the cross-section can be differentiated, the penetration does not seem to exceed ½-way through the dermis' cross-sections. The visual examination of the skin cross-sections from the Evenk culture shows that artefacts display similar colour profiles for all three skin types, which again indicates that the same or similar methods are used for all skin types.

Visual examination of the skin cross-sections from the Sámi culture artefacts proposes a different situation. For leg skin (LS) and depilated skin (DS) the colour difference between skin colour (dried and scraped) and tanning agents is greater, and tannin penetration is more easily observed. For depilated skin the tannin penetration lies between ½ and 1/1 of the dermis' cross-section. For leg skin, only the surface, up to 1/3 of the dermis' cross-section, seems to be coloured by the tanning agent (Fig. 4.16).

In addition to the colour from the tanning agent, surface colouring as part of decorating an artefact is observed, particularly in the Evenk culture artefacts (Fig. 3.51, 3.52).

Obtaining a raw streak in certain skin materials, such as leg skin, has a purpose of keeping moisture

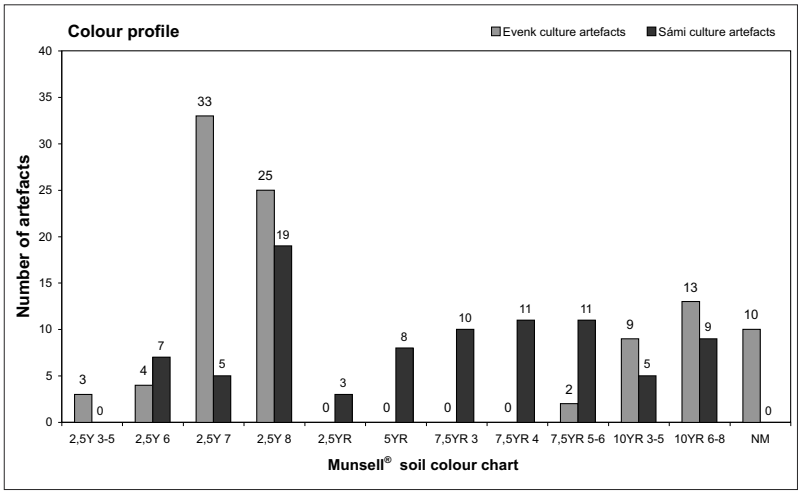


Fig. 4.14. Colour profile chart for the historic artefacts encompassed in the study. NM = not measured.

Fig. 4.15. Possible red rot observed on a depilated skin artefact (Sámi culture), thereby indicating the use of a condensed plant polyphenol in the tanning process. Museum number SVD-1171. Samiid Vuorká-Dávvirat. Karasjok, Norway. November 2006.

Fig. 4.16. Surface tanned/coloured leg skin (LS) of reindeer, reference sample LS-N13-01. Notice the low penetration of the vegetable tannin (willow bark extract). The thickness of the skin is 0.9-1.0 mm.

away from the body as well as making the skin stronger. The importance of a humidity barrier in the skin has decreased today as alternative modern materials are used to keep the body dry (Kemi Eira, 2006, pers. comm.). The decreasing importance of a raw streak is also confirmed in interviews, where it is stated that the use of washing machines for tanning purposes, usually obtaining a higher tannin penetration of the skin, has increased also for leg skin (Kemi Eira, 2006, pers. comm.). The importance of keeping a raw streak in some Sámi culture artefact types is acknowledged, as it improves the waterproofing qualities of skin material required for specific purposes. Rejecting or losing this feature in depilated skin material, limits the areas in which these skins can be used (Hætta, 1993:36). Visually comparing cross-sections of leg skin show that there is a raw streak in the skin material.

Cracking of epidermis or parting of hairs is a characteristic feature which is found when studying the condition of skin (SWH) artefacts. It can be discussed if this feature should be characterised as deterioration, or as a result of the processing method, or both. Cracking in general, and not only of the epidermis, can be an active part in the processing of skin. It can also be the result of an incomplete tanning process as well as a result of wear and tear in the artefact. Depending on how advanced the feature is, it can develop further over time, and in its worst consequence small "islands" of hair and epidermis may fall off (Fig. 4.17, 4.18).

In some arctic cultures, the cracking of the epidermis is part of the mechanical action to obtain a soft and pliable skin (Klokkernes, 1994:45; Otak, 2005:76; Klokkernes & Sharma, 2005:94). This feature is not mentioned as a deliberate technique in skin processing in the Evenk or the Sámi culture. On the contrary, in whole skins with hairs attached (SWH), the success of the method of using the tanning agents or lubricants, whether plant polyphenols, fats or combinations of the two, is measured in the lack of or low degree of visible cracking of the epidermis (Nilsen Eira, 2005, pers. comm.).

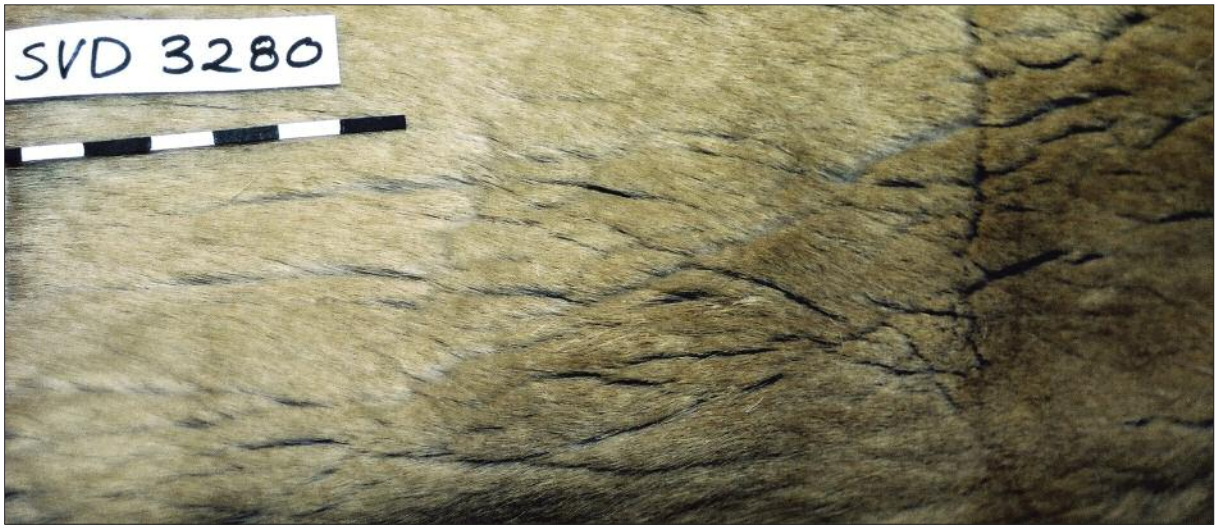


Fig. 4.17. Cracking of the epidermis, visible as the skin is handled. Museum number SVD-3280. Samiid Vuorká-Dávvirat. Karasjok, Norway. December 2004.

Fig. 4.18. Cracking of the epidermis seen in its worst consequence, as "islands" threatening to loosen from the artefact. This illustration is not from this study. Museum of Cultural History, University of Oslo, Norway. 1993.

Cracking of the epidermis and the dermis is also visible on the flesh side of the artefact. Here it resembles lines crossing each other in a root pattern. (Fig. 4.19, 4.20) It appears that the cracking of the epidermis and the root pattern visible on the flesh side follow each other closely. If there is no root pattern present, then there is no or very little cracking of the epidermis. These 'fracture marks' in the dermis leave the skin more susceptible to physical damage, and the continuous movement at these locations may weaken the artefact. Cracking of the epidermis and the root pattern is not observed in leg skin material. The epidermal/dermal association has the appearance of being more robust in these skins even though the tanning substance here, as with other skins, does not penetrate the whole dermis. Only in the upper part of the leg skin, close to belly skin, is this feature present.

The root pattern is also visible in depilated skin, and the pattern is seen more often in thinner skins than in thicker skins. However, the pattern is often more prevalent in areas of the artefact where the skin has been bent, worn or extensively used.

Fig. 4.19. The root pattern is seen as crossing lines on the flesh side of the skin artefact. Museum number SVD-2109. Samiid Vuorká-Dávvirat. Karasjok, Norway. December 2004.

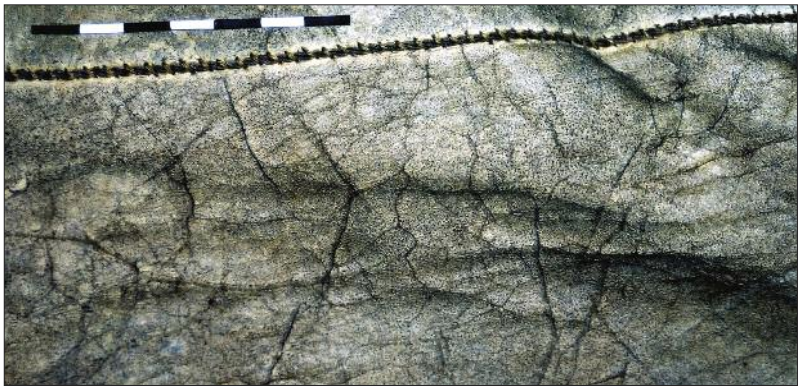


Fig. 4.20. Detail of crossing lines, resembling a root pattern on the flesh side of the skin artefact. Museum number SVD-1644. Samiid Vuorká-Dávvirat. Karasjok, Norway. December 2004.

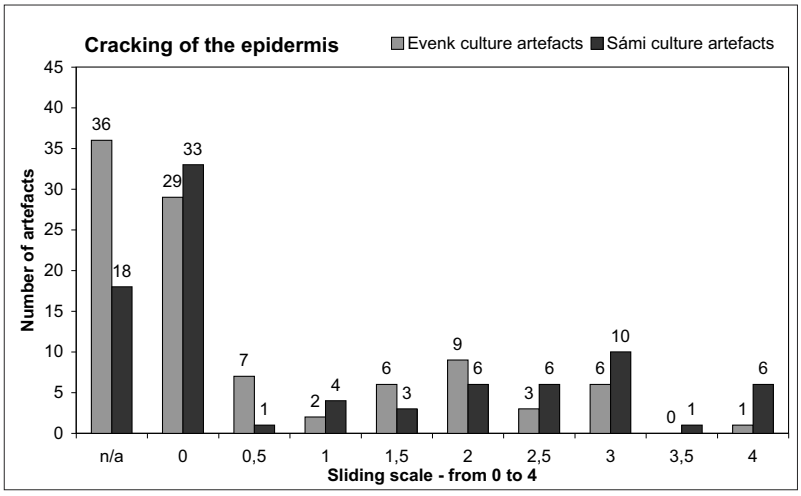


Fig. 4.21. Cracking of the epidermis visible in the 187 Evenk and Sámi culture artefacts included in the study. 0 means that no cracking can be observed and 4 indicate a high level of epidermal cracking. n/a = not applicable, for example in depilated skin.

In figure 4.21 the overall distribution of observed cracking in the Sámi culture and Evenk culture artefact material is presented. The feature is present in both Evenk and Sámi culture artefacts, but there is slightly more in the Evenk culture artefact group. The feature can, however, not be evaluated as a separate feature as it originates from technological aspects as well as from the extent of wear and tear in the artefact, and, furthermore, it may have developed over time.

Visible hair follicles on the flesh side of the skin are another feature which indicates how the mechanical action has been executed. This characteristic is not observed in the artefacts encompassed in the study. However, it is reasonable to assume that skin processing methods, which solely depend on mechanical processing, are more likely to exhibit this feature. This was clearly observed in the Netsilik culture artefact material studied in 1992-94, where the bottom of the hair follicles was visible on the flesh side of the skin, and especially on whole skin with hairs attached (SWH) (Klokkernes; 1994:45).

Fig. 4.22. The scraping quality of the flesh side of a tanned depilated skin from the Sámi culture defined as smooth and furthermore defined as even in colouring.

Fig. 4.23. The scraping quality of the flesh side of a whole skin with hairs attached (SWH) from the Sámi culture, defined as rough.

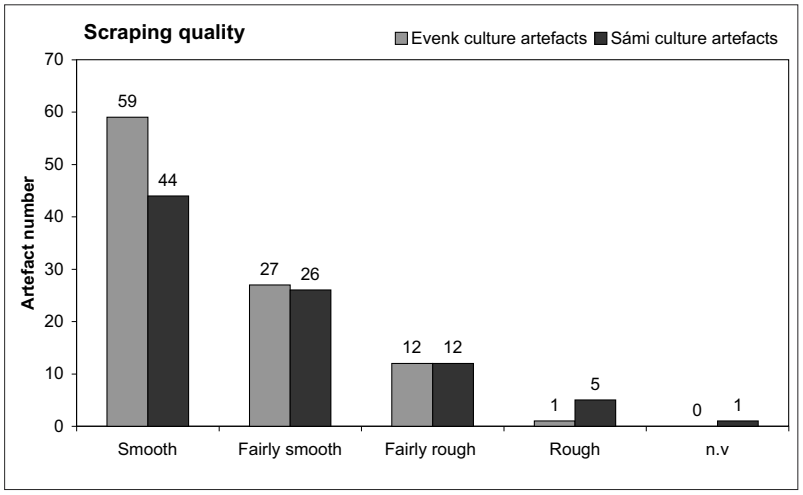


Fig. 4.24. The scraping quality of the skins surface, flesh side. N.v = not visible.

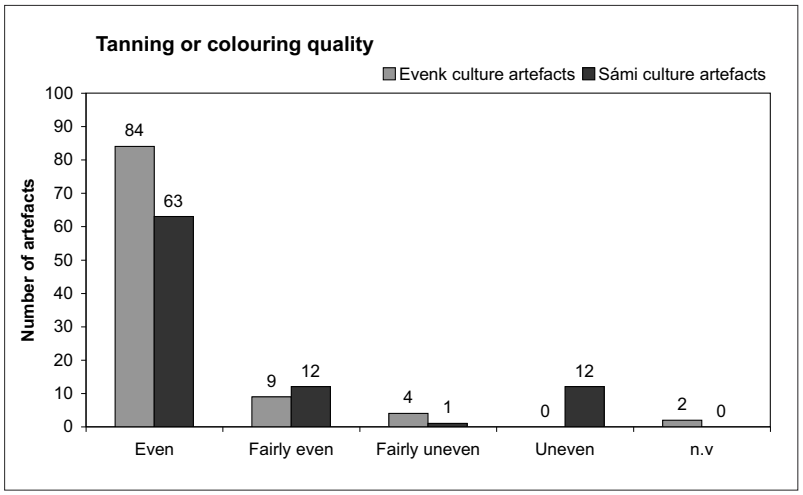


Fig. 4.25. The tanning or rather colouring quality of the skins surface, flesh side. N.v = not visible.

The scraping quality is a measure of the smoothness of the flesh side surface of the artefacts. This feature, along with the characteristic of tanning or rather colouring quality, indicates the experience and skill of the manufacturer and the time spent on the skin. It furthermore indicates the obtained quality of the skin from the pre-processing stages, as the end-result will never be satisfactory if the quality of the skins is not good from the start. The quality of the tanning material, such as bark or wood, will also influence the final result, particularly the colouring aspects. Figure 4.22 and 4.23 show the outermost ranges in scraping quality; smooth and rough.

As fig. 4.24 and 4.25 show, the quality of the skin concerning both scraping quality and tanning or colouring quality are generally good. This would indicate a high level of knowledge and skill in performing skin processing both in the Evenk and Sámi culture.

Smell is a sensory feature commonly used to characterise oxidation in fatty substances (Frankel, 2005:99). It was therefore suggested that this feature could be explored in this study. However, as the history of the artefacts concerning the use of pesticides is not fully known, this feature was not included in the study after all.

4.3 Indicators from the use of the artefact

Included in the study are indicators referring to the period when the artefacts were in use or stored in between use. This includes soiling, such as dirt, fat, and dust. It includes physical damage, such as wear and tear, insect- and rodent-damage, hair loss, grain damage, and tears. Furthermore, elements from the maintenance of the artefacts were observed, such as patches and stitching. In addition it includes features from the museum period of the artefacts' history, such as soiling, fading and physical damage.

Examination of wear and tear on the artefact indicates that approximately 50 % of the artefacts are worn from a slight to medium degree (Fig. 4.26). Separating wear and tear from other damage scenarios may be difficult; for example, material creasing and insect damage may visually overpower the features of general wear and tear resulting from the use of the garment (Fig. 4.28, 4.29, 4.30, and 4.31). This also includes the observation soiling of the artefact. The differences between soiling accumulated on the artefacts during museum storage or during use are not easily separated. The observed soiling of the artefact shows that as for wear and tear, approximately 50 % of the artefacts are soiled from a slight to medium level (Fig. 4.27 and 4.32). There are in the Evenk culture artefact material a few artefacts with an overall and even grey to black

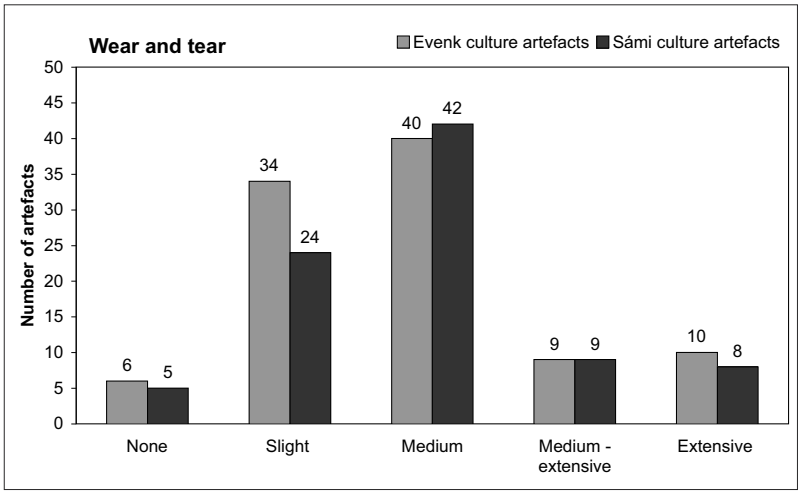


Fig. 4.26. General wear and tear in Evenk and Sámi culture artefacts included in the study.

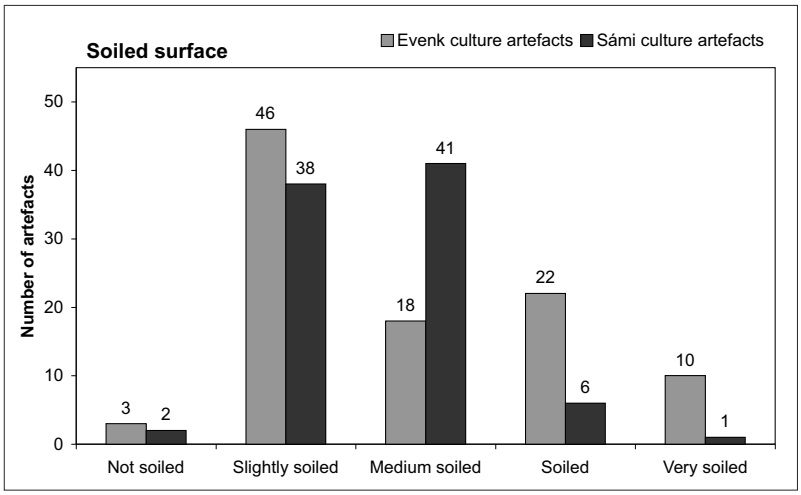


Fig. 4.27. Soiling of the artefacts' surfaces in Evenk and Sámi culture artefacts included in the study.

colouring of the flesh side. These artefacts seem to have been intentionally coloured (Fig. 3.52) as the colour of the surface is of a different character than soiled surfaces.

General wear and tear from when the artefacts were in use contributes to the continuous deterioration of the artefact. Worn surfaces, for example as in the bag SVD 1171 (Fig. 4.33), flaking of the full grain surface continues unless it is handled and kept under controlled climatic conditions.

Insect damage and mould formation were expected to be two of the visually most important characteristics of the damage of the artefacts. However, only a relatively small part of the collections in the study area show clear signs of insect damage or mould formation (Fig 4.34, 4.35). The presence of damage from insect infestations is, how-

Fig. 4.28. Sámi culture coat (inside out) exhibiting medium to extensive wear and tear, especially in the shoulder area. Museum number: SVD-1553. Samiid Vuorká-Dávvirat. Karasjok, Norway. December 2004.

Fig. 4.29. Evenk culture coat exhibiting extensive wear and tear, soiling and insect damage. Museum number: IMRS-0544. Irkutsk Museum of Regional Studies. Irkutsk, Russia. March 2005.

ever, greater in the Evenk culture artefact collection than in the Sámi culture artefact collection, and the damage seems to follow geographic areas and not collections. This means that in geographic areas where moth and other fur attracted insects generally thrive, the rate of damage is higher than in areas where these insect are not generally found. This can to a certain degree be seen in the southern part of the study area where insect infestations are plentiful, and logically, but not entirely, less frequent in the northern study areas. It is also dependent upon the regular use of pesticides in the institutions where the collections are kept and on how long the artefact has been in a museum institution. Extensive insect infestations are detrimental to the artefacts' presentation and in the worst cases to future preservation as can be observed in figure 4.36 and 4.38.

Mould seems to be a minor problem in the collections studied. In Samiid Vuorká-Dávvirat, in Karasjok, most of the fur skin coats are stored inside out, as the tradition is for storing skin coats in the Sámi culture. This prevents the trapping of moist air between the flesh sides of the coat and inhibits extensive mould formation (Fig. 4.39). However, turning all coats inside out is a major physical strain on the artefact material and is not recommended for museum artefacts.

Fig. 4.30. Sámi culture trousers exhibiting medium to extensive wear and tear from use. Museum number: TM-1153. Museum, Tromsø, Norway. October 2004.

Fig. 4.31. Sámi culture bag, made from depilated tanned skin, exhibiting medium to extensive wear and tear from use. Museum Number: SVD-1171. Samiid Vuorká-Dávvirat. Karasjok, Norway. December 2004.

Fig. 4.32. Top: Sámi culture coat showing very little soiling. Museum number: SVD-0461. Middle: Sámi culture coat showing medium soiling. Museum number: SVD-1549. Lower: Sámi culture coat very soiled. Museum number: SVD-2333. All coats turned inside out for storage. From: Samiid Vuorká-Dávvirat. Karasjok, Norway. November/December 2004.

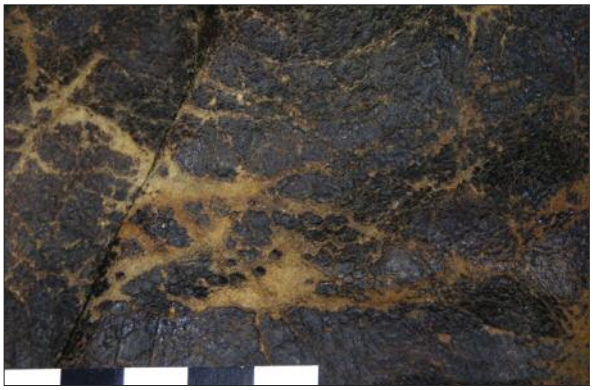


Fig 4.33. Flaking of the full grain surface. Bag, SVD-1171. Samiid Vuorká-Dávvirat. Karasjok, Norway. November 2004.

Fig. 4.36. Above: Breast piece from the Evenk culture which has lost all the hairs through insect infestations. Below: detail from the same chestpiece. Museum number REM-6749-5. The Russian Museum of Ethnography, St. Petersburg, Russia, 2005.

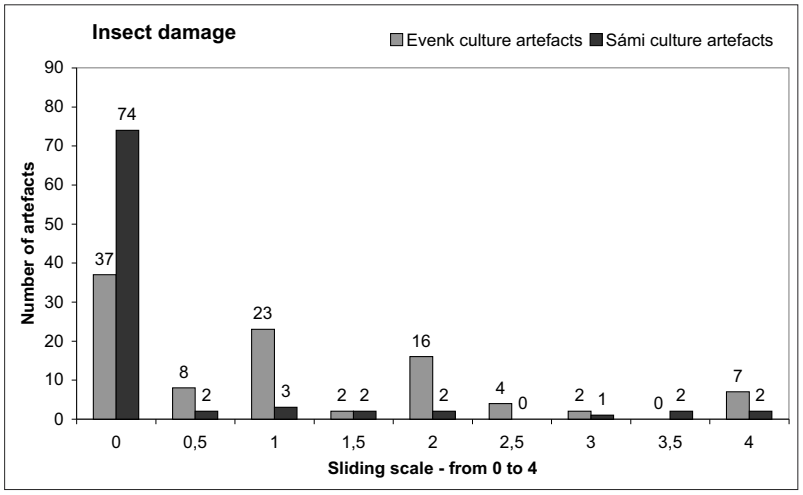


Fig. 4.34. Distribution of insect damage observed in the 187 artefacts included in the study.

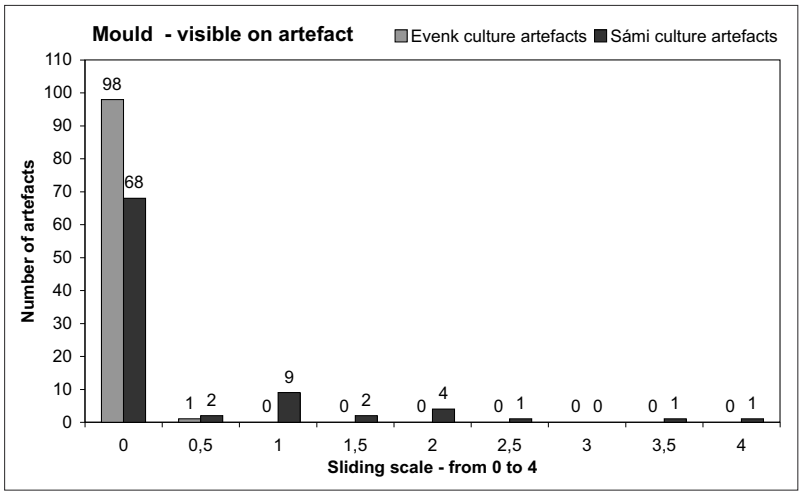


Fig. 4.35. Distribution of mould observed in the artefacts included in the study.

Fig. 4.37. Chestpiece from the Evenk culture composed mainly of strips of leg skin. Probably how REM 6749-5 (above) may have looked previous to the insect infestations. Museum number: VK-4934:183. Museum of Cultures, Helsinki, Finland. November 2004.

Fig. 4.38. Upper shoulder and sleeve of Evenk culture coat, extensively damaged by insect infestation. Museum number IMRS-0544. Irkutsk Museum of Regional Studies. Irkutsk, Russia. March 2005.

Fig. 4.39. Sámi culture coats, turned inside out and stored in cool storage. Sámiid Vuorká-Dávvirat, Karasjok, Norway.

4.4 Summary

The visual assessment in this study comprises information gathered and grouped in three categories: indicators characterising the pre-processing stages prior to processing; identification of material and skin processing; indicators characterising the user period which includes the museum period of the artefacts. In an overall examination of museum artefacts, it is obvious that the damage profile indicates an ongoing interaction between different characteristic features in addition to the mutual interaction of deteriorating features. This means that indicative characteristics of all categories can not be viewed separately but must be interpreted in relation to each other.

Characteristics and damages present in the skin from the production stages and damages or features developing as the artefact is in use may advance over time and manifest themselves further as the artefact is worn, stored, exhibited and handled in a museum environment. It is possible from a visual examination, to indicate which characteristics in the processing stages and in the following stages of use including museum handling that have an effect on the artefacts condition. It is, however, in this process difficult to free oneself from the visually disturbing images of artefacts with extensive physical damage from, for example, insect infestations or of artefacts which are heavily influenced by wear and tear. It is natural from such images of an artefact to conclude that the artefact may be in a fairly poor condition, without knowing if the material itself as well, is in a fairly poor condition. An outline of the visual identification indicators and the indicators applied in assessing the condition of the artefacts have been summarised in table 4.2.

The visual characteristics are summarised in the group: "General condition". The distribution is displayed in figures 4.40, 4.41, and 4.42. Considering all 187 artefacts; 29 % of the artefacts lie within the category *very good* (0-0.5), 37 % within the category *good* (1-1.5) and 21 % within the category *fair* (2-2.5). 13 % of the artefacts lie within the category poor (3-4).

This picture is different when considering the two cultural groups of artefacts separately. For the Evenk culture artefacts 31 % lie within the category *very good*, whereas 25 % of the Sámi culture artefacts are included in this category. For the category *good*, 43 % of the Evenk culture artefacts and 27 % of the Sámi culture artefacts occupy this category. This shows that 76 % of the Evenk culture artefacts lie within the categories *very good* to *good*, and only 52 % of the Sámi culture artefacts do so.

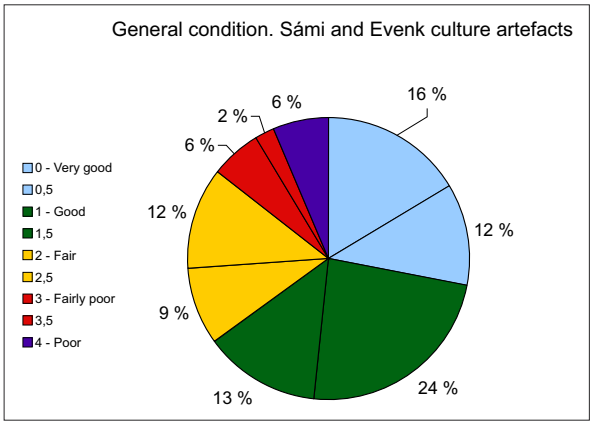


Fig 4.40. General condition of the 187 artefacts included in the artefact study.

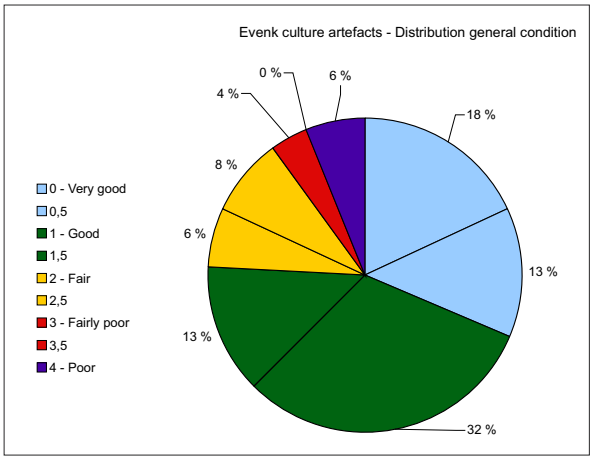


Fig. 4.41. General condition of the 99 Evenk culture artefacts included in the artefact study.

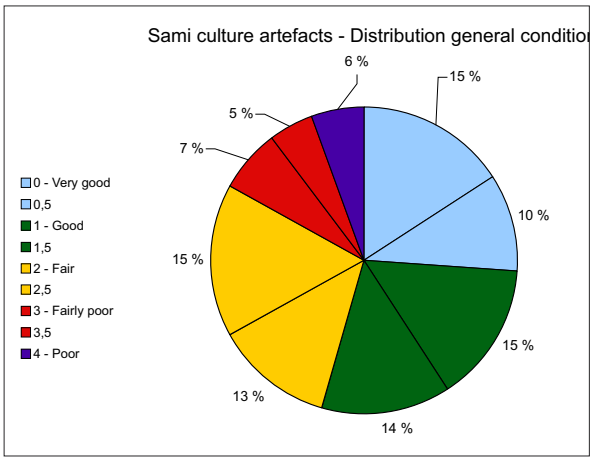


Fig. 4.42. General condition of the 88 Sámi culture artefacts included in the artefact study.

The difference in general condition continues for the categories *fair* to *poor* as 24 % of the Evenk culture artefacts are included in these categories, while they

Choice of skins	Sámi culture DS artefacts have access to follicle pattern and follicle size. It is thereby possible to determine type and approximate age of the animal. Hair follicles are not present in Evenk culture depilated skin material. In both Evenk and Sámi culture skin artefacts, the presence of recovered larvae holes indicates if it is a calf skin (under one year) or a skin from a mature animal.
Depilation	Main difference in Evenk and Sámi skin processing technology and important for identification purposes. Various characteristic flaws (blister, loose grain, epidermis and hair remains) are connected to the process of depilation and have an effect on preservation.
Drying	Excessive drying assists in the formation of blisters and loose grain layer. This is however only part of the cause for grain flaws, which also rest on problems in the depilation process. This has an impact on the interpretation of Sámi culture artefacts and less on Evenk culture artefacts.
Cracking of the epidermis/root pattern	Important feature in identifying skin processing, but the information must be used with care as use, wear and tear, and incorrect environmental conditions may enhance the feature. May elucidate on the quality of the skin processing technology. The features are the same in both the Sámi and the Evenk culture artefacts.
Colour, tannin penetration, and raw streak	Mainly important in the discussion of the reason for using plant polyphenols (tanning and/or colouring) and furthermore important in relation to what the skins are to be used for. Can suggest the use of a plant polyphenol, only specifying condensed (CT) and hydrolysable (HT) plant polyphenols if deterioration features such as "red rot" is present (in CT). The observation of a raw streak in the skin may indicate that strength and waterproofing qualities are desired.
Tool marks	Suggesting the use of tools and mechanical action. Both cultures.
Tanning and scraping quality	No major difference in Sámi or Evenk culture artefact material. It is primarily a sign of the tanning degree, the skill and the level of experience of the manufacturer, and it gives an idea of the time spent on the skin processing method. Remains of subcutaneous layer on the flesh side affect the quality of the skin both visually and functionally.
Wear and tear, soiling, and physical damage	The features are the same in both the Sámi and the Evenk culture artefacts.
Mould and insect/rodent	Highly visible sign of incorrect or problematic storage/exhibition/handling, both before and after acquisition. Insect infestations may appear as serious damage, but are primarily an aesthetic damage, unless of course extremely developed.

Table 4.2. The main features in visually identifying skin processing and assessing artefact condition.

contain 46 % of the Sámi culture artefacts. From these numbers there is reason to indicate that the Evenk culture artefacts are generally in a better condition than the Sámi culture artefacts.

There are, however, still many considerations which may be investigated and which may nuance these indications. These will be further investigated in the forthcoming analyses.

5 THE NATURE OF AND THE IDENTIFICATION OF TANNING SUBSTANCES IN COLLAGEN MATERIALS

Skin material processed in indigenous cultures is normally referred to as being semi-tanned. This is based on the fact that most tanning processes are not as efficiently applied as in an industrial tanning process (chapter 3). This chapter describes the compositional characteristics of tanning materials, such as plant polyphenols (vegetable tannins), fats, and lubricants and the various tanning agents' ability to interact with skin protein to produce a durable functional material for clothing purposes. The main part of this chapter focuses on the results from the laboratory analysis applied in the characterisation and identification of substances, such as plant polyphenols and fats, and the description of other substances added during skin processing in indigenous cultures. Identification is here an issue, but as this type of analysis has not earlier been performed on skin artefact material from indigenous cultures, the characterisation of these substances are an equally important issue.

The results are discussed in relation to the samples from historic artefacts and the three skin material types: depilated skin (DS); whole skin with hairs attached (SWH); and leg skin with hairs attached (LS). The comparative aspects of skin processing and the use of tanning substances are discussed, correlated to these skin material types and to the reference samples from the Sámi and the Evenk cultures.

5.1 The nature of and the identification of plant polyphenols

Tannins are one of many extracts from plant material. They are extracted from the bark, heart wood and sap wood of these plants. Generally, the tannin content is higher in bark than in heart wood and sap wood (Harborne, 1989:554). Tannins may also be extracted from leaves, fruits, galls and roots of plants, and their specific use is based on their properties as tannins. A short and much used definition of vegetable tannins is quoted from Haslam: "Vegetable tannins are polyphenols with a molecular weight in the range of 500-3000" (Haslam, 1966:2), which is also suggested as the range in which their effect as tannins is based. Lower molecular mass compounds, are defined as non-tans and higher molecular mass compounds which are not soluble, are for example gums (Covington, 2006:23). Various other authors have defined vegetable tannins, and a more specific definition is as follows: "Tannins are polyphenolic secondary metabolites of higher plants, and are either galloyl esters and their derivatives, in which galloyl moieties or their derivatives are attached to a variety of polyol-, catechin- and triterpenoid cores (gallotannins, ellagitannins and complex tannins), or they are oligomeric and polymeric proanthocyanidins that can possess different interflavanyl coupling and substitution patterns (condensed tannins)" (Khanbabaee & Ree, 2001:641).

Plant polyphenols may from this definition be divided into three main groups; 1) Condensed tannins (CT) (proanthocyanidins), 2) polyester based on gallic, and 3) hexahydroxydiphenic acid and their derivatives (both so-called hydrolysable tannins – HT) (Haslam, 1989:10); though some condensed tannins may also contain gallic acid substituents (Lewis and Yamamoto, 1989:24) esterified to the 3-OH of ring C (Fig. 5.2) (Schofield *et al.,* 2001:35). A fourth group of tannins is also described, namely complex tannins. As the name indicates this group of phenolic metabolites contains features that are related to both condensed and hydrolysable tannins (Fig. 5.1), as can be seen in barks of *Quercus* species (Haslam & Cai, 1994:58-59; Sakai, 2001:260).

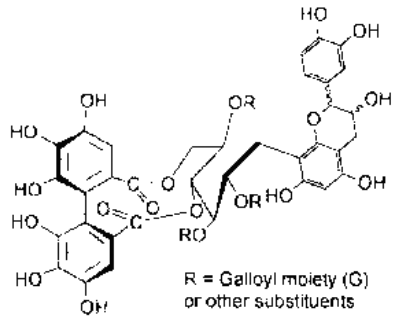


Fig. 5.1 Example of complex tannin. Two gallic acid units and a catechin unit are linked to the glucose core (from Khanbabaee & Ree, 2001:643).

5.1.1 Condensed tannins - CT (polymeric proanthocyanidins - catechol tannins)

"Proanthocyanidins are colourless flavanoids and when treated with mineral acids they form anthocyanidins" (Freudenberg & Weinges, 1960:336). The red-blue colour of leaves, fruits and flowers is caused by anthocyanidins. Proanthocyanidins are oligomers and polymers of 2 to 50 (or more) flavanoid (Fig. 5.2) units that are joined by carbon-carbon bonds, and are not susceptible to being cleaved by hydrolysis.

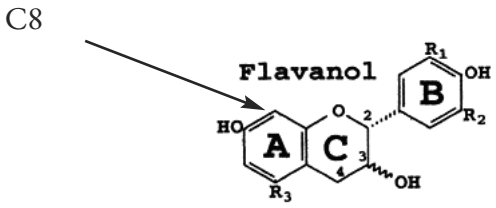


Fig. 5.2. The flavanoid unit (Hernes & Hedges, 2004:1294).

The A ring usually contains phenolic hydroxy groups, and the presence of the C ring makes both rings reactive to forming carbon-carbon bonds, to create flavanoid polymers; the B ring does not exhibit the same reactivity as it often contains the dihydroxyphenyl moiety; therefore the alternative name for this group of compounds is the catechol tannins (Covington, 2006:25). The polymer may be inter-molecularly linked by the C4 → C8 or the C4 → C6 to oligomers and high molecule weight polymers (Behrens *et al.,* 2003:1160). The C4 → C8 link is more common, but C4 → C6 also commonly occurs, leading to branching of the polymer (Hernes & Hedges, 2004:1293). There are approximately a dozen known variants of condensed tannins, and the nature of the extender and terminal units illustrated below are examples of the variety (Fig. 5.3). There are two types of condensed tannins on the basis of A-ring oxidation. Type 1 is those containing flavanoid units with a phloroglucinol (Fig. 5.4) pattern A-ring: the propelargonidins, the procyanidins and the prodelphinidins in their extender unit and are distributed in all woody plants; while type 2 is those containing flavanoid units with a resorcinol (Fig. 5.5) pattern A-ring: the proguibourtinidins, profisetinidins, and prorobinetinidins which are confined to certain families such as the Leguminosae and Anacardiaceae but often co-existing with type 1 in the same or in different organs in the plant. Wattle (*Acacia mearnsii*) and quebracho (*Schinopsis sp.*) wood belongs to type 2 (Porter, 1989:652).

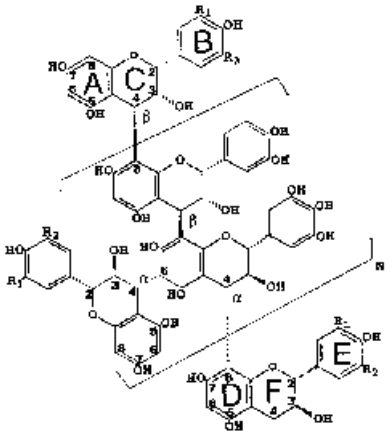


Fig. 5.3. Example of structure of condensed tannin, with extender unit "ACB" and terminal unit "DFE".
Extender unit "ACB": Epicatechin: R_1 = OH, R_2 = H. Epigallocatechin: $R_1 = R_2$ = OH.
Epiafzelechin: $R_1 = R_2$ = H.
Terminal unit "DFE": Catechin: R_1 = OH, R_2 = H. Gallocatechin: $R_1 = R_2$ = OH. Afzelechin: $R_1 = R_2$ = H (Hernes & Hedges, 2004:1294).

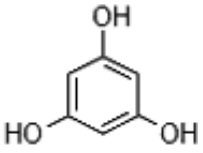


Fig. 5.4. Phloroglucinol, as in type 1 condensed tannins.

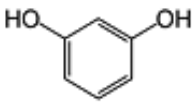


Fig. 5.5. Resorcinol, as in type 2 condensed tannins.

5.1.1.1 Structural diversity of condensed tannins

Structural diversity in oligomeric proanthocyanidins is a result of a rearrangement of the compounds. It is, for example, based on variations in the hydroxylation pattern of the extender unit as well as the structure of the terminal unit. It is furthermore based on the stereochemistry of the three chiral centres of the heterocyclic ring as well as the location and type of interflavanoid bond (Hemingway, 1989:83).

The polymerised flavan-3-ol units, which are formed in the proanthocyanidin biosyntheses of 3,4-

diols (4-ols are also found), may occur in four isomeric structures, however only two structures are generally found in nature. These are 2,3-*trans* (2**R**, 3**S**) and 2,3-*cis* (2**R**, 3**R**)-isomers (Strack, 1997:412). Profisetinidin is an example of an important polyflavanoid, forming the major constituents of wattle (*Acacia mearnsii*) and quebracho (*Schinopsis sp*) tannins, and is terminated with corresponding flavan-3,4-diols. Differences between profisetinidin in heartwood extracted tannin of quebracho and of black wattle are an illustration of the similarity but still the difference between these two tanning compounds. Quebracho is presented as a 2**S** profisetinidin and black wattle as a 2**R** profisetinidin (Fig. 5.6 and 5.7 respectively) (Hemingway, 1989:83).

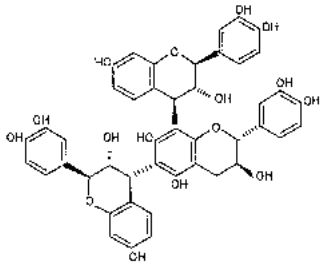


Fig. 5.6. 2**S** profisetinidin (Hemingway, 1989:89).

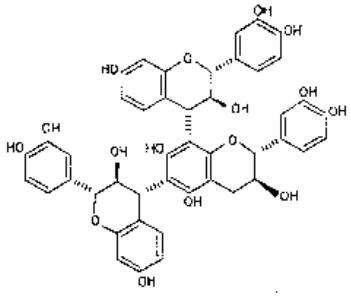


Fig. 5.7. 2**R** profisetinidin (Hemingway, 1989:89).

5.1.2 Hydrolysable tannins

Hydrolysable tannins are galloyl and hexahydroxydiphenoyl esters and their derivatives. They are secondary metabolites found as multiple esters with most often a D-glucose core. They are further divided into gallotannins and ellagitannins, where gallotannins (Fig. 5.8) are based on glucose esterification with gallic acid, and in ellagitannins (Fig. 5.9) glucose is esterified with gallic acid, ellagic acid and chebulic acid. Ellagitannins differ from gallotannins in that at least two gallic acid units surrounding the core are linked through carbon-carbon bonds.

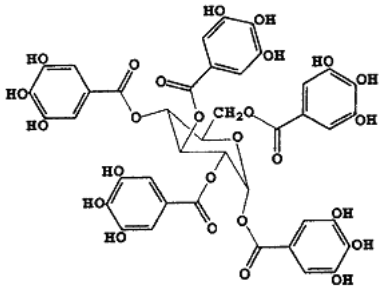


Fig. 5.8 Example of hydrolysable tannin – Gallotannin (Hernes & Hedges, 2004:1294).

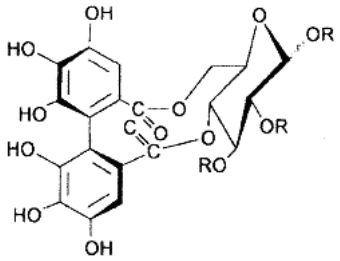


Fig. 5.9 Example of hydrolysable tannin – Ellagitannin (Khanbabaee & Ree, 2001:643).

Hydrolysable tannins are also called pyrogallol tannins caused by the presence of the trihydroxyphenyl moiety, allowing complexation with metal ions which yields a semi-metal tannage of skin (Covington, 2006:23-24). Hydrolysable tannins are readily hydrolysed by acids to yield gallic acid (Fig. 5.10) and ellagic acid (Fig. 5.11) (Sakai, 2001: 256).

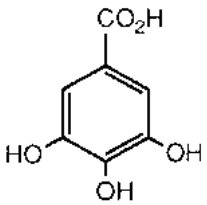


Fig. 5.10 Chemical structure of gallic acid (Wikipedia, 2006).

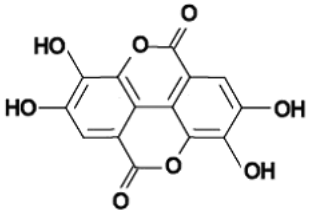


Fig. 5.11 Chemical structure of ellagic acid (Wikipedia, 2006).

5.1.2.1 Structural diversity of hydrolysable tannins

As for condensed tannins, hydrolysable tannins also achieve their structural diversity as a result of rearranging the compounds. Haslam (1989:120-153) describes the diversity of structures of hydrolysable tannins, and the metabolism of the central galloyl ester β-penta-*O*-galloyl-D-glucose. He writes: "This intermediate appears to mark a biosynthetic watershed for many plants and from it other synthetic pathways subsequently diverge to give the gallotannins and various ellagitannins" (Haslam, 1989:121). Intermediate here means: β-penta-*O*-galloyl-D-glucose. The three main metabolic patterns: 2A, 2B, and 2C are illustrated in figure 5.12.

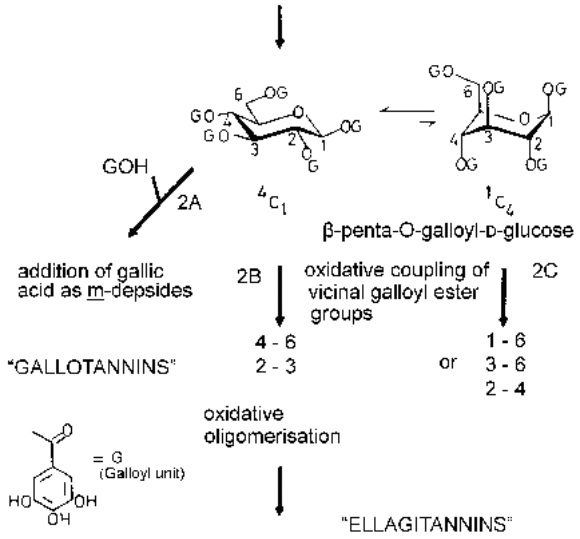


Fig. 5.12 Patterns of metabolism of β-penta-*O*-galloyl-D-glucose (Haslam, 1989:122).

The pattern group that leads to gallotannins (2A) encompasses a range of compounds from β-penta-*O*-galloyl-D-glucose to possibly deca - and undeca-galloyl-D-glucose, and the distribution of each type regulates the composition of the gallotannin (Haslam, 1989:126). The pattern groups that lead to ellagitannins (2B and 2C) are formed by C - C coupling of at least two galloyl units (Khanbabaee & Ree, 2001:643).

5.1.3 Plant polyphenol ↔ protein complexation

In characterising polyphenols most descriptions mention the fact that they have the ability to precipitate protein and that they are more or less astringent. Polyphenol astringency, or rather the polyphenol's binding capability to protein, such as collagen, is a basic feature in the conversion of raw hide into leather. How the polyphenol binds to collagen is, however, not fully understood, but there are theories as to how it occurs. The most noted explanations are that the multidentate polyphenols have the ability to simultaneously bind to more than one point on the protein's surface and thereby to cross-link protein chains (McManus *et al.,* 1981:311; Haslam, 1989:11, 170). That is, one tannin molecule binds more than two protein molecules simultaneously. These protein ligands have a large number of binding sites made available by numerous phenolic groups and aryl rings located on the periphery of the molecule (Spencer *et al*., 1988:2400, 2408-2409). An alternative explanation, although maybe not so different, describes the precipitation of protein by tannins as a process with two stages. The first stage is an initial complexation of polyphenolic molecules to a protein molecule through hydrophobic interaction and a subsequent strengthening through hydrogen bonding. This is followed by a second stage in which an aggregation of these complexes occurs (Umezawa, 2001:235). Tang *et al.,* (2003:411) has shown, in a recent study examining the interaction of hydrolysable tannins and collagen fibres, that hydrophobic interaction most likely is more important than hydrogen bonding in the collagen ↔ plant polyphenol interaction.

How well a polyphenol is able to complex skin protein (tan skin protein) depends on several factors. One factor is the polymerisation degree (DP) which indicates how large the polyphenol molecule is. Other factors are conformational flexibility, solubility, and the astringency of the polyphenol. The pH and the temperature of the solution/extract also play an important role during the tanning process (Kawamoto & Nakatsubo, 1997:479; Luck *et al.,* 1994:361; Spencer *et al.,* 1988:2400; Umezawa, 2001:235; Buren, van & Robinson, 1969:772). An increase in DP suggests an increase in the plant polyphenol's binding capacity to skin protein as long as there is a conformational flexibility in the molecule. A less flexible molecule and a too high DP will lead to molecules that are too large and less soluble and will therefore also have a lower binding capacity. This is explained with hydrolysable tannin as an example, using the galloyl-D-series mentioned above. The effectiveness of the protein-phenolic association is increased as galloyl ester groups are added (di→tri→tetra→penta) and reaches its maximum binding capacity at β-penta-*O*-galloyl-D-glucose. The conformational flexibility of the tannin plays a role in how well it complexes with collagen. A large and rigid structure with few free binding sites reduces the binding capacity (Spencer *et al.,* 1988:2400).

The astringency is, as mentioned above, related to the binding capacity of the polyphenol molecule. It also seems to be related to the molecular weight (MW) of the polyphenol, as high MW reflects higher astringency than low molecular weight polyphenols (Porter, 1984:1256). Ionic strength of the tannin solution may add stability to the tanning process. The binding capability of tannin is furthermore dependent on the isoelectric point of the protein. Each protein has a specific isoelectric point where the optimum binding capacity lies. An increase or decrease in the pH of the protein, away from the isoelectric point, decreases the binding capacity severely (Hagerman & Butler, 1978:811; Buren, van & Robinson, 1969:773; Spencer *et al.*, 1988:2399).

5.1.4 Aspects of the ageing/degradation of vegetable tannins

In the analysis of phenolic compounds, it is indicated that loss of tannin content and chemical alterations may take place prior to or in the preparation process of the phenolic extracts. High temperatures may cause the tannin to decompose or to combine with other plant components, thereby inhibiting subsequent tannin extraction (Julkunen-Tiitto, 1985:215). This is noted in condensed tannins extracted from leaf and needle litter.

Similarly the content of phenolic compounds in willow leaf litter decreases over time. The probable cause for this is leaching. Leaching tannins are supposedly absorbed by the ground, as tannins are not subsequently detected in the leachate (Schofield *et al.*, 1998:1418). These examples are included to elucidate some of the challenges in describing indigenous cultures vegetable tanning compounds and, specifically, to enquire into the tanning potential or the lack of tanning potential of brown rotted larch wood used in Evenk culture skin processing. If the above argument is accepted, it can be argued that the condensed tannins of brown rotted larch wood have leached from the log to the ground underneath, leaving the brown coloured lignin as the main component of the log. There are no available studies to confirm this; there is only one study of spruce wood and logs where the tannin content was not reported to decrease in the log during the first year of decay (Kelsey & Harmon, 1989:1033); it was not mentioned if the logs had developed brown rot. The oxidative degradation of the condensed tannins may also lead to an increase in molecular size, which may be another reason for the lack of tanning capacity of the brown rotted larch wood (Larsen, 2007, pers. comm.).

The nature of the bark material used in Sámi skin processing varies, dependent upon when it is collected, whether it has been taken from young or mature twigs, and whether it is used fresh or dried. This influences the tannin content of the material. The production of bark extract is also performed at high temperatures (boiling point), and may therefore result in the formation of tannin degradation products already at this stage.

The degradation of plant polyphenols mainly occurs through two pathways: degradation through hydrolysis or condensation (polymerisation) and oxidative degradation.

Characteristic of the condensed tannins is their ability to produce coloured solutions and precipitates, called phlobaphenes or "tannin reds", which is a reaction product of an acid condensation. This progressive polymerisation causes their interflavan bonds to break (Haslam, 1966:11-12; Santappa & Rao, 1982:705; Schofield *et al.,* 2001:30).

Due to the condensed tannin's capacity to undergo oxidative cross linking, they also have the disposition to change the colour of skin: that it becomes darker, when exposed to light (Rottsieper, 1946:7; Covington, 2006:26). The phenomenon of darkening upon exposure to light is not observed in skin tanned with hydrolysable tannins.

Hydrolysable tannins are readily hydrolysed when exposed to acids. Gallotannins yield the monomer gallic acid and ellagitannins yield ellagic acid and gallic acid. Ellagitannins furthermore have the ability to form sludge or bloom on leather surfaces. Glucose is a reaction product of hydrolysis for both tannin types (Santappa & Rao, 1982:705-706).

In chromatographic analysis (for example HPLC) of leather tanned with plant polyphenols it is seen that ageing or deterioration occurs through formation of monomers, such as gallic acid and ellagic acid in hydrolysable tannins. Although gallic acid and ellagic acid are also found in condensed tannins, the best known monomer is protocatechuic acid (PCA). There are however other monomers formed which bear spectral resemblance to components such as gallic acid and PCA, but so far these monomers are not identified. Analysis furthermore shows that the amount of extractable tannins decrease upon ageing (Larsen, 1995:119; Wouters & Clayes, 1996:89), which is also noted in the analysis of condensed tannins from decaying fresh leaf and needle material (Maie *et al.,* 2003:586).

5.2 Chromatographic analysis of plant polyphenols in reindeer skin samples

The historic sample materials, as well as the references, are heterogeneous, both in composition and with reference to age, deterioration and preservation history. The priorities are therefore to characterise vegetable tannin material used in the Sámi and the Evenk culture based on chromatographic analysis (high performance liquid chromatography, HPLC), as well as indicating vegetable tannin type. The samples are described in chapter 1, and consist of twelve reference samples from the Sámi and Evenk culture of which there is a reasonable knowledge of age and tanning method for the various samples. The samples furthermore consist of 48 historic samples (group 1 and 2) from coats, boots, trousers, and bags where the tanning method is unknown.

5.2.1 Experimental

Each skin sample is cut into small pieces which are then immersed into a glass vial holding a 50% acetone aqueous solution (ratio 100mg/10ml leather/water-acetone). The glass vial is closed with a silicon lined, aluminium crimp-top. The vial is placed on a magnetic stirrer at room temperature for 24 hours. After 24 hours the solution is filtered using Waters membrane Acrodisc GHP type, at 0.45 µm.

500 µl of this solution is placed in a clean glass vial for complete drying. The solution dries in a vacuum chamber in the presence of NaOH pellets and is then diluted in 1000 µl water-methanol (50/50 v/v) for chromatographic analysis.

The HPLC system is the Alliance model from Waters with UV detector diode array. The column is a Waters ACQ Tag reverse phase C18, length 150 mm, internal diameter 4.6 mm, particles size 4 µm, and is heated at 27 °C during the analysis. The solvents used are A: aqueous phosphate buffer and B: methanol 100 %. The elution conditions are: 10 % B for 3 minutes, increase from 10 % to 90 % B in 22 minutes, 90 % B for 3 minutes, decrease from 90 % to 10 % B in 2 minutes, and 10 % B for 6 minutes. The flow rate is 1 ml/minute.

The sample solution volume which is analysed is 100 µl and the UV detection is performed at 240 and 280 nm (Juchauld, 2007, pers. comm.).

5.2.2 General description of chromatographic pattern

The general chromatographic patterns of the twelve reference samples and 48 historical samples indicate that the tannins used are condensed tannins. Condensed tannins characteristically have a broader elution profile than hydrolysable tannins as illustrated in figure 5.13 and 5.14. The presence of protocatechuic acid, characteristic to condensed vegetable tannins is likewise an indication that condensed tannins have been used. The initial examination of the spectral characteristics of both reference samples with known tanning history and historic samples with unknown tanning history, however, indicates that there are skin samples where vegetable tannins are not present, or are only present to a very low degree. This applies especially to the Evenk culture skin samples, but also to the LS and SWH samples from the Sámi culture. In these modern and historic samples it should be discussed if the application of fats or lubricants plays a more important role in the tanning of the skin than the vegetable tannins.

The Sámi culture depilated skin (DS) reference samples, and similarly the Sámi culture historic DS sample material, stand out in the examination of the chromatographic patterns and exhibit clear peaks in the chromatogram which can be identified as belonging to plant polyphenols.

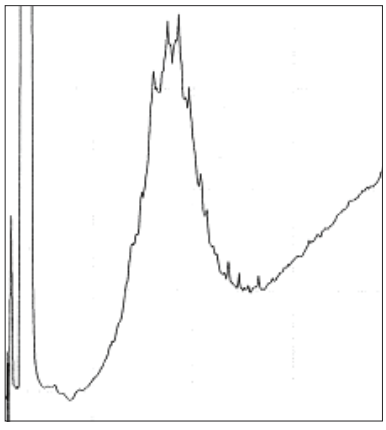


Fig. 5.13. Condensed tannins

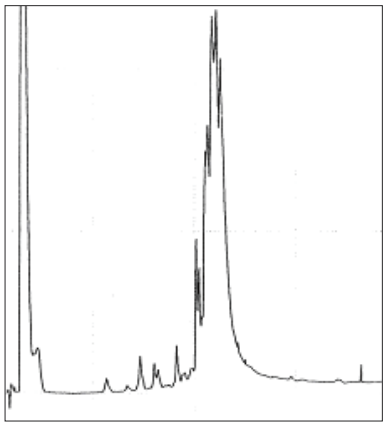


Fig. 5.14. Hydrolysable tannins

General chromatographic pattern of condensed and hydrolysable tannins. From Wouters, 1994/95:202.

5.2.2.1 Tannin, OD/4100 mg

Tannin, OD/100 mg indicates the amount of extracted tannin from a sample. It is measured in V/sec (Volt pr seconds) and is explained as follows: "The optical density at 280 nm which would be obtained if 100 mg of leather was extracted with 1 ml of water-acetone and this extract was measured with an optical path-length of 1 cm" (Wouters & Claeys, 1996:88). In the analysis of all samples, both reference and historic samples, it is observed that the amount of tannin, including plant polyphenols, in the material varies. This variation is probably a consequence of the tanning degree and also the individual skills and experience of the performers. It is moreover a demonstration of the use of plant polyphenols as colouring agents and not merely as tanning agents.

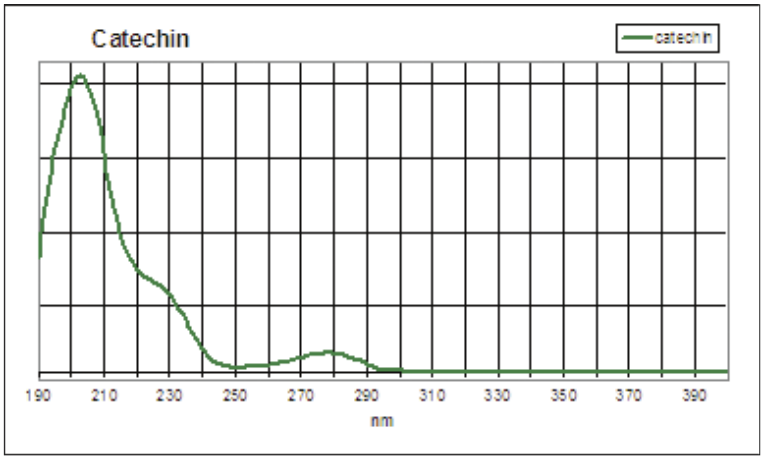


Fig. 5.15. Spectral characteristics of catechin at integration (I) 280 nm. From: Juchauld, CRCDG, 2006.

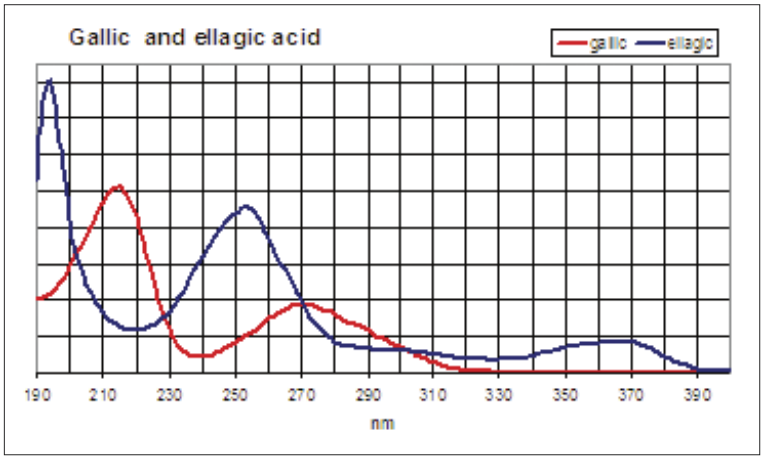


Fig. 5.16. Spectral characteristics of gallic and ellagic acid at integration (I) 280 nm. From: Juchauld, CRCDG, 2006.

5.2.2.2 Peak identification and characterisation

Distinct peaks that have been identified in this study are generally observed in the chromatographic profile up to retention times of 15-18 minutes. Monomers are particularly observed in the lower areas from 5-9 minutes. Peaks at higher retention times are generally not identifiable or are identified in the blank chromatogram.

Peaks which represent a spectrum similar to catechin have been observed in a few samples. Gallic acid or peaks similar to gallic acid were detected in several samples, especially in the Sámi culture DS material. Ellagic acid or peaks resembling ellagic acid spectral characteristics were only detected in very few samples.

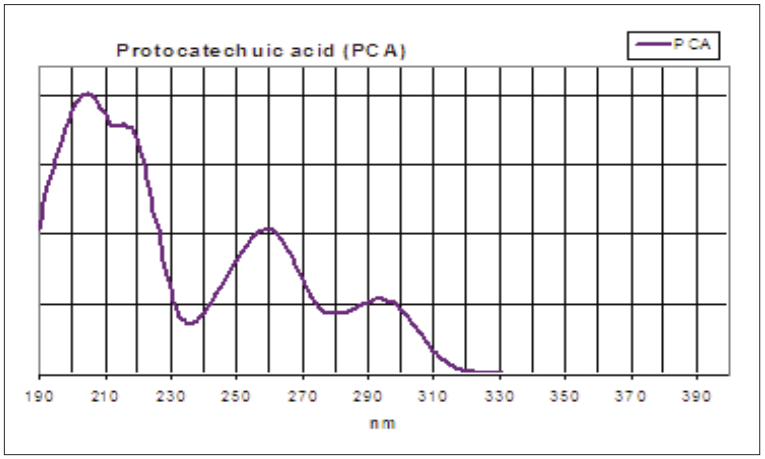


Fig. 5.17. Spectral characteristics of protocatechuic acid (PCA) at integration (I) 280 nm. From: Juchauld, CRCDG, 2006.

The monomers PCA, T20, and T22, and possibly T10 as described in Wouters and Claeys (1996:91) and in Poulsen (2000:36), were also found in the sample material. PCA is however the most common found in this study and often appears in the beginning of the elution profile at 5.2 minutes. In addition there are peaks resembling PCA at retention times 9.1 minutes.

The interpretation is mainly performed at integration 280 nm and 240 nm, by looking at the retention time of the identified peaks and the spectrum profile. To aid in the interpretation of the chromatograms, the retention times and the spectrum profiles of catechin, gallic acid, ellagic acid and protocatechuic acid (PCA) are used (Fig. 5.15, 5.16, and 5.17). These spectrograms are provided by CRCDG (Centre de Recherches sur la Conservation des Documents Graphiques), where the HPLC analysis was performed.

5.2.2.3 tannin-R, I240/I280 nm

In order to distinguish between condensed and hydrolysable tannins, it has been indicated that the ratio obtained as the area size at integration 240 nm divided by the area size at integration 280 nm, may prove useful in indicating tannin type. It is not recommended to rely on this number as a sole indicator, but rather to use it as a guiding feature in addition to other features in an array of analyses which may be carried out. In the analysis of leather book bindings in the Environment leather project a value of 1.0 and below indicate a hydrolysable tannin type, and a value above 1.3 indicates condensed tannins. Ratios between 1.0 and 1.3 seem to fall into the category of condensed tannins for the samples examined in this project (Wouters & Clayes, 1996:90). From interviews and from the available literature it is stated that the tannin type used in the Sámi and Evenk culture is of the condensed type. Willow bark, larch wood, alder bark and birch inner bark are in the literature all confirmed to be of the condensed type (Rottsieper, 1946; Haslam, 1966), and the ratio for most samples, at least the reference samples, should therefore be expected to lie above 1.0. However, it is also shown that as the tanned skin material ages, the ratio will fall and condensed tannins may have ratios close to hydrolysable tannin (Poulsen, 2000:37). Relying on the ratio as a method for differentiation of the two main tannin types must therefore be done with care.

In an attempt to investigate whether it was possible to improve the identification of the tannin type, an additional integration was performed at 230 nm and tannin-R mass (Rm2) at I230/280 nm and tannin-R 'peaks-only' (Rp2) was calculated for the DS sample material (Juchauld, 2007, pers comm.). These results will be discussed later in the chapter.

5.2.2.4 Tannin-I1% and I2% at I280 nm

To examine changes in vegetable tannin due to degradation, a method of dividing the elution profile, I1 and I2, may be explored (see fig. 5.32). The elution profile is divided into integration 1 (I1) and integration 2 (I2) at 280 nm. The degradation of the tannin molecule occurs as a condensation reaction yielding larger, more hydrophobic molecules, which appears at higher retention times. The division is initially performed on a suitable reference sample and subsequently the same retention time is used for dividing elution profiles of historic samples. A degraded tannin may, due to the increased hydrophobic properties, appear later in the elution profile, shifting the elution profile towards longer retention times. This will yield higher values for I2, compared to the reference samples' I2 value. As vegetable tannins age, the elution profile shifts towards longer elution times and the size of the I1 will decrease while the size of I2 will increase, although not necessarily making up for the loss in I1 (Wouters, 1994/95:205; Wouters & Claeys, 1996:89). It was difficult to assess if the method is suitable for this study, as the vegetable tannins in the historic samples are unknown. A chosen reference sample would have to be assumed to belong to the same plant polyphenol group as the subsequent samples, to obtain a realistic result.

A modification to this method was developed in order to solve the problem of the lack of a suitable reference sample. Instead of measuring the difference of the areas, a direct measure of the shift of the mass area, by calculating the retention time of its middle, was performed.

This method is based on calculating the retention time corresponding to the middle of the mass surface area at 280 nm for all samples, and investigating whether this retention time is specific for different vegetable tannin types (Juchauld, 2007, pers. comm.). The samples Ref-Larix, Ref-Alnus and Ref-Betula and sample DS-N9-14 (Salix) were used as references, and the method was primarily tested on the DS samples. The results from applying both these methods to the DS sample material in this study are discussed later in this chapter.

5.2.3.1 Results and discussion

A general rule in interpreting chromatograms for condensed tannins is that only mass surface area in chromatographic profiles visible at more than one wavelength (for example both at I280 nm and I240 nm) should be considered as containing condensed tannins (Juchauld, 2007, pers.comm.). Although the mass area may be difficult to observe if the tannin content is very low, this rule is applied as a general guideline in the forthcoming interpretation.

Characterisation of Sámi culture reference samples

Number	Method	Location	Collected - year	
LS-N13-01	Willow bark extract, fat	Kautokeino, Norway	2004	
LS-N3-04	Willow bark extract	Karasjok, Norway	2004	
SWH-N13-09	Willow bark extract, fat, flour	Kautokeino, Norway	2004	
SWH-N1-11	Fat, flour, fermented milk	Karasjok, Norway	2004	
DS-N9-14	Willow bark extract, fat	Kautokeino, Norway	2004	
DS-N7-16 'old'	Willow bark extract, fat	Karasjok, Norway	2004	20-30 years old
DS-N7-17	Willow bark extract, flour, fermented milk, salt	Karasjok, Norway	2004	
REF-Untreated	Dried reindeer skin (SWH)	Karasjok, Norway	2004	

Table 5.1. Sámi culture skin reference samples.

Sample number	tannin-R, 240/280	tannin, OD/100 mg	10.3 peak OD/100 mg	Rm2 30/280 nm mass	Rp2 230/280 nm total minus mass	EA in OD/100 mg	GA in OD/100 mg	PCA in OD/100 mg	T20, T22, T10 in OD/100 mg	Total monomer in OD/100 mg	I1 %	I2 %
DS-N7-16 'old'	0.7	108	70	0.0	0.9	0	0	3	0	2.3		
DS-N7-17	2.3	1776	120	5.0	0.5	0	0	0	0	0.0	12	13
DS-N9-14	2.2	10986	3574	6.2	0.4	0	16	0	0	0.1	48	52
LS-N13-01	1.7	104	0			0	68	0	0	66.1		
LS-N3-04	2.1	14	8			0	0	0	0	0.0		
SWH-N1-11	1.4	105	64			0	0	0	0	0.0		
SWH-N13-09	1.3	26	3			0	6	0	0	24.0		
REF-Untreated	1.6	13	0			0	0	0	0	0		

Table 5.2. HPLC analysis of Sámi culture reference samples.

For the Sámi culture reference samples only three samples have peaks visible at more than one wavelength, and the remaining samples have very low total OD/100 mg. This includes the DS samples (except the naturally aged sample) and one LS sample. The tannin content (tannin, OD/100 mg) of the reference samples varies significantly (Table 5.2) and is higher for the three samples which have peaks visible at more than one wavelength. The DS samples have a higher tannin content than the LS and SWH samples, which also corresponds to the general skin processing methods (chapter 3) and indicates that the use of plant

polyphenols for the LS and SWH skin types have more a colouring and immediate softening effect than a tanning effect. Further examination shows that the amount of extracted vegetable tannin in apparently similarly treated skin samples also varies. These should from an analytical perspective be similar, but in reality they are not. These variations are dependent upon several aspects including the variety of methods: the experience and preference of the performer and the nature of the bark extract (bark harvesting time, the use of dry or fresh bark, and extraction method).

Characteristic for the Sámi culture reference sample material is the presence of a peak at 10.3 minutes at 280 nm and 240 nm. This peak is not identified and although it is not gallic acid, it may resemble gallic acid in its spectral characteristics (Fig. 5.18). All but one sample (LS-N13-01) display the 10.3 minute peak at 280 nm. Apart from the reindeer skin itself, willow extract is the only visible common denominator for these samples. The 10.3 peak is not found in the untreated reference sample (Table 5.5). Still, without further research, the assumption that it is connected to willow bark extract is premature.

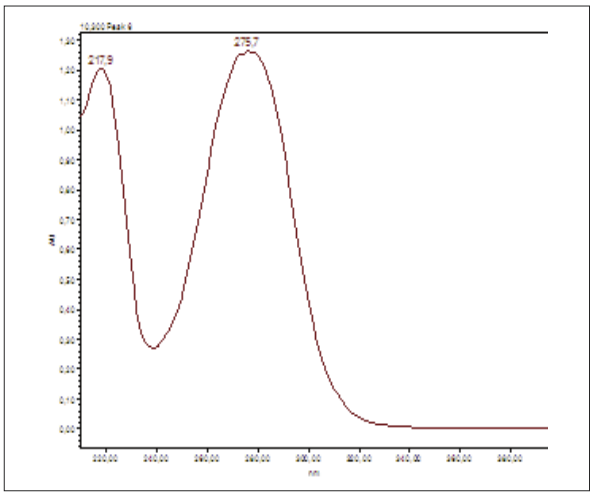


Fig.5.18. Spectral characterisation of the peak at retention time 10.3 minutes at 280 nm.

Both DS-N7-17 and DS-N7-16 show a distinct peak at 10.3 minutes. DS-N7-16 is naturally aged, approximately 20-30 years old and considerably less plant polyphenols are extracted from the sample (Table 5.2). This is demonstrated in previous studies: that there is a decrease in extractable tannins as the material ages. The same studies show that, as vegetable tannins age, the elution profile also shifts towards longer retention times (Wouters & Clayes, 1996:89). There seems to be a general shift in the elution profile under acidic condensation (37 % HCl) of the tannin extract. This is observed in the extract from reference samples DS-N7-17 and DS-N7-16 when studied individually, but no shift is observed in the position of the peak at 10.3 minutes and there is no change in the area (Fig. 5.19, 5.20). In these two reference samples no visible shift in the elution profile was observed, assuming that these two samples are comparable (Fig. 5.21).

The tannin ratios (tannin-R, 240/280 nm) vary for all samples and are difficult to interpret due to low vegetable tannin content found in most samples. How-

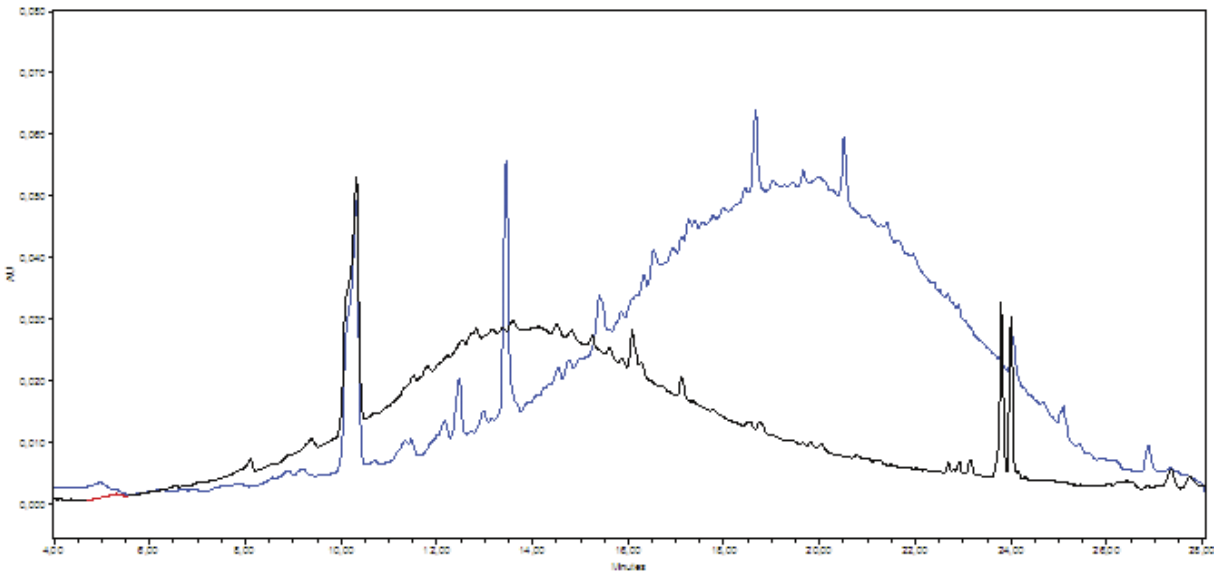


Fig. 5.19. DS-N7-17 (black line) and DS-N7-17 + HCl (blue line) at 280 nm. The elution profile is shifted towards longer elution times, but the 10.3 peak remains in the same position.

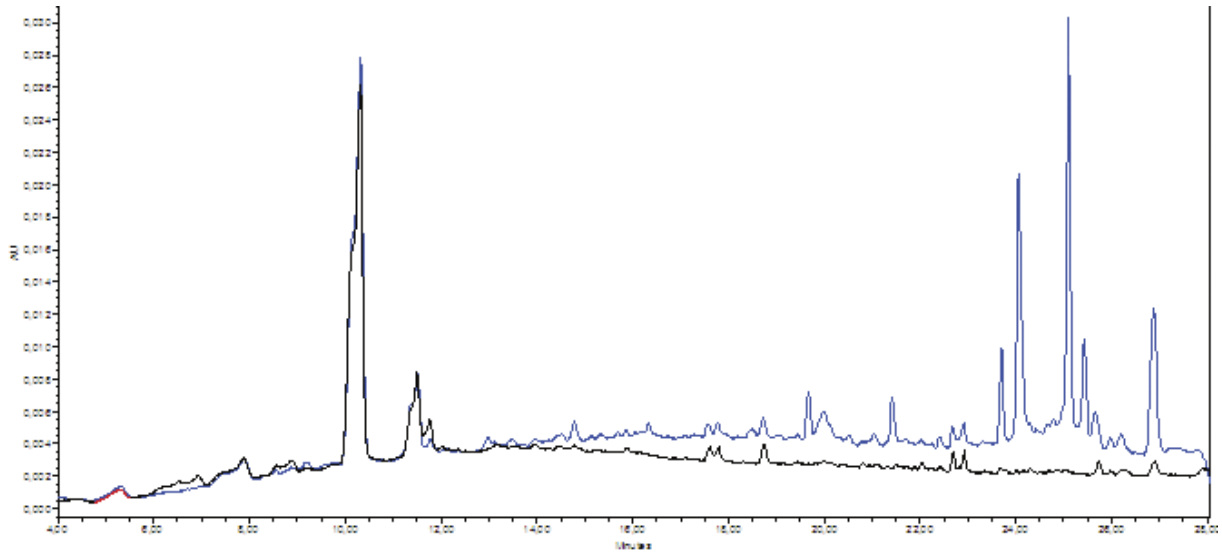


Fig. 5.20. DS-N7-16 (black line) and DS-N7-16 + HCl (blue line) at 280nm. The elution profile is shifted towards longer elution times, but the 10.3 peak remains in the same position.

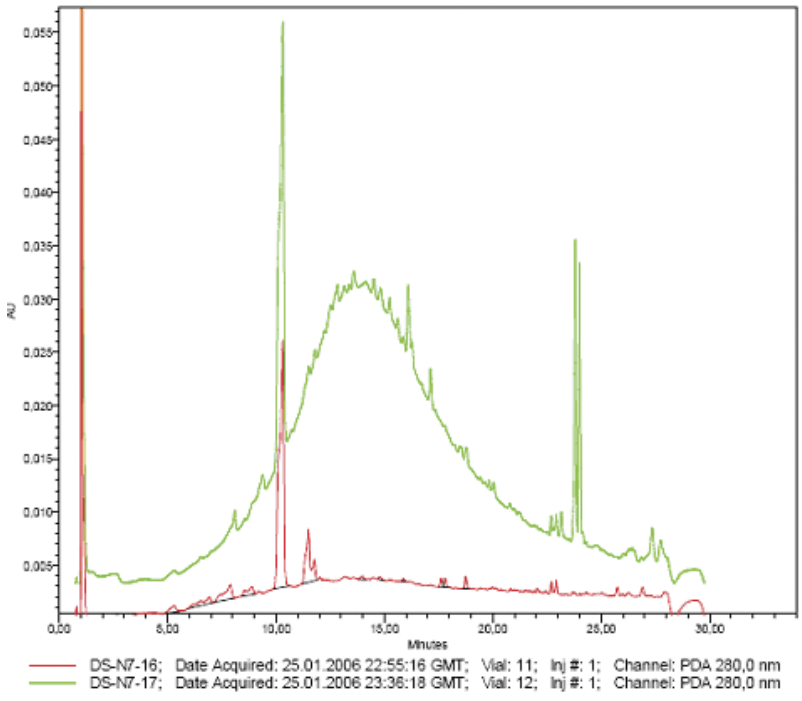


Fig. 5.21. Overlay report DS-N7-16 (aged) and DS-N7-17 at 280 nm. The characteristic peak at 10.3 minutes is present in both samples.

ever, two DS samples with significant tannin content have ratios above 1.3, which would confirm that condensed tannins are used. Monomers are formed as plant polyphenols age and degrade, particularly for condensed vegetable tannins (Wouters, 1993:671; Wouters, 1994/95:201). The naturally aged reference sample DS-N7-16 (Fig. 5.22) also exhibits the presence of the monomer protocatechuic acid (PCA). None of the other Sámi culture reference samples have formed monomers visible in the chromatograms at I280 nm.

The tannin-R of the reference samples DS-N7-17 and DS-N7-16 are an example of the possible deterioration which has taken place in the naturally aged sample (DS-N7-16). These are both depilated reindeer skins tanned with willow bark extract and fat. DS-N7-17 is tanned approximately two to three years ago and DS-N7-16 is made by the grandmother in the same family, about 20-30 years ago. HPLC analysis show that the tannin-R for DS-N7-17 is 2.3 which indicates condensed tannins and the naturally aged reference sample, DS-N7-16 has a ratio of 0.7 which theoretically would indicate hydrolysable tannins. In this example it is confirmed through interviews that willow bark extract was used in both samples. This example may indicates that the naturally aged sample is deteriorated and hence has a tannin-R lower than 1.0.

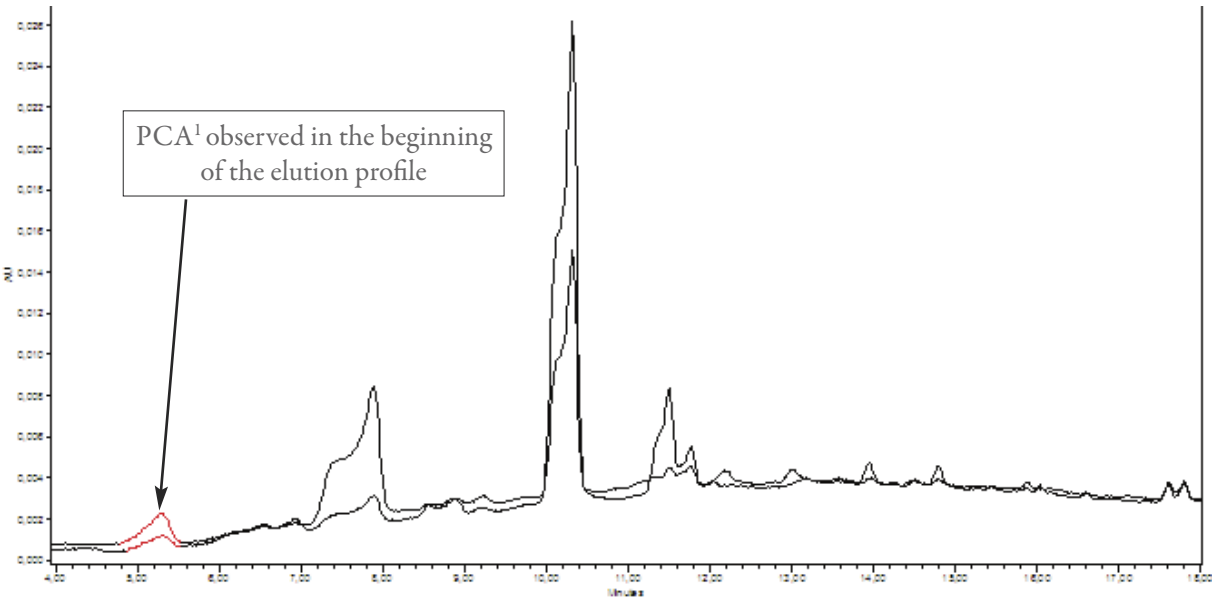


Fig. 5.22. Monomers, and particularly protocatechuic acid (PCA[1]), are if present observed early in the chromatogram. Here at 5.2 minutes in the elution profile for sample DS-N7-16 at 280 and 255 nm.

Reference samples – reindeer skin

Number	Method	Location	Collected - year
LS-R16-08	Larch brown rot wood, smoke, reindeer liver	Kharyyalach, Siberia	2004
SWH-R10-12	Larch brown rot wood, reindeer liver	Kharyyalach, Siberia	2004
DS-R10-20	Larch brown rot wood, smoked	Kharyyalach, Siberia	2004
DS-R10-21	Larch brown rot wood, reindeer liver	Kharyyalach, Siberia	2004
DS-R16-22 'old'	Larch brown rot wood, smoked, reindeer liver	Kharyyalach, Siberia	2004 - 20 years old
REF-Untreated	Dried reindeer skin (SWH)	Karasjok, Norway	2004

Table 5.3. Evenk culture skin reference samples.

5.2.4 Characterisation of Evenk culture reference samples

5.2.4.1 Results and discussion

Following the guideline that the visibility of peaks at more than one wavelength should be present, indicate that only one reference sample from the Evenk culture contains reasonable amounts of vegetable tannins. This is sample DS-R10-20 tanned with brown rotted larch wood and smoke (Fig. 5.23). However, sample DS-R10-21 and the naturally aged sample DS-R16-22 contains the monomer PCA, which also indicates that condensed tannins are used in these samples. The samples exhibit a large variation which again illustrates the heterogeneous nature of manually tanned skin. The tannin content (tannin, OD/100 mg) of the reference samples is generally very low. There seems to be slightly higher values for DS samples than for LS and SWH samples (Table 5.4). Monomers such as protocatechuic acid (PCA) are present, confirming the notion that vegetable tannins have been used in the processing methods. However, this is observed in the DS samples only. The assumption that the vegetable tannins from brown rotted larch wood have leached from the log or

Sample number	tannin-R, 240/280	tannin-R, mass	tannin, OD/100 mg	10.3 peak in OD/100 mg	EA in OD/100 mg	GA in OD/100 mg	PCA in OD/100 mg	T20, T22, T10 in OD/100 mg	Total monomer in OD/100 mg
DS-R10-20	0.5	0.0	223	0	0	0	0	10	10
DS-R10-21	1.4	0.0	112	0	0	0	3	0	3
DS-R16-22 'old'	4.1	0.0	11	0	0	0	1	0	1
LS-R16-08	2.1	0.0	9	0	0	0	0	0	0
SWH-R10-12	3.4	0.0	16	0	0	0	0	0	0

Table 5.4. HPLC analysis of Evenk culture reference samples.

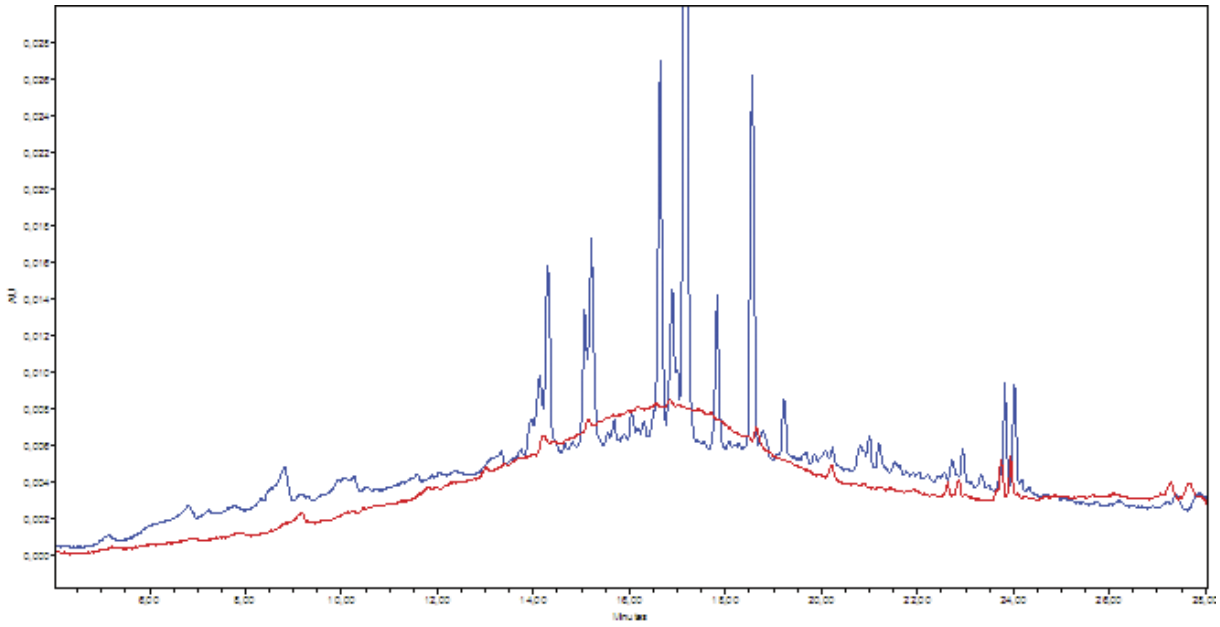


Fig. 5.23. Overlaid chromatogram of DS-R10-20 (blue line) and the reference sample Ref-Larix (red line), at 280 nm.

are degraded prior to application on the skin is one explanation for the observation of the low tannin content in these samples.

The tannin ratios (tannin-R, 240/280 nm) of the analysed reference samples vary from 0.5 to 4.1. All samples, except one (DS-R10-20) have values above

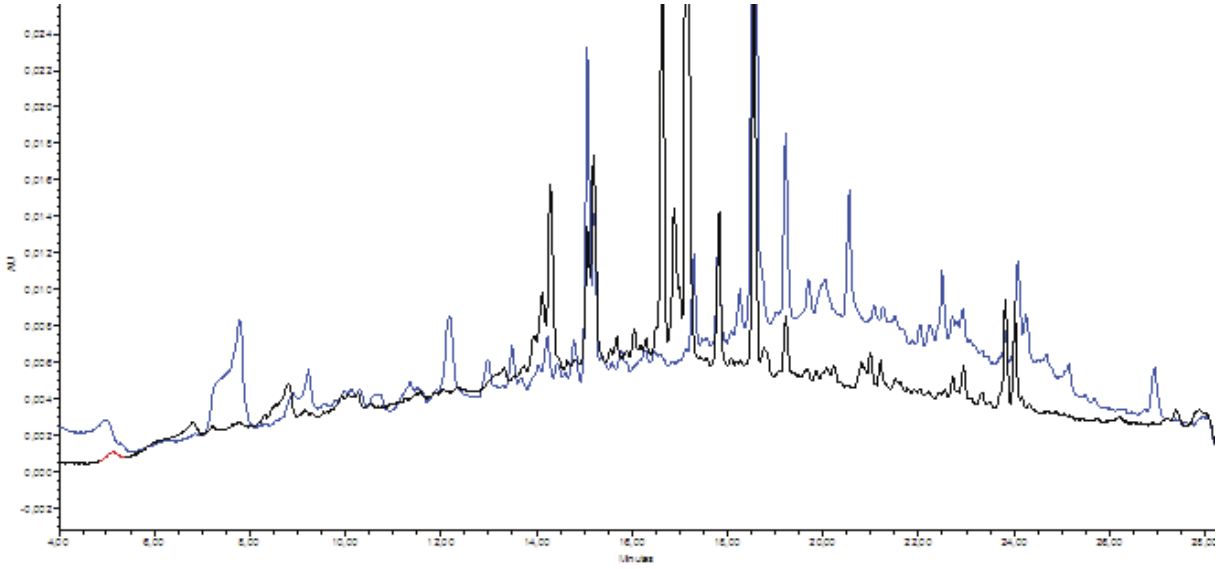


Fig. 5.24. There is a slight shift in the elution profile for the reference sample DS-R10-20 (black line) and DS-R10-20 + HCl (blue line) at I280 nm.

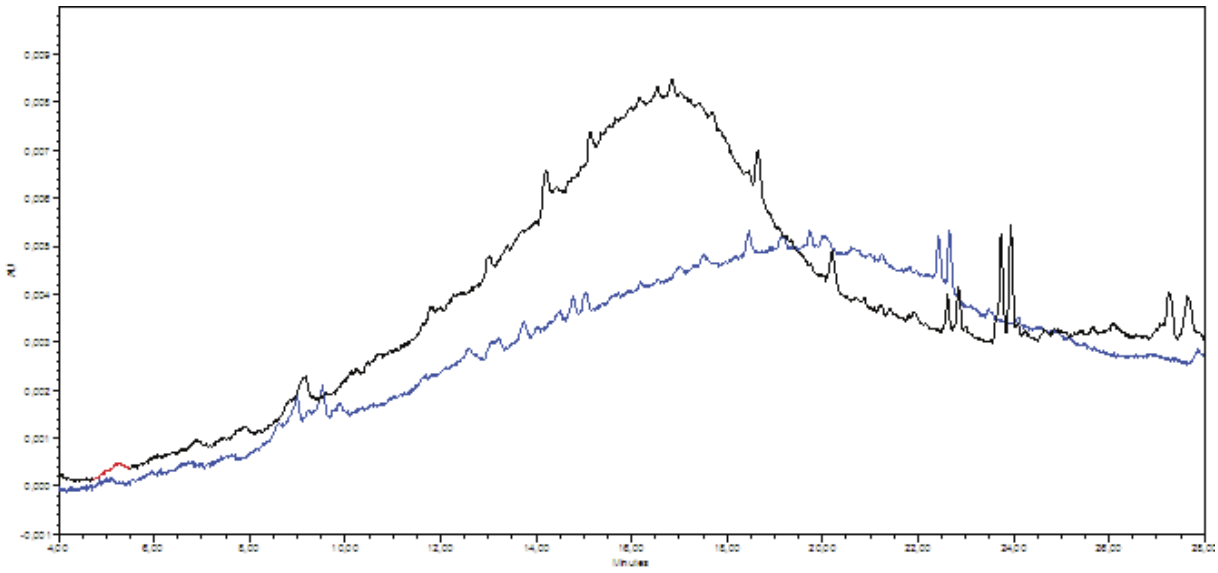


Fig. 5.25. There is a shift in the elution profile for the additional reference samples: Ref-Larix (black line) and Ref-Larix + HCl (blue line) at I280 nm.

1.4 which would suggest that the vegetable tannin is of the condensed type. Again, the tannin content of most reference samples is very low, and possibly indicates the presence of other substances such as fats which may affect the results of the chromatographic analysis.

In the acidic condensation (37 % HCl) of the tannin extract of the Evenk culture reference samples, the samples extract exhibit the same shift in the elution profile as does the Sámi culture reference samples. This is observed to a slight degree in the reference sample DS-R10-20 (Fig. 5.24) and is observed more clearly in the additional reference sample Ref-Larix (Fig. 5.25).

5.2.5 Experimental reference samples

Number	tannin-R, 240/280	tannin-R, mass	tannin, OD/100 mg	10.3 peak in OD/100 mg	EA in in OD/100 mg	GA in in OD/100 mg PCA in	OD/100 mg T20, T22, T10 in	OD/100 mg	Total monomer in OD/100 mg	CLO in OD/100 mg	RDL in OD/100 mg	Untreat in OD/100 mg
Ref-Larix	1.2	1.6	424	0	0	0	3	0	3			
Ref-Betula	2.3	2.6	5326	0	0	248	0	0	248			
Ref-Alnus	1.3	1.6	6511	0	0	5	0	0	5			
Ref-Untreated	2.8	0.0	13	0	0	0	0	0	0	2	4	3

Table 5.5. Reindeer skin tanned with alder bark extract, brown rotted larch wood extract and birch inner bark extract. Including values calculated for untreated reindeer skin.

5.2.5.1 Results and discussion

During the analysis of the reference samples a number of peaks were neither recognized nor could be linked to a known substance. Samples of reindeer skin tanned with alder bark extract (Ref-Alnus) (Fig. 5.26) and birch inner bark extract (Ref-Betula) (Fig. 5.27) were produced in the laboratory to obtain experimental skin samples for these tannins. In addition a reindeer skin sample was tanned with brown rotted larch wood in water (Ref-Larix) (Fig. 5.28), to obtain a reference sample not containing added substances such as lubricants or fats, and which is not smoked. At the same time an untreated (only dried) sample of reindeer skin and the available substances, pure home made cod liver

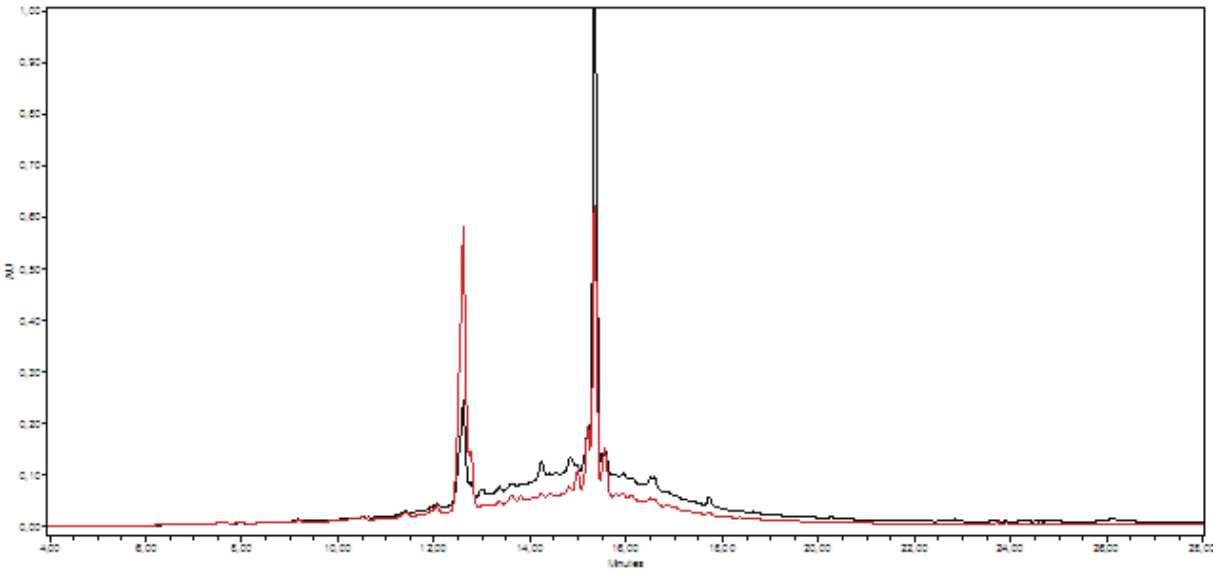


Fig. 5.26. Overlaid chromatogram of Ref-Alnus at I280 nm (black) and I240 nm (red). Tannin-R, 240/280 = 1.3.

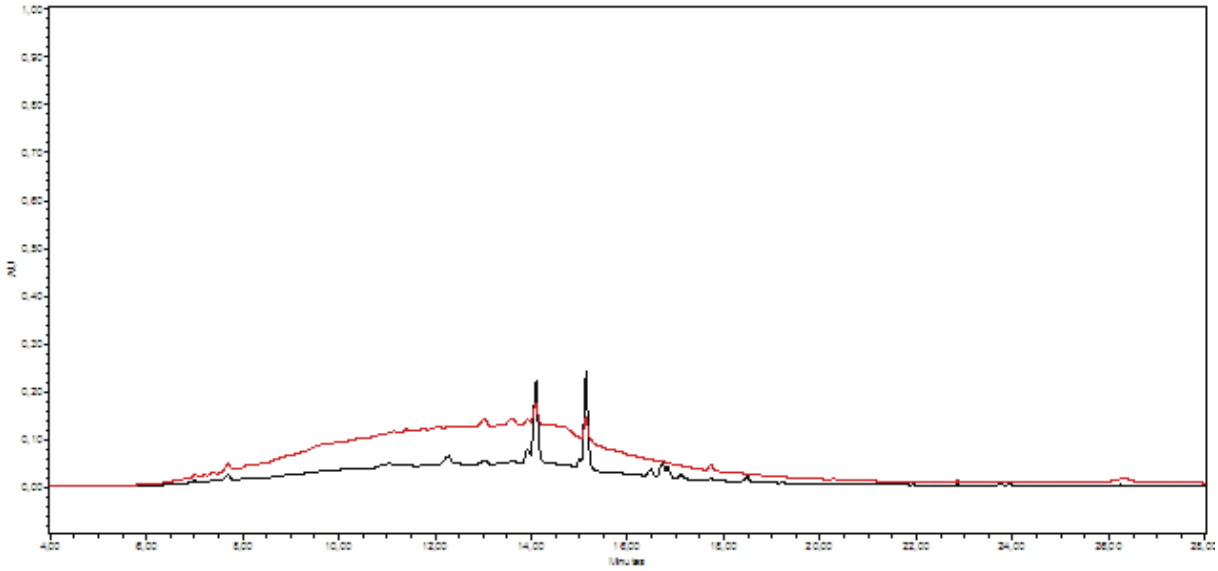


Fig. 5.27. Overlaid chromatogram of Ref-Betula at I280 nm (black) and I240 nm (red). Tannin-R, 240/280 = 2.3.

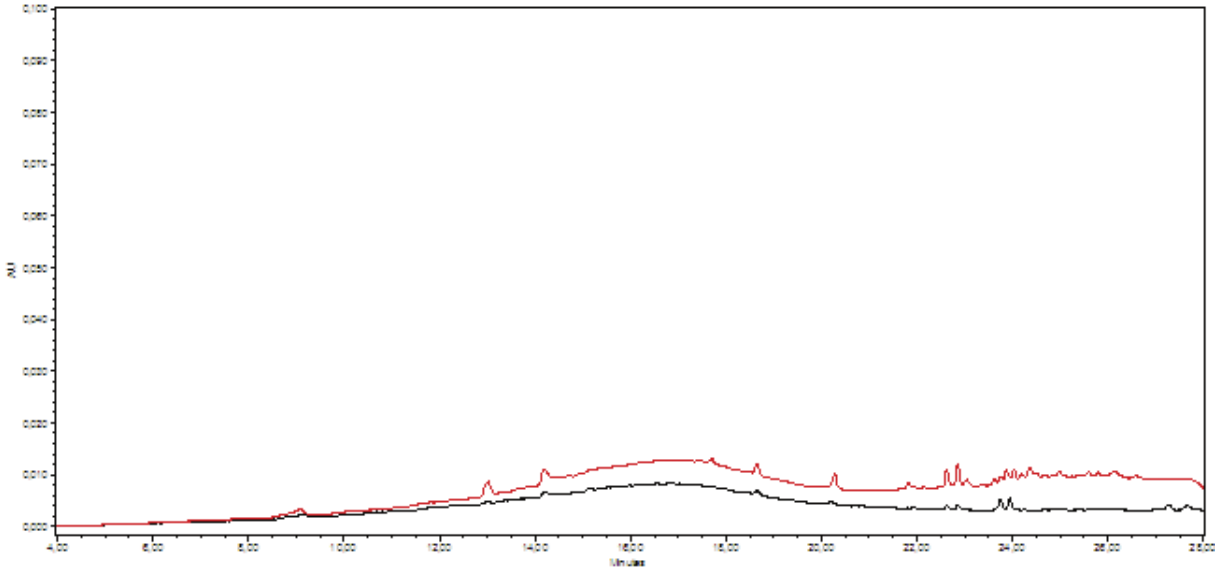


Fig. 5.28. Overlaid chromatogram of Ref-Larix at I280 nm (black) and I240 nm (red). Note that the absorption scale is different from the above chromatograms. Tannin-R, 240/280 = 1.2.

oil (CLO), pure boiled reindeer liver (RDL) and pure fermented cow's milk (FM), were analysed and applied as references in the forthcoming interpretation.

The tannin content for Ref-Alnus and Ref-Betula are 6511 OD/100 mg and 5326 OD/100 mg respectively. The value is considerably lower for Ref-Larix, namely 424 OD/100 mg. Monomers are not observed in Ref-Alnus and Ref-Betula, but are observed as PCA in Ref-Larix, which again could indicate that the amount of tannins has decreased and that they also possibly are degraded. The calculation of tannin content and tannin ratio for untreated reindeer skin is included to illustrate possible source errors.

5.2.6 Characterisation of historic sample material from the Sámi culture

The Sámi culture historic samples are heterogeneous both in ageing history and in presumed composition.

This is visible in the interpretation of the chromatograms concerning the tannin content, the tannin ratio and the amount of monomers present. However, these historic samples group themselves primarily into two groups; the DS samples and the LS/SWH samples. This is mainly due to the tannin content which lies reasonably within a range from 1100 to 4500 OD/100 mg in the DS samples (although one sample has considerable higher tannin content) (table 5.6). The LS/SWH sample material has considerably lower tannin content values; between 22 and 900, although two samples have higher values. See table 5.6.

The characteristic peak of 10.3 minutes which were observed in the Sámi culture reference samples is also observed in most of the historic samples, but is slightly shifted to 10.2 minutes. There is, however, an interesting exception of all the seven samples starting with NFSA in their museum number. The NFSA samples come from the same museum and have a fairly similar ageing history and are furthermore the oldest samples in the Sámi culture sample collection (95-100 years since acquisition). If the 10.2/10.3 minute peak is assumed to be associated with the use of willow bark extract, these results indicate that the vegetable tanning material for the NFSA samples differs. Another reason for the NFSA samples to deviate may be that the 10.2/10.3 minute peak has decrease or disappeared as the material ages. During acidic condensation (37 % HCl) the samples containing the 10.3 minute peak do not, however, show a decrease in peak surface area, but a temporary increase in the surface area before the surface area again decreases slightly below the % size for the untreated sample (Fig. 5.29). In the Sámi culture historic sample material, the size of the 10.2 minute peak varies significantly from 1 % to 33 % of the total integration

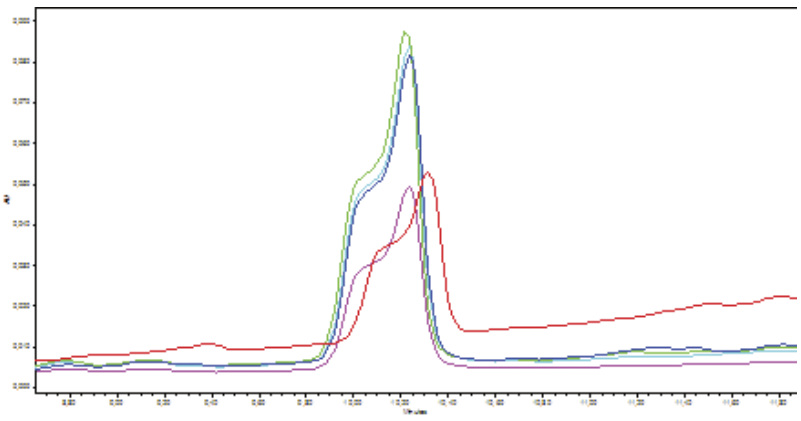


Fig. 5.29. 10.3 peak in DS-N7-17 – untreated – red line – 6.7 % of total area size at 280 nm.
10.2 peak in DS-N7-17+ HCl - 20 minutes – blue line – 4.7 % of total area size at 280 nm.
10.2 peak in DS-N7-17+ HCl - 40 minutes – green line – 5.8 % of total area size at 280 nm.
10.2 peak in DS-N7-17+ HCl - 60 minutes – turquoise line – 6.4 % of total area size at 280 nm.
10.2 peak in DS-N7-17+ HCl - 80 minutes – pink line – 6.0 % of total area size at 280 nm.

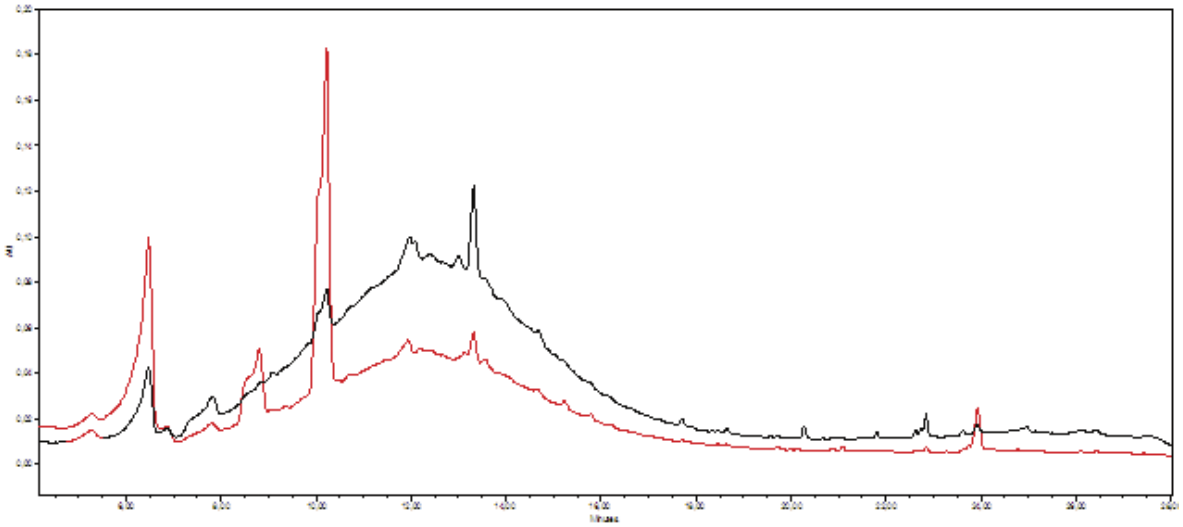


Fig. 5.30. DS-SVD-2205 with the 10.2 peak calculated to 12.9 % of the total integration at 280 nm (red line).

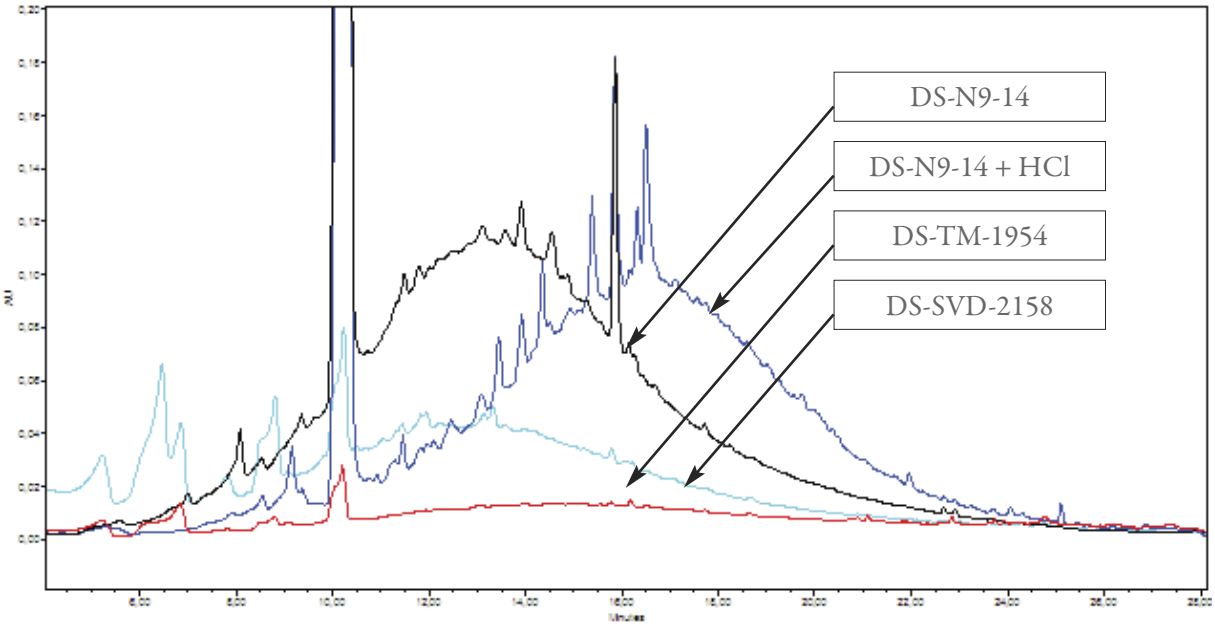


Fig. 5.31. Chromatogram for the reference sample DS-N9-14 – black line, DS-N9-14 + HCl – blue line, and the historic samples DS-TM-1954 – red line and DS-SVD-2158 – turquoise line.

value at 280 nm (Fig. 5.30). By calculating the mean % of total area size for the 10.2 minute peak for the three material types, another interesting feature appears. The LS samples have the highest mean of 12.8 % while the DS samples have a mean of 4.5 %, and the mean for the SWH samples is as low as 1.6 %. This indicates that although the LS samples generally exhibit low tannin content, the 10.2 min. peak is still quite strong.

There does not seem to be a corresponding shift in the historic samples towards longer retention times as is observed in the acidic condensation of the reference samples (Fig. 5.31). The reason for this is not known. It is suggested that the vegetable tannins in their deterioration have not condensed to larger molecules (becoming more hydrophobic) and therefore not shifted towards longer retention times (table 5.6).

The tannin-R for DS samples are fairly similar and lie within a range from 1.1 to 1.5 (table 5.6), indicating that condensed tannins have been used. Likewise it indicates that the deterioration of the samples is not extensive, since the tannin-R has not dropped below 1.0.

The DS samples, apart from two samples, furthermore include a fairly high amount of monomers, typically protocatechuic acid, which again confirms the use of condensed tannins in the tanning process. In addition there are contents of the unidentified monomers T20, T22 and T10. The total monomer content of the LS and SWH samples is significantly lower, and only present in four out of 15 samples, confirming the low amount or the absence of vegetable tannin from these material types.

The tannin ratios for the LS and SWH samples are difficult to interpret, as extracted amount of tannin is very low. Considering the care at which these values should be used and the low tannin content of the sample material, these values will not be explored further.

The calculation of I1-% and I2-% is in previous research applied to explore changes in vegetable tannins in artificial ageing (oxidation) (Wouters, 1994/95:207). Recognising that the historic DS samples contain condensed tannins, as in willow bark extract, DS-N9-14 is chosen as the reference sample for the Sámi culture historic DS material (Fig. 5.32). In previous studies it has been observed that I1 % decreases upon ageing. This is also the case in the acidic condensation reaction of the reference sample DS-N9-14 + HCl (Fig. 5.33). The results are clear in the interpretation of the historic samples, as all but one sample demonstrate a decrease in I1 % area. An expected corresponding increase in I2 is however not observed. At the same time an increase in the monomer formation compared to the reference sample is observed in most samples (Table 5.6), thereby assuming that a deterioration of the vegetable tannin has occurred.

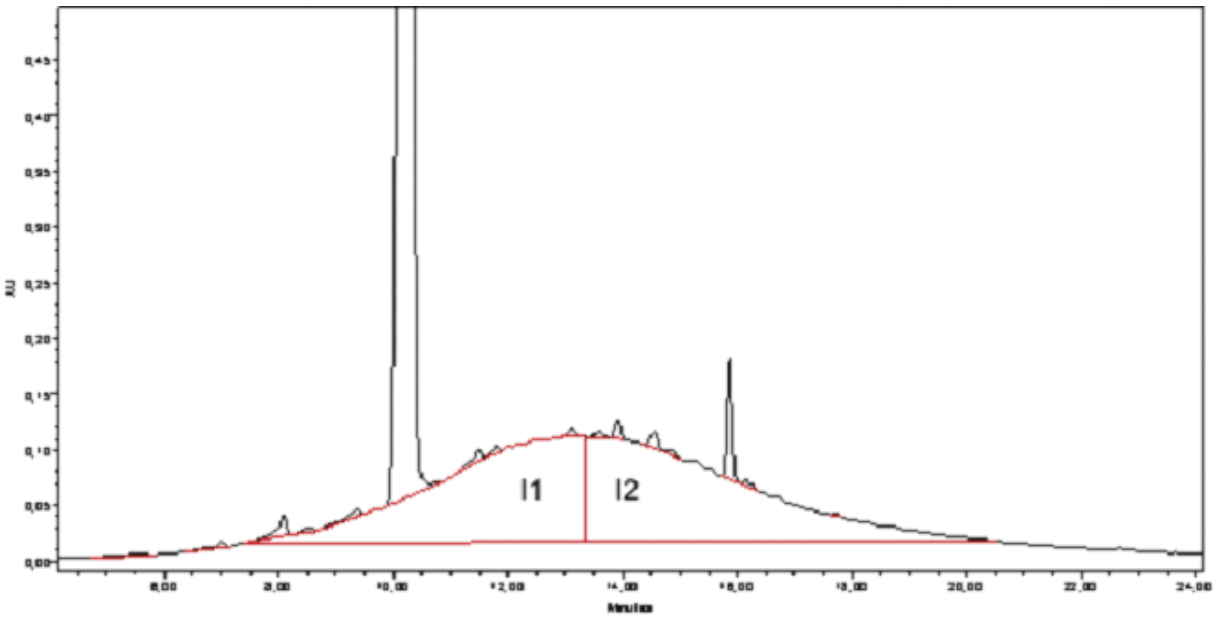


Fig. 5.32. DS-N9-14 – reference for I1-% and I2-% for the DS historic samples calculated from mass at 280 nm. Division at 13.3 minutes. I1- 48 % and I2-52 %.

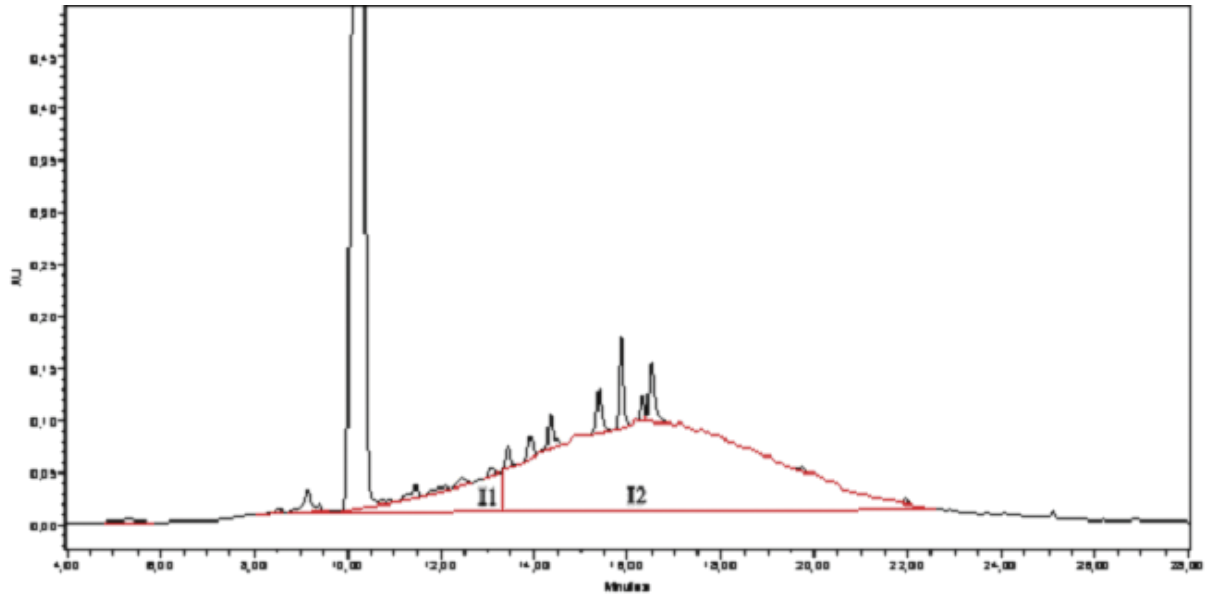


Fig. 5.33. DS-N9-14 + HCl. Division at 13.3 minutes as sample DS-N9-14. Demonstrating that I1 decreases to 10 % and I2 increases to 81 % of the total mass area, also at 280 nm.

5.2.7 Characterisation of historic sample material from the Evenk culture

The 23 historic samples of the Evenk culture skin artefacts are heterogeneous in both ageing history and in presumed composition. These artefacts are generally older than most of the historic Sámi culture artefacts, with an average age of approximately 91 years (including three artefacts which are only 15 years old).

Applying the guidelines of the visibility of a mass surface area in two or more wavelengths, only three out of 23 of the historic Evenk culture samples would be considered as containing vegetable tannins. These three samples are all DS material (DS-VK-6161-17, DS-MAE-0376-59c, and DS-IMRS- 0736-1). An additional seven samples contain PCA-resembling peaks, adding up to a total of ten samples where vegetable tan-

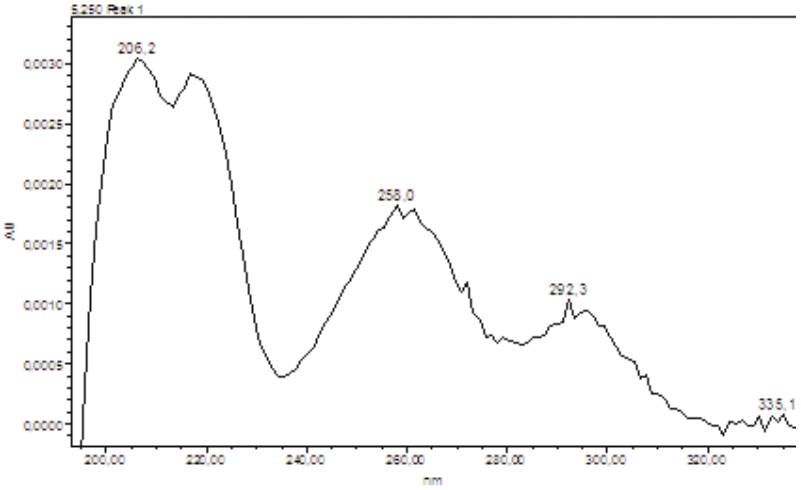


Fig. 5.34. Spectral characteristics of 5.2 peak for DS-IMRS- 0736-1 at 280 nm, resembling PCA.

nins may have been used. See table 5.7. The PCA peak characteristically appears at 5.2 minutes (PCA[1]) (Fig. 5.34), and there are PCA resembling peaks at, 8.8 and 9.1 minutes. Comparing the reference sample Ref-Larix to the historic sample with the highest tannin-OD/100 mg shows the characteristic peaks resembling PCA at 8.8 and 9.1 minutes (Fig. 5.35).

Ten out of the 23 historic samples do not exhibit peaks that resemble monomers with known spectral characteristics. Five out of the ten samples, where vegetable tannins seem absent, display peaks with possibly fat characteristics of: FM, CLO, and RDL (table 5.7).

Apart from the three DS samples there are similarities between the remaining DS, LS and SWH skin types. Figure 36 further illustrates the division between the DS samples and the LS/SWH samples, where two samples have been analysed for the same artefact, DS-MAE-0376-59c and LS-MAE-0376-59c (the red and the black line). The DS sample is taken from the upper edge of the boot and the LS sample is taken from the front upper part of the boot. The DS sample has higher tannin content (OD/100 mg) and also a higher content of PCA as observed in table 5.7.

The three samples which most probably contain vegetable tannins have a tannin ratio (I240/I280) of 1.1. This can be interpreted as condensed tannins, although the values are a bit low. The tannin ratios for the mass surface area are also very close to each other: 0.9 – 1.0 for these three samples. These are also the only three samples where a ratio for tannin-R of the

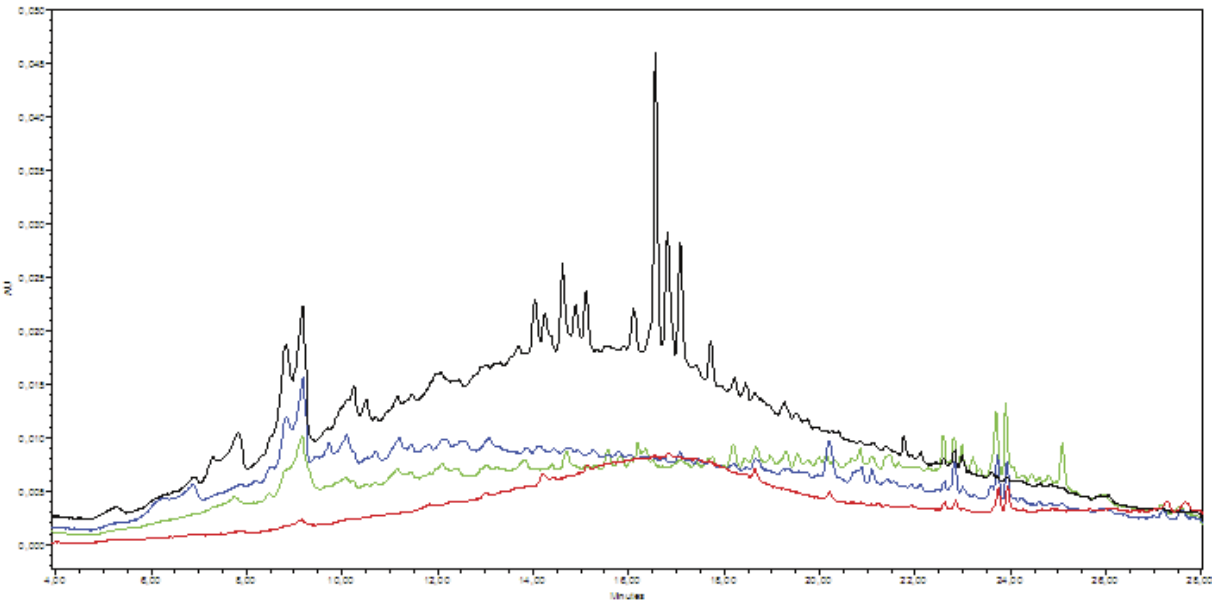


Fig. 5.35. Samples containing the highest amount of tannin from the Evenk culture artefact material. Overlaid chromatogram of DS-VK-6161-17 = light green line, DS-MAE-0376-59c = blue line, and DS-IMRS-0736-1 = black line, at 280 nm. Ref-Larix = red line is added for comparison.

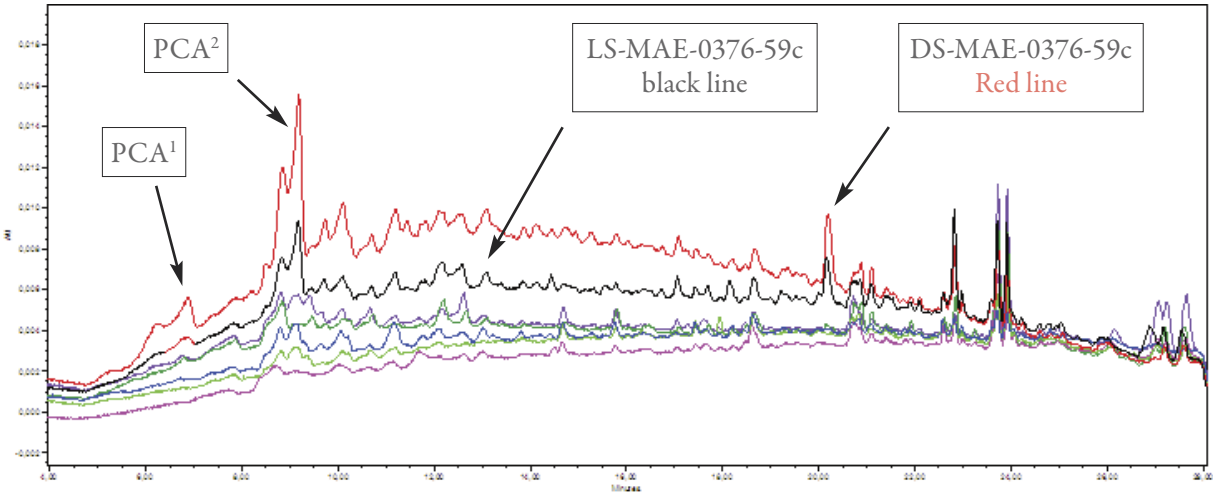


Fig. 5.36. Two samples from the same artefact but from different skin types, DS-MAE-0376-59c and LS-MAE-0376-59c, seen as the red and the black line. The remaining samples shown in the overlaid chromatogram comes from DS, LS and SWH samples from the same museum.

mass can be calculated. The ratios for the rest of the samples vary from 0.3 to 4.1. See table 5.7.

PCA is the most common monomer found in these samples. There is some indication that other monomers resembling T20 and T22 are found, but in small amounts. Gallic acid is only present in the sample with the highest tannin content.

5.2.8 Summary

"Similarly treated and equally aged skin samples will give similar results in the analysis of vegetable tannins". Is this true? As the results from these analyses show, it is not true. The variation in the reference material is as variable as the results from the historic sample material. These differences are caused by a number of reasons, such as varieties in tanning degree, in method, in the treatment of the artefacts material and the condition. There are however characteristic features which can be described and which give basis for further research.

Tannin content in the Sámi and the Evenk culture samples differs immensely. The DS samples exhibit the largest difference, as the Sámi culture DS samples contain considerably more plant polyphenols than the DS samples from the Evenk culture.

The Sámi culture samples generally divide in two groups, the DS samples and the LS/SWH samples. This division is less significant in the Evenk culture samples, although the majority of the samples containing monomers are DS samples. The Evenk culture samples divide in three sample groups: DS samples containing the monomer PCA, LS samples displaying possible fat peaks and SWH samples which have few characteristics.

The differences between Sámi culture sample material and Evenk culture sample material is concurrent with the indications from the visual analysis, such as the studies of colour profile and tannin penetration, where the differences in tanning method for the various skin types in the Sámi culture have a broader range than the methods applied to the Evenk culture skin types. The vegetable tannin analyses confirm this, and they also support the impression that vegetable tannins for some material types are used primarily for the purpose of colouring the skin's surface rather than being a tanning method.

A significant difference between the Sámi and the Evenk culture samples material is the presence or absence of the 10.2/10.3 minute peak. None of the Evenk culture samples exhibit this peak, and it is not present in the additional samples. There are at this point no characteristics relating this peak to plant polyphenols, and therefore no assumption can be made that this peak is significant for willow bark extract (Juchauld, 2007, pers. comm.).

Tannin degradation is often seen as a shift in the elution profile towards longer retention times. This is observed in artificial ageing treatment of modern sample material (oxidation) and also in the acidic condensation of the tannin extracts of this study. A shift towards longer retention times is not obvious when studying the historic sample chromatograms and com-

Museum number	Age	tannin-R 240/280	Rm2 230/280 mass	Rp2	tannin, OD/100 mg	10.2 peak in OD/100 mg	10.2 peak in %	EA in OD/100 mg	GA in OD/100 mg	PCA in OD/100 mg	T20, T22, T10 in OD/100 mg	Total monomers in OD/100 mg	CLO, FM, RDL in OD/100 mg	I1-%	I2-%
DS-NFSA-3930	100	1.2	1.8	1.2	10361	0	0	0	0	342	653	995		53	69
DS-NFSA-4066b	100	1.3	1.5	1.7	1516	0	0	0	10	87	0	97		9	10
DS-SVD-0023	unknown	1.4	1.4	1.0	3823	89	2.3	0	51	209	0	260		17	29
DS-SVD-2158	30	1.2	1.9	0.9	4495	141	3.1	0	16	210	0	226		28	22
DS-SVD-2205	unknown	1.5	3.3	0.4	3553	457	12.9	0	0	0	0	0		24	10
DS-TM-0712	unknown	1.4	1.3	2.1	1394	44	3.2	0	0	0	0	0		2	15
DS-TM-1954	30	1.1	1.8	1.4	1124	67	6.0	4	25	42	78	149		4	8
DS-TM-2239B	unknown	1.4	0.8	1.4	1359	31	2.3	0	0	71	80	151		4	12
SWH-NFSA-0582	100	0.4			330	0	0	0	0	0	0	0			
SWH-NFSA-3715	100	0.5			229	0	0	0	0	0	0	0			
SWH-NFSA-4064	100	1.9			73	0	0	0	0	0	0	0	2		
SWH-SVD-2110	65	0.4			3134	13	0.4	0	0	0	0	0			
SWH-SVD-2240	unknown	0.5			321	5	1.6	0	5	0	0	5			
SWH-SVD-2565	unknown	1.3			360	4	1.1	0	0	0	0	0			
SWH-TM-1149	65	0.2			616	15	2.4	0	0	3	0	3			
SWH-TM-1273b	40	1.2			357	9	2.4	0	0	0	0	0			
LS-NFSA-3934a	100	0.5			237	0	0	0	0	0	0	0			
LS-NFSA-4066a	100	2.6			22	0	0	0	0	0	3	3			
LS-SVD-0790	unknown	1.7			752	115	15.3	0	0	0	0	0			
LS-SVD-2212	unknown	0.4			174	6	3.2	0	0	0	11	11			
LS-SVD-2220	30	2.8			478	47	9.8	0	0	0	0	0			
LS-SVD-3374	unknown	0.6			1708	576	33.7	0	0	0	0	0			
LS-TM-0545	55	2.0			985	17	1.8	0	0	0	0	0			

Table 5.6. Results from the HPLC analysis of historic samples from the Sámi culture.

Museum number	Age	tannin-R 240/280	Rm2 230/280 mass	Rp2	Tannin, OD/100 mg of total	I280nm	10.2 peak in OD/100 mg	EA in OD/100 mg	GA in OD/100 mg	PCA in OD/100 mg	T20, T22 in OD/100 mg	Total monomer in OD/100 mg	CLO, FM, RDL in OD/100 mg	I1-%	I2-%
DS-IMRS-0092-4	120	0.5	0.0	3.8	214	0	0	0	0	0	0		41	34	
DS-IMRS-0736-1	120	1.1	0.3	-4.6	1855	0	0	70	69	0	139		511	337	
DS-MAE-0376-59c	115	1.1	0.0	2.6	600	0	0	0	36	13	49		159	53	
DS-MAE-1524-168	100	2.4	0.0	2.9	40	0	0	0	6	0	6	2	0	0	
DS-REM-1210-2	100	0.3	0.0	1.9	309	0	0	0	13	0	13		90	21	
DS-VK-4934-174	95	0.7	0.0	3.0	319	0	0	0	36	9	45		43	58	
DS-VK-6161-17	15	1.1	0.6	2.3	462	0	0	0	25	0	25		80	80	
SWH-IMRS-0345-1	100	0.6			232	0	0	0	11	0	11				
SWH-IMRS-0510A	100	1.2			161	0	0	0	0	0	0				
SWH-MAE-0273-1	110	0.5			171	0	0	0	0	6	6				
SWH-MAE-1524-3	100	2.3			48	0	0	0	0	0	0	2			
SWH-VK-4934:170	95	1.8			115	0	0	0	10	0	10				
SWH-VK-4934:182	95	0.6			203	0	0	0	0	0	0				
SWH-VK-5275-1	85	0.5			249	0	0	0	0	9	9				
SWH-VK-6161:14	15	4.1			29	0	0	0	0	3	3				
LS-IMRS-0544 A	100	0.3			254	0	0	0	0	0	0				
LS-MAE-0376-59c	115	0.6			248	0	0	0	9	0	9				
LS-MAE-1004-62/2	100	1.7			23	0	0	0	0	0	0	1			
LS-MAE-1524-2	100	1.9			27	0	0	0	0	0	0	3			
LS-REM-6749-5	75	0.4			117	0	0	0	0	0	0				
LS-VK-4934:175	95	3.8			36	0	0	0	0	0	0	2			
LS-VK-4934:176	95	3.2			26	0	0	0	0	0	0	3			
LS-VK-6161:25	15	1.7			112	0	0	0	30	0	30				

Table 5.7. Results from the HPLC analysis of historic samples from the Evenk culture

paring these to the chromatograms of the reference samples.

The results, from the method based on calculating the retention time corresponding to the middle of the mass surface area at 280 nm for all DS samples and selected reference samples, are difficult to interpret. Initially, it requires a more homogenous sample material and suitable reference samples for investigating this further. This was not possible with the available sample material and resources in this project. There is however a basis for developing such a project based on the experiences obtained through this study.

5.3 The nature of and the identification of lipids

The objective of the chromatographic analysis (gas chromatography – mass spectrometry GS-MS) is to study the nature and fate of fats and oils used in the skin processing technology. The analyses describe the present fatty acid composition of the lipids applied to the sample material, but do not reflect the original fatty acid composition. The manipulation of the fats and oils, prior to application, and the transformation and decomposition of fats over time may reduce the number of fatty acids. At the same time changes occur in the relative percentage composition of fatty acids in the sample material. This makes identification of specific lipids difficult. Comparing the fatty acid composition in the reference samples, however incomplete, may shed some light on the use of fats and oils in the historic sample material. The determination of the total amount of fatty acids present in the sample material is an approximate value. The fat content in each artefact depends on a number of factors, such as wear and tear through years of being worn, exhibited and handled, where both tanning agents and lubricants may have deteriorated. Another aspect, which is also important to consider, is the possibility that lubricants may have been added during the "museum life" of the artefact. Most of the artefacts in this study do not have detailed descriptions of what they have been exposed to in their respective museums, and the possibility that fats have been added to soften the skin can not be ignored. The fats and oils which are used in skin processing are described in the following sections, along with a specification of the fatty substances' physical and chemical properties, and the reactions that take place in the skin fibre structure in the application. The fatty acid composition of the sample material is illustrated and interpreted to further the understanding of fats and oils used in skin processing technology and to explore the effect which the fatty substances may have on the preservation of skin materials.

5.3.1 Fat tanning substances and lubricants

Various natural and synthetic fats as well as mixtures of fats are applied in skin processing technology, either as a tanning agent or as a lubricant, to obtain and maintain certain properties in the skin material. In nature, fats either appear as solid fats, such as lard and tallow or as liquid; oils such as vegetable oils, marine (fish and marine mammals) oils and mineral oils. Lard usually refers to fat from pigs, and tallow is the wax-like body fat of animals, such as sheep and beef (DeMouthe, 2006:148). Tallow furthermore refers to the body fat of the deer family. The fatty layer of fur skins, from animals living in cold climates, may be quite thick. This layer can be scraped off the fur skins and melted to produce oil (DeMouthe, 2006:149) for use in skin processing. An example of this is marmot and fox oil which is sometimes used in the processing of skin in the Evenk culture (Vasilievna, 1999, pers. comm.).

Most naturally occurring fats and oils of plant or animal origin consist of triacylglycerols, which means that a glycerol (the backbone of the structure) is esterified with three fatty acids (Fig. 5.37). The bond between the glycerol and the fatty acids is called an ester linkage. These triacylglycerols are called simple lipids (Christie, 2006; Wikipedia, 2006).

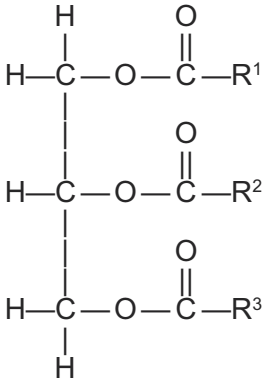


Fig. 5.37. General formula of triacylglycerols where R are long alkyl chains; the three fatty acids R^1COOH, R^2COOH and R^3COOH can be all different, all the same, or only two of the same (Mills & White, 1999:32; Wikipedia, 2006).

Phospholipids are a subgroup of lipids which are divided into two major groups, depending on the backbone structure. If the backbone consists of a glycerol unit it is called phosphoglycerides, and if the backbone consists of a sphingosyl, it is called sphingophospholipids. Phosphoglyceride is the major lipid which is contained in the liver, brain and pancreas of an animal. These are called complex lipids. The structure for the phosphoglyceride phosphatidylcholine is shown in Fig. 5.38. Phosphoglycerides are similar to the triacylglycerols in structure but contain only two fatty acids. The third position on the glycerol is occupied by phosphoric acid through a phosphate ester bond. In addition there can be a complex amino alcohol attached to the phosphate through a second phosphate ester bond (Christie, 2006; Wikipedia, 2006).

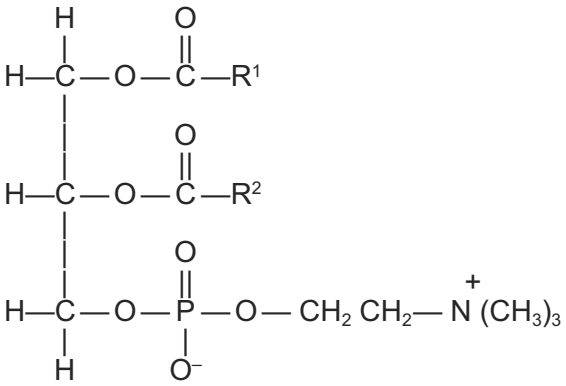


Fig. 5.38. Formula of the phosphoglyceride phosphatidylcholine (which for example occurs in egg yolks) containing a phosphate and an amine alcohol in position three and where R^1 and R^2 contain different or identical fatty acids (Ophardt, 2003; Gunstone *et al.,* 1994; Wikipedia, 2006).

Fats may contain both saturated and unsaturated fatty acids in their triacylglycerol structure. Saturated fatty acids (SFA) do not have double bonds or additional functional groups in their chain structure and are therefore considered less reactive and hence more stable (Fig. 5.39) (Wikipedia, 2006).

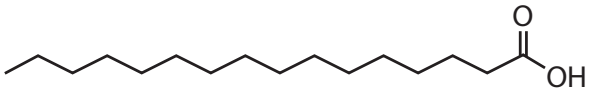


Fig. 5.39. n-hexadecanoic acid (palmitic acid) a saturated fatty acid. One of the most common fatty acids found in nature (Wikipedia, 2006).

In unsaturated fatty acids (UFA) one or several single CH_2=CH_2 bonds are substituted with double CH=CH bonds which may exist as isomers with *cis-* or *trans-* conformation. However, most naturally occurring fats belong to the *cis-* conformation isomer.

Fatty acids are divided into sub groups on the basis of the number of double bonds in the carbon chain, such as one double bond in monounsaturated fatty acids (MUFA); two, three, four etc. double bonds in polyunsaturated fatty acids (PUFA) (Fig. 5.40). They differ from each other in position of double bond, chain length or both (Markley, 1947:24-25).

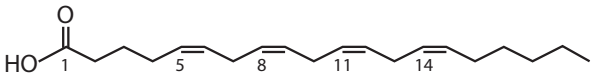


Fig. 5.40. A polyunsaturated fatty acid: *cis*-5,8,11,14-eicosatetraenoic acid (arachidonic acid). Found in liver, brain and depot fats of animals. It is also present in herring and cod liver oil (Hilditch & Williams 1964: 641; Wikipedia, 2006).

The proportion of saturated and unsaturated triacylglycerols in a fat or oil determines whether it is a solid or a liquid. The more unsaturated fatty acids that are present in a fat or oil, the higher is the liquidity.

5.3.2 Naturally occurring fats

The most abundant saturated fatty acid in both animal and plant tissue is straight chain fatty acids with 14, 16, and 18 carbon atoms in the chain. The most frequently occurring saturated fatty acids are palmitic acid (16:0) and stearic acid (18:0). Of the monounsaturated fatty acids, oleic acid (18:1 *cis*-9) is the most common, and of the polyunsaturated fatty acids the most common fatty acids in plant lipids are linoleic acid (18:2 *cis*-9,12) and α-linolenic acid (18:3 *cis*-9,12,15) (Tuck, 1983:3; Padley *et al.,* 1994:49-52; Christie, 2006).

The naturally occurring fats that have been investigated in the literature concerning skin processing technology from the Eurasian sub arctic and arctic and which have been described in the interviews include: land animal adipose, liver and brain fats, fish liver fats, and milk and egg fats. The most commonly available vegetable oils are; olive oil, soy oil, sunflower oil, linseed oil and rapeseed oil. In addition there are commercial products such as hand cream, leather fat and unidentified oils and fats which most probably are a

mixture of vegetable, animal, and synthetic oils. The fatty acid composition of naturally occurring fats and oils are for comparative and interpretive purposes summarised below. An overview of the saturated and unsaturated fatty acids found in the sample material from this study is summarised in tables 5.8 and 5.9.

5.3.2.1 Fat from land animals

Land animal adipose tissue (here as in cattle tallow) contains a high proportion of oleic acid (18:1 *cis*-9) and palmitic acid (16:0), approximately 20-50% and 20-35% respectively and approximately 6-40% stearic acid (18:0). It furthermore contains smaller quantities of myristic acid (14:0), linoleic acid (18:2 *cis*-9,12), and also a small fraction of linolenic acid (18:3 *cis*-9,12,15). In addition, tallow contains isomeric fatty acids with *trans* unsaturation and significant amounts of odd-chained and branched chain fatty acids (Padley *et al.,* 1994:160; Gunstone, 2004:21). Bone marrow fat shows a similar composition to adipose tissue, where oleic acid constitutes the highest value followed by palmitic acid. The fatty acid composition is furthermore shown to be affected by the animal's diet. An example is polar bear which exhibit a marine pattern in the fatty acid distribution (Innis & Kuhnlein, 1987:107; Grahl-Nielsen *et al.*, 2003:277). Likewise, medium sized mammals from Western Canada showed a fatty acid pattern resembling their main diet, which is berries, seeds or nuts (Malainey *et al.*, 1999a:92).

Land animal liver fats and brain substance contain high levels of phospholipids. One kilogram (kg) of mammalian liver may contain from 60-116 grams (g) of fat. The saturated fatty acids mainly consist of palmitic acid (16:0) and stearic acid (18:0) up to 30-40 % of the total fatty acid content. Liver phosphatides are also rich in unsaturated fatty acids in the C18 series and in the C20-C22 series. Brain substance is described as having tri- and tetra-ethenoid acids of the C20 series and tri-, tetra-, penta-, and hexa-ethenoid acids of the C22 series, although not in large amounts. Brain tissue is also rich in sterols as opposed to other tissues (Hilditch & Williams, 1964: 133-137; Padley *et al.,* 1994:198-199).

Milk fats show a high content of oleic acid (18:1 *cis*-9) followed by palmitic acid (16:0) and stearic acid (18:0). Furthermore, these fats contain a large complexity in the mixture of short and medium chain fatty acids, such as caprylic acid (8:0), capric acid (10:0), lauric acid (12:0), and myristic acid (14:0) from 2-9 weight (w) %. Odd-chain acids and *trans*- fatty acids, although at low levels are also present. The lipid content of milk fats varies from 16 g/litre (l) (horse) to 105 g/l (deer), and triacylglycerols can encompass 98 % of the total lipid content (Padley *et al.,* 1994:195).

The major fat constituent of egg yolk is phospholipids (phosphoglycerides), and an example of this is phosphatidylcholine (Fig. 5.38). Egg yolk lipid furthermore consists of triacylglycerols, and the fatty acid composition between the two lipid types varies. The fatty acid composition of the egg yolk is highly dependent on the hen's diet. The major fatty acid is oleic acid (18:1 *cis*-9) with, for example, 53 % in the triacylglycerol and 43 % in the phospholipid, and palmitic acid (16:0) with 25 % in the triacylglycerol and 32 % in the phospholipid. In addition the fatty acids include linoleic acid (18:2 *cis*-9,12) and stearic acid (18:0), with 9 % and 8 % respectively in the triacylglycerol, and 8 % and 4 % respectively in the phospholipid (Padley *et al.,* 1994:193).

5.3.2.2 Fats from marine and fresh-water fish

The fatty acids composition of cod liver oil shows a high content of long chain unsaturated fatty acids. The major saturated fatty acids are palmitic (16:0) and myristic acid (14:0). The major unsaturated fatty acids are oleic acid (18:1 *cis*-9) and palmitoleic (16:1 *cis*-9), and eicosenoic acid (20:1 *cis*-11) following with 12-13 mol%. In addition, cod liver oil contains proportions of erucic acid (22:1 *cis*-13), and lower amounts of stearic (18:0), linoleic (18:2 *cis*-9,12) and myristoleic acid (14:1 *cis*-9). Cod liver oil is a source of long polyunsaturated chains, such as for example 20:5, 22:5 and 22:6 fatty acids (DeWitt, 1963:95; Padley *et al.*, 1994:167; Gunstone, 2004:21-23; Christie, 2006, Lipid Library). The fatty acids composition of fish liver and body fat may vary within one species and according to diet, and do differ from marine to fresh-water fish (Ackman, 1967:907; Ackman & Hooper, 1968:549; Kirsch *et al.,* 1998:1379).

5.3.2.3 Fats from plant sources

Linseed oil contains a large amount of unsaturated fatty acids; linolenic acid (18:3 *cis*-9,12,15) up to 50-60 %. It furthermore contains oleic acid (18:1 *cis*-9) and linoleic acid (18:2 *cis*-9,12), and smaller quantities of saturated fatty acids such as palmitic acid (16:0) and stearic acid (18:0). For this reason it oxidizes and polymerises rapidly and is known for its drying properties. It therefore has very low lubricating properties (Gunstone, 2004:5-6; Tuck, 1983:4).

Olive oil contains a large proportion of the monounsaturated fatty acid oleic acid (18:1 *cis*-9) in the range of 55-80 %, and lower quantities of the polyunsaturated fatty acid linoleic acid (18:2 *cis*-9,12), as well as saturated fatty acids such as palmitic acid (16:0) and stearic acid (18:0). Olive oil is described as having good lubricating values and to be a stable oil, despite its content of the polyunsaturated linoleic acid (18:2 *cis*-9,12). The stability is however caused by its high content of unsaponifiable constituents (Gunstone, 2004:6, Tuck, 1983:4).

Sunflower oil, soy oil, and corn oil are vegetable oils with high quantities of linoleic acid (18:2 *cis*-9,12) in the range of 50-60 %, and a fairly high quantity of oleic acid (18:1 *cis*-9) in the range of 20-30 %. In addition they contain significant amounts of palmitic acid (16:0), stearic acid (18:0), and small amounts of the polyunsaturated linolenic acid (18:3 *cis*-9,12,15) (Gunstone, 2004:4-11).

Rapeseed oil is produced in two forms, one containing a large amount of erucic acid and another containing a lower proportion of erucic acid. The 'low erucic acid oil' consists of a large proportion of oleic acid (18:1 *cis*-9) approximately 60 %, as well as lower amounts of linoleic acid (18:2 *cis*-9,12) and linolenic acid (18:3 *cis*-9,12,15), than the 'high erucic acid oil'. It also contains a lower proportion of palmitic acid (16:0) and stearic acid (18:0). The 'high erucic acid oil' contains lower amounts of oleic acid (18:1 *cis*-9), approximately 16 % and up to 50% of erucic acid (22:1 *cis*-13) as well as 6 % of eicosenoic acid (20:1 *cis*-11) (Gunstone, 2004:7-8).

5.3.3 Fat ↔ leather interaction

From the skin processing methods described by the informants of this study, and in the literature studies, fats are not applied to skin to obtain a full oil tannage (chamois tannage). This requires not only the application of highly unsaturated oils, such as cod liver oil but also a subsequent heating process to initiate and complete the autoxidation leading to an oil tanned skin. At the same time the skin must be mechanically manipulated (Sharphouse, 1995:212-219). Kuntzel takes this further and claims that a subsequent alkaline reaction is necessary to complete the process of aldehyde tanning by the fish oil aldehydes which are formed in the heating process. This formation can not take place under acidic (low pH) conditions (Kuntzel, 1958:430, 431). Another important feature is the characteristic of the fish oil at the time of application. In oil tannage, the cod liver oil must be applied before the oil is fully oxidised (Sharphouse, 1995:216). The grade of oxidation may be illustrated by the colour of the oil. In the Sámi culture where cod liver oil is still produced for skin processing, the cod liver is placed in a jar with a lid and left standing until the oil is formed. Over the months, the colour changes from a light yellow to a darker yellow brown colour. When asked whether the age of the oil would affect properties of the oil, the informants stated that it did not matter and that it also would only get better as it ages. This again would indicate that the main purpose of applying a fatty substance is a fat liquoring effect or a lubricating effect on the skin.

The aldehydes formed in the oxidation of, for example, cod liver oil in the skins' structure, may participate in the stabilisation of the collagen structure by forming intermolecular cross-links. These cross-links are suggested to occur through the formation of Schiff's base between an aldehyde and a free ε-amino group in an adjacent collagen molecule (Fig. 5.41) (Piez, 1968:553, 560; Sundholm *et al.*, 1978:755). If the aldehydes formed in the autoxidation of the oil, and which generally are known to have a tanning effect on the skin, are inhibited by decreasing oxidation of the oil taking place in the skin, is not known.

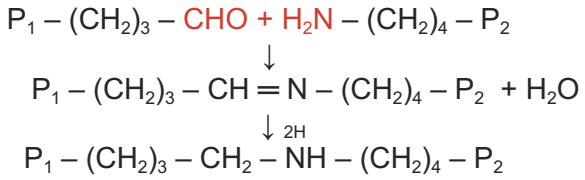


Fig. 5.41. The suggested cross-link reaction of the very reactive aldehyde group (– CHO) and an amino group (– NH_2) between two polypeptide chains in a collagen molecule. P = polypeptide chain (Modified from Piez, 1968:560).

In the Sámi and Evenk culture, if fats are applied at all, they are generally applied late in the process, prior to the finishing stages of drying and softening. Fats are applied to dry, damp or wet skin, combined with other substances such as vegetable tannin extracts, by themselves, or in combination with fillers, such as flour. A soft and flexible skin is obtained if the fat, as an emulsion, is added to water (or tannin extract solution) and a gradual and even coating of the fibres takes place. This is called fat liquoring. This technique is applied in the tanning of some depilated skin in the Sámi culture,

as the oil/emulsion is added to the last vegetable tannin bath. For heavy skins, for example as Ludmila Vasilievna describes in the processing of skin used for the soles of boots, the fat is applied to dry depilated skin (both sides) and is worked mechanically into the skin. This is called 'hand stuffing' in the leather industry (Sharphouse, 1995:254). A thicker fat layer coats the fibres and superfluous fat fills the fibre structure, yielding a more waterproof skin.

5.3.4 Properties and ageing of fats

Through the oil production and oil refining process, fats and oils are modified to provide appropriate qualities such as purposive viscosity, colour, and chemical stability. Several of the oils and fats used in skin processing technology are household oils or solid fats which primarily are meant for consumption. In edible fats and oils, modifications are applied to obtain products with agreeable taste and properties which give health benefits for the consumer. The influence on fat properties includes the degree of saturation or unsaturation of the fatty acids, which has an effect on several fat properties including melting point. The introduction of double bonds in a fatty acid chain lowers the melting point from that of the corresponding saturated fatty acid (Thorstensen, 1976:201; Mills & White, 1999:32). It thereby also affects the lubricating effect of the fat (Thorstensen, 1976:201). The lubricating effect is determined by how easily the oil penetrates the skin, yielding a supple and flexible material as the oil/fat minimizes the friction between the collagen fibres.

Modification of fatty substances is achieved through, for example, part or full hydrogenation of oils to reduce the degree of unsaturation. This furthermore results in a less reactive fat, and the iodine value (IV) is lowered. Oils and fats produced for the leather industry are modified though various processes, and they are generally related to creating oils which are able to form emulsions. This also affects the oil's ability to penetrate the skin. One of the processes is sulphation, where sulphuric acid (– O – SO_2H groups) are introduced to the oils, thereby allowing the oil to react with water (Reed, 1972:67). Oils may be sulphated to various degrees (lightly, medium and highly sulphated) and obtain various properties dependent on the degree of sulphation. Highly sulphated oils have better penetrating qualities than lower sulphated oils (Reed, 1972:67). Oils may also be mixed with cationic or nonionic surfactants, for the same purpose of obtaining self-emulsifying oils (Tuck, 1983:7).

Some oils have what are called drying properties. This quality is appreciated in the production of varnish and paint, but is not necessarily a desired quality in the lubrication of skin materials, except when used in a full oil tannage, such as for chamois leather (for example, wash leather). Characteristic of a drying oil is a high iodine value (IV) and consequently a high degree of unsaturation. The 'drying' of the oil is accomplished through autoxidation where, through an exothermal reaction with oxygen, the oil polymerises forming a solid film (Mills, 1966:96). Linseed oil is a typical drying oil. Cod liver oil is also regarded as a drying oil, and is used in the oil tannage where continuous mechanical action during autoxidation is advantageous for the oil to penetrate and coat the fibres in the skin. This yields skins which have the ability to absorb water but which are easily wrung out (Sharphouse, 1995:219).

The iodine value (IV) of a fat is a measure of average unsaturation of the fat, and a high iodine value, that is, a high level of unsaturation, indicates that the fat is less stable and more susceptible to oxidation. A high iodine value may also suggest a low melting point, as the introduction of double bonds in a fatty acid chain lowers the melting temperature from that of the corresponding saturated fatty acid (Thorstensen, 1976:201; Mills & White, 1999:32). Measuring the iodine value is no longer used as a standard method in modern lipid research. Instead, the peroxide value is seen as a more correct method for determining the oxidative change in lipids. The primary product of lipid oxidation is hydroperoxides, and hence measuring the total concentration of peroxides and hydroperoxides is useful in establishing the extent of oxidation which has taken place in the lipid substance at a certain point in time. Oxidation is seen as the most forceful change in lipids and is initiated through exposure to heat and/or light. The oxidation occurs through autoxidation and/or photo-oxidation. Autoxidation, also called lipid peroxidation, is considered a free radical chain reaction between oxygen and lipids and may be catalysed by metals. Autoxidation is accomplished through a chain reaction in three stages, described as initiation, propagation and termination processes. Autoxidation is related to unsaturated fatty acids, and the rate increases with an increasing number of double bonds (Frankel, 2005:16). The autoxidation of polyunsaturated fatty acids produces a more complex mixture, which decomposes easily. Thus, 18:3 isomers react faster than 18:2 isomers which again react faster than oleic acid (18:1 *cis*-9) (Frankel, 2005:34). The oxidation of phospholipids has been shown to follow a similar pattern (Frankel,

2005:46). The advanced oxidation of fish oils is characterised by their unpleasant smell. This involves decomposition of the unsaturated fatty acids and the initial formation of peroxides through autoxidation which again leads to the development of volatile sensory characteristics such as rancidity (Aidos *et al.*, 2002:808). Other reaction products from various stages in the lipid oxidation are aldehydes, carbonyl compounds, conjugated dienes and the formation of free fatty acids.

Photo-oxidation is the interaction between the double bonds of the unsaturated fatty acid and singlet oxygen, which is highly reactive. This reaction is many times faster than autoxidation and is not as easily inhibited by antioxidants (Kanner & Rosenthal, 1992:1963; Padley *et al.,* 1994:566). According to Mills (1966) films which are formed through oxidation of drying oils retain a stable ratio of saturated fatty acids which lie close to each other, such as palmitic (16:0) and stearic (18:0) acid (P/S ratio). The P/S ratio varies in different oils and can thereby be used as identification of fatty material applied to artefacts. So far it is possible to identify linseed oil, poppy oil and walnut oil with the use of the P/S ratio (Mills, 1966:97; Mills & White, 1999:171-172).

5.4 Chromatographic analysis of fats andlubricants in reindeer skin samples

Gas chromatography with mass spectrometry (GC-MS) is applied to the reference and historic sample material to investigate the fatty acid composition in various fats which may have been used in skin processing methods. The samples are described in chapter 1, and consist of twelve reference samples and 81 historic samples obtained from coats, boots, trousers, and bags from the Sámi and the Evenk culture. To further illustrate the complexity of the potential fatty acid composition of the historic samples, experimental skin samples (XSM-series) have been produced and analysed. The experimental samples consist of reindeer skin (SWH) that has been processed with raw reindeer brain substance, home made cod liver oil, as well as an untreated reindeer skin sample and a pure sample of reindeer liver.

5.4.1 Experimental

The internal standard used is from Restek Chromatography Products (part no.: 35077, FAME food industry mix). The chromatogram of a 1.2 µg (microgram) mixture is seen in figure 5.42.

The standard is diluted 1:20 and 1:100 and these two dilutions are used to prepare standards of 24, 60, 120, 240, 600 and 1200 ng (nanogram) of the analysed fatty acid methyl esters.

Preparation of internal standard: Deuterated "All-d-palmitic acid" is used as internal standard. The internal standard is diluted 1:40000 and the diluted solution is added directly to the leather samples.

Extraction of fatty acids: Cyclohexane is used for the extraction of fatty acids. Before extraction, 20 µl (microliter) of the internal standard solution is added to the sample. To each sample is then added 200 µl and the sample is placed in an ultrasonic bath for 20 minutes. The solvent is then transferred to a 0.3 ml (millilitre) reacti-vial (Wheaton). To the sample is again added 200 µl of solvent and placed in the ultrasonic bath for 20 minutes. The solvent is again transferred to the same reacti-vial. After extraction, the solvent is evaporated to dryness from the reacti-vial using nitrogen purge. To the reacti-vial is now added 50 µl of a 10% KOH-solution in 1:1 methanol: water. The reacti-vial is left for 2 h (hours) at 60 °C, and after cooling to room temperature a 6 N HCl-solution in water is added, together with 175 µl of methyl-t-butyl ether (MTBE). This mixture is mixed for 10 seconds on a whirl mixer, and the upper layer (the MTBE, which now contains the hydrolysed fatty acids) is transferred to an auto sampler vial.

The solution is again evaporated to dryness, and to the vial is added 50 µl of a diazomethane solution (Glastrup, 1998). This solution is injected directly into the gas chromatograph.

The Analyses were performed on a Varian 3400 Gas Chromatograph connected to a Varian 2000 Mass Spectrometer. The chromatographic conditions were:

Carrier gas:	Helium at15 psi.
Injector:	On-column (SPI), initial temperature: 60°C for 0.5 minutes, rate 200°C/minute to 200°C, hold for 2 minutes.
Column:	Varian CP-WAX 58 (FFAP)-CB 25m, 0.2 mm id., 0.3µ.
Column oven:	Initial temperature: 60°C for 0.5 minutes, rate 40°C/minute to 160°'C, hold for 3 minutes.
Detector:	Varian Saturn 2000 MS.
Transfer line:	220°C, Manifold: 60°C, trap: 160°C MS tuned through autotune. (Glastrup, 2007, email)

In the sample preparation the glycerides in the fat samples, as well as in the internal standard, are converted to methyl esters. The reason for the derivatisation is practical, as fatty acids are difficult to analyse if not derivatised. It is then possible to quantify the amount of each ester in the fat sample by comparing the integrated areas with the known concentration of the standard.

After extraction, and conversion of the triacylglycerols to fatty acid methyl esters, the methyl esters are separated by gas chromatography and identified by the detector response, which is proportional to the quantity (Christy, 2006).

5.4.2 Characterising fatty acid composition

There are several sources of errors which must be considered in the interpretation of fatty acid composition in naturally aged skin material. Besides changes due to decomposition, hence the decrease in poly-unsaturated fatty acids, the extractability of the fatty acids may change as the material ages (Bos *et al.,* 1996:99). At the same time, short chain fatty acids may for example undergo hydrolysis and leach from the sample (Evershed, 1993:85; Malainey *et al.*, 1999b:98). Unsaturated fatty acids may also cross-link as in conventional drying. It is therefore problematic to compare results from the analysis of fresh lipid extracts to results from the analysis of lipid extracts from naturally aged samples. These reservations must be taken into consideration when the results are interpreted.

An interpretation of the fatty acid composition of the sample material must furthermore be seen in relation to the lipids found naturally in the reindeer skin itself, and to the fact that not all samples necessarily have been treated with a fatty substance. The fatty acid composition of dried reindeer skin is illustrated in figure 5.43.

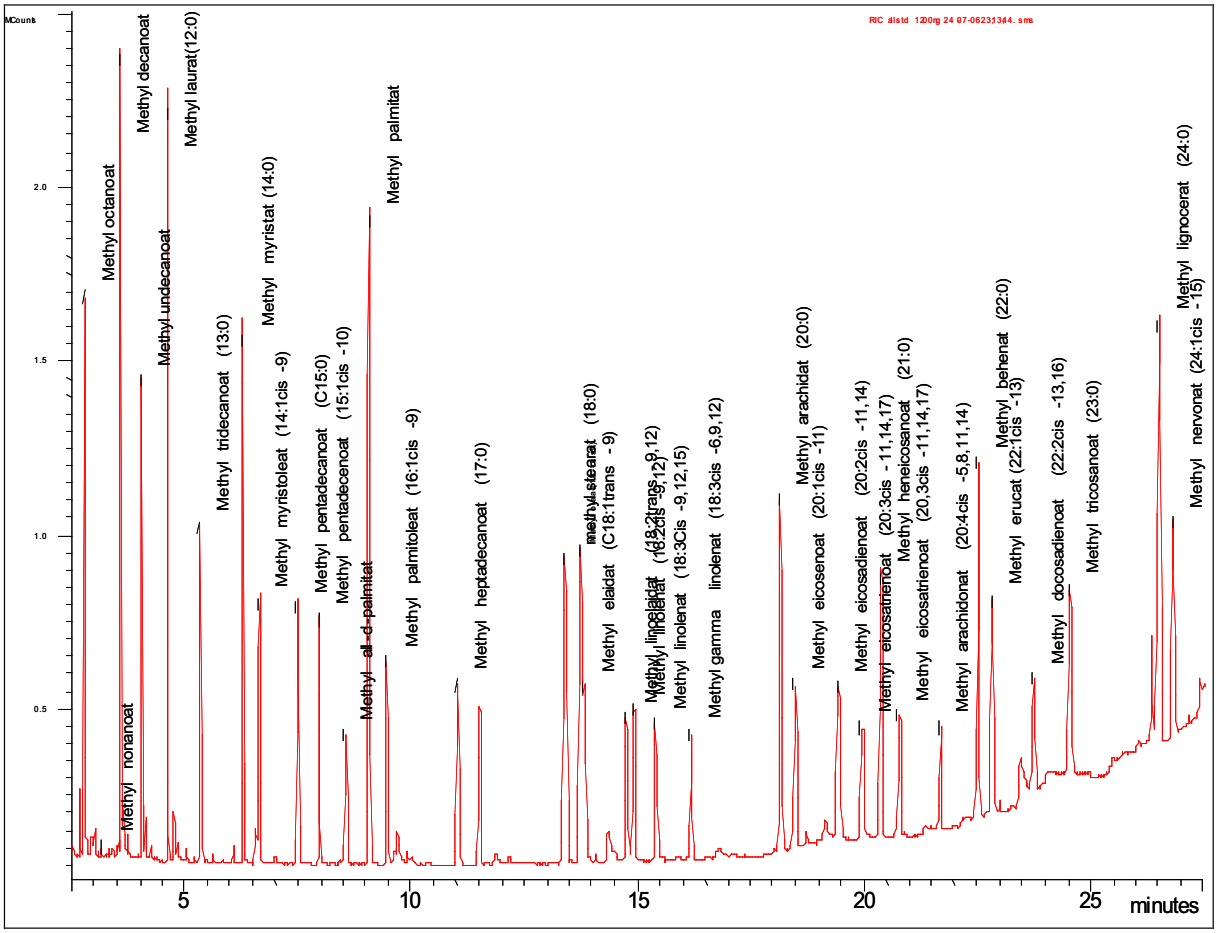


Fig. 5.42. The chromatogram of the standard; FAME food industry mix, part no. 35077 (Restek Chromatography Products), in a 1.2µg mixture.

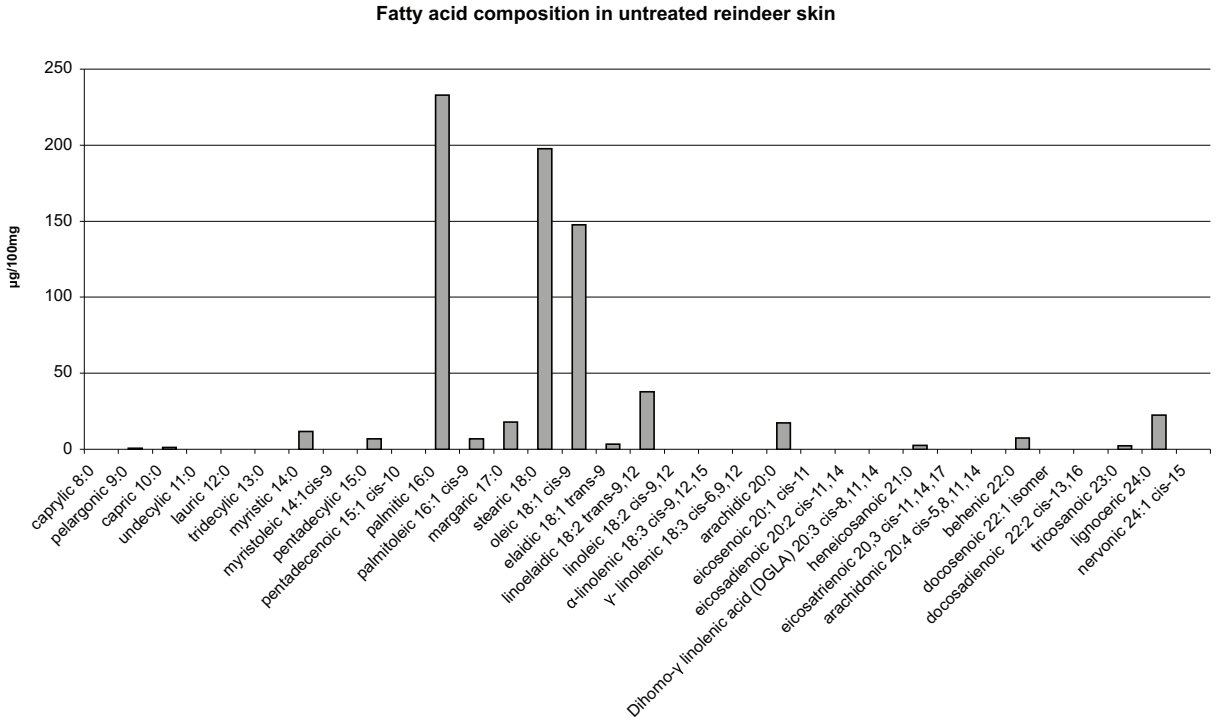


Fig. 5.43. Fatty acid distribution in untreated reindeer skin. The skin is from a 4-5 month old reindeer calf, slaughtered in Finnmark, Norway in August 2004.

Major fatty acids, such as palmitic (16:0), stearic (18:0), and myristic (14:0) acid, along with unsaturated fatty acids such as oleic acid (18:1 *cis*-9) and polyunsaturated fatty acids which have a significant presence, are included in the interpretation. They are presented as µg fatty acid found in 100 mg (milligram) of skin sample and consequently also express the amount of fatty acids present in the samples.

The fatty acid composition has also been illustrated using the UFA/SFA ratio, which expresses the relative distribution of saturated and unsaturated fatty acids (in %) in a sample. In addition, the relation between docosenoic acid (22:1 isomers) acid and eicosenoic (20:1 *cis*-11), the C22/C20 ratio, is tested to investigate the possible presence of fish oils.

5.4.3 Fatty acid content

The fatty acid (FA) content of skin material artefacts is an approximate value. The samples have in this study been obtained from an area on the garment where wear and tear is expected to be extensive. The skin garment may also have been exposed to additional fatty substances through regular activities such as slaughtering, skin processing spill and cooking, which can disrupt the results. In addition the individual method of skin processing and fat application will cause a variance in the total FA content. Another factor which must be considered is that the skin of the animal may contain more or less fat, based on dietary factors such as grazing quality and access, as well as being based on the time of year the reindeer is slaughtered. Skin from reindeers slaughtered in early fall generally contain more inherent fat than skin from animals slaughtered in late winter or spring, when access to food is lower. This feature, that some skins contain more fat than other skins, is confirmed by the informants (Kemi Eira, 2005, pers. comm.).

Variation in fat content can be observed in figures 5.44 and 5.45. The Sámi culture historic samples generally contain more fats than the Evenk culture historic samples. The reference material does not show the same tendency (Fig. 5.44). It is expected that when a garment is worn, the wear and tear in addition to decomposition of the fatty acids will cause a decrease in FA content. Consequently the historic sample material should generally have a lower FA content than the reference samples. This is however not observed. One reason may be that the original fat content of newly made manually processed skin varies significantly as a result of individual preference, skill and tradition. Comparing newly made and historic sample material regarding fat content is therefore especially interesting.

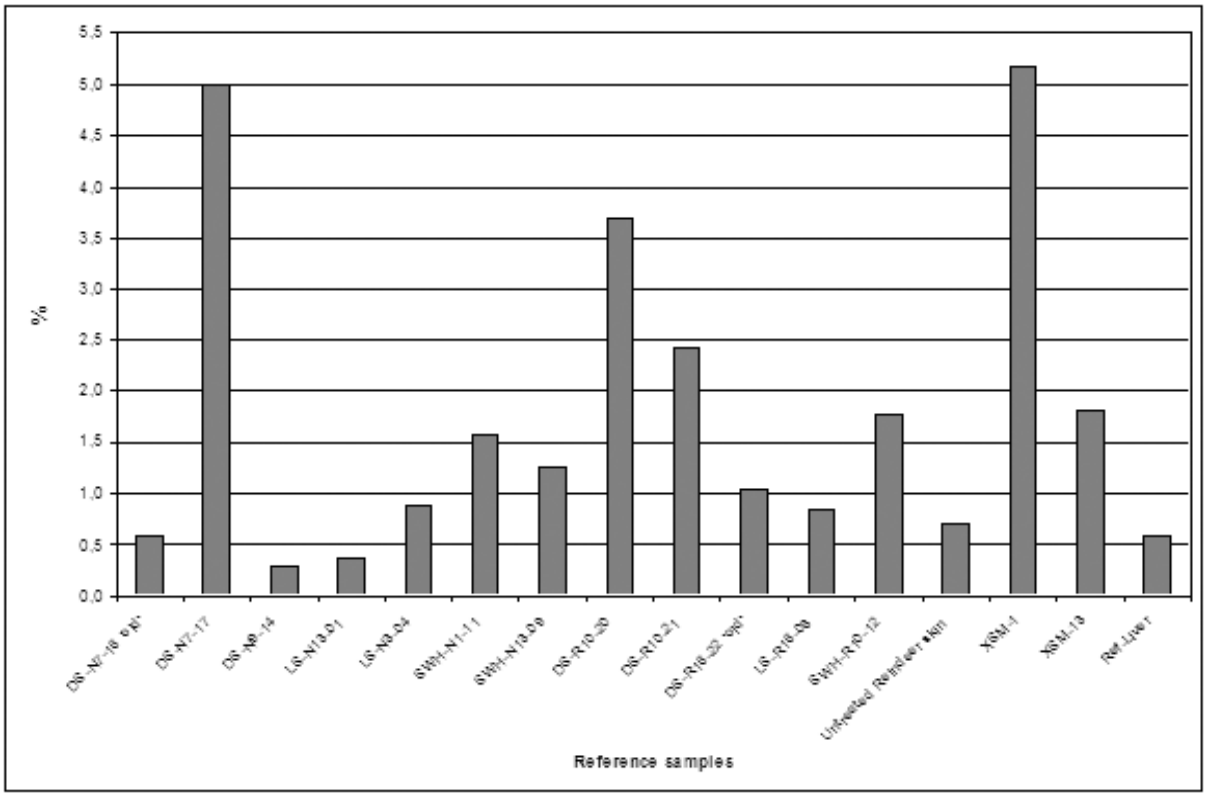


Fig. 5.44. Fatty acid content in Sámi and Evenk culture reference samples and experimental samples. % of total sample weight.

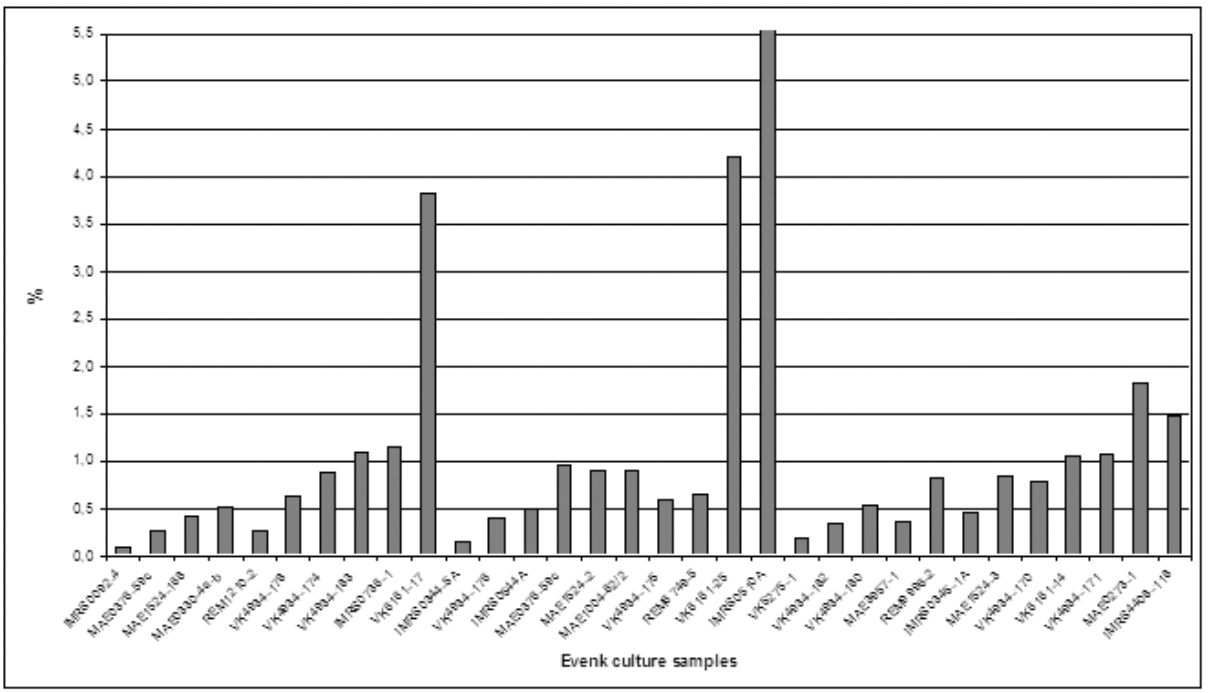


Fig. 5.45. Fatty acid content in Evenk culture historic samples. % of total sample weight.

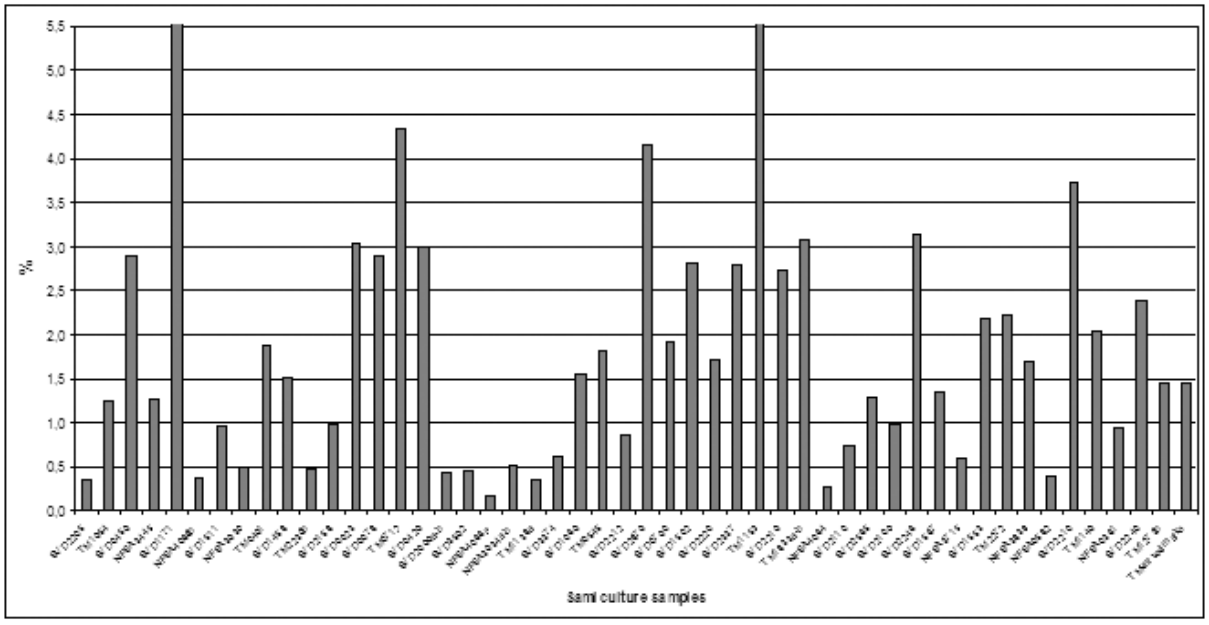


Fig. 5.46. Fatty acid content in Sámi culture historic samples. % of total sample weight.

Fat content may be used for different purposes, for example in investigating the 'leather ↔ fat' interaction regarding deterioration and preservation.

5.4.4 Characterisation of Evenk and Sámi culture reference samples

The oils used in the Sámi culture references are mixtures of oils bought locally as skin processing oils, and these typically stay on the market for a fairly short period of time. The informants refer to the oils, which have been utilised the last few years, as the dark oils, the light oils, and the pinkish white oils. The darkest oils are not preferred by the informants because they yield a hard and dark surface with an unpleasant smell, indicating that the oil mixture possibly contains fish oils and/or self-drying oils. The pinkish white oil, which is an emulsion, is preferred for its good penetrating characteristics, its pleasant smell, and for yielding a soft and pliable skin. The composition of these oils is unknown. Skin processing oils of this type are, however, often sold by the tanning industry, as a by-product from leather production. They are often mixtures of different oils, both synthetic and natural oils, and may contain fatty substances left over from skin processing in the commercial leather industry. A weak scent resembling a solvent is possibly due to an added mineral oil (Granberg Garveri, 2005, e-mail). Mineral oils are not generally favoured in skin processing as they are non-polar and can migrate as the leather comes in contact with water. However, they have good penetrating abilities and are sometimes added to the skin processing oil for this reason (Thorstensen, 1976:205).

None of the reference samples contain fish oil, with the possible exception of DS-N7-17. By comparing the fatty acid distribution of DS N7-17 and the experimental sample XSM-1, where cod liver oil is used as a lubricant, the type and relative amount of fatty acids are related (Fig. 5.47). Fish oils have characteristic peaks for myristic (14:0), palmitic (16:0), palmitoleic (16:1 *cis*-9), stearic (18:0), oleic (18:1 *cis*-9), and stearidonic acid, and particularly the long chain unsaturated fatty acids, such as eicosenoic (20:1 *cis*-11), eicosapentaenoic (20:5) docosahexaenoic (22:6), and docosenoic acid (22:1 isomer) (DeWitt, 1963:95; Wouters *et al.,* 1996:107). With the FAME standard used in the analysis, 22:1 *cis*-13 is the only docosenoic acid isomer determined in the fatty acid distribution. In most of the literature concerning the fatty acid composition of fish oils, the specific 22:1 acid isomer is rarely mentioned. The docosenoic acid generally presented in the analysis of fish oils is 22:1 *cis*-9 and 22:1 *cis*-11. However, docosenoic n-11 and n-13 are mentioned together as monounsaturated fatty acids found in marine oils (Padley *et al.*, 1994: 3,170,173). In the following interpretation, the term docosenoic acid (22:1 isomer) will be used instead of specifying the isomer of this fatty acid.

The long-chain unsaturated fatty acids change upon decomposition. The decomposition rate depends on the degree of unsaturation, and they are not

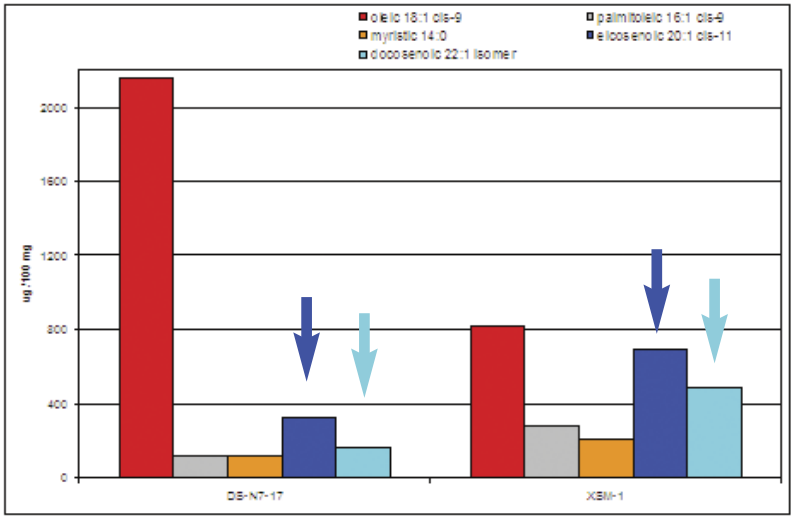


Fig. 5.47. The correlation between eicosenoic (20:1 *cis*-11) acid and docosenoic acid (22:1 isomer) in reference sample DS-N7-17 and the experimental sample XSM-1.

generally found in the fatty acids distribution in the sample material. An exception is the docosenoic (22:1 isomer) and eicosenoic acid (20:1 *cis*-11) found in DS-N7-17. A differentiating characteristic of cod liver oil is the relatively large amount of oleic acid (18:1 *cis*-9), a comparatively small peak of myristic acid (14:0) and equal amounts of 20:5, 22:1, and 22:6. Furthermore, the amount of 20:1 is less than double that of 22:1 (DeWitt, 1963:95). The reference samples DS-N7-17 and XSM-1 encompass these characteristics (Fig. 5.47 and 5.48). Calculating a ratio of docosenoic and eicosenoic acid, the C22/C20ratio of the skin sample treated with cod liver oil, XMS-1, is 0.7. Using this value as a mean, it can be argued that DS-N7-17, with a value of 0.5, does contain fish oils. The value of this ratio seems to lie between approximately 0.4 up to 2.0, with an average on 0.5-1.0. These values are acquired from fatty acid distribution tables in literature sources, and the ratio is calculated from these distributions (DeWitt, 1963:96; Ackman, 1967:910,912; Innis & Kuhnlein, 1987:107; McGill & Moffat, 1992:362; Padley, *et al.,* 1994:170, Kirsch *et al.*, 1998: 1381-1382; Budge *et al.,* 2002:890). It is not

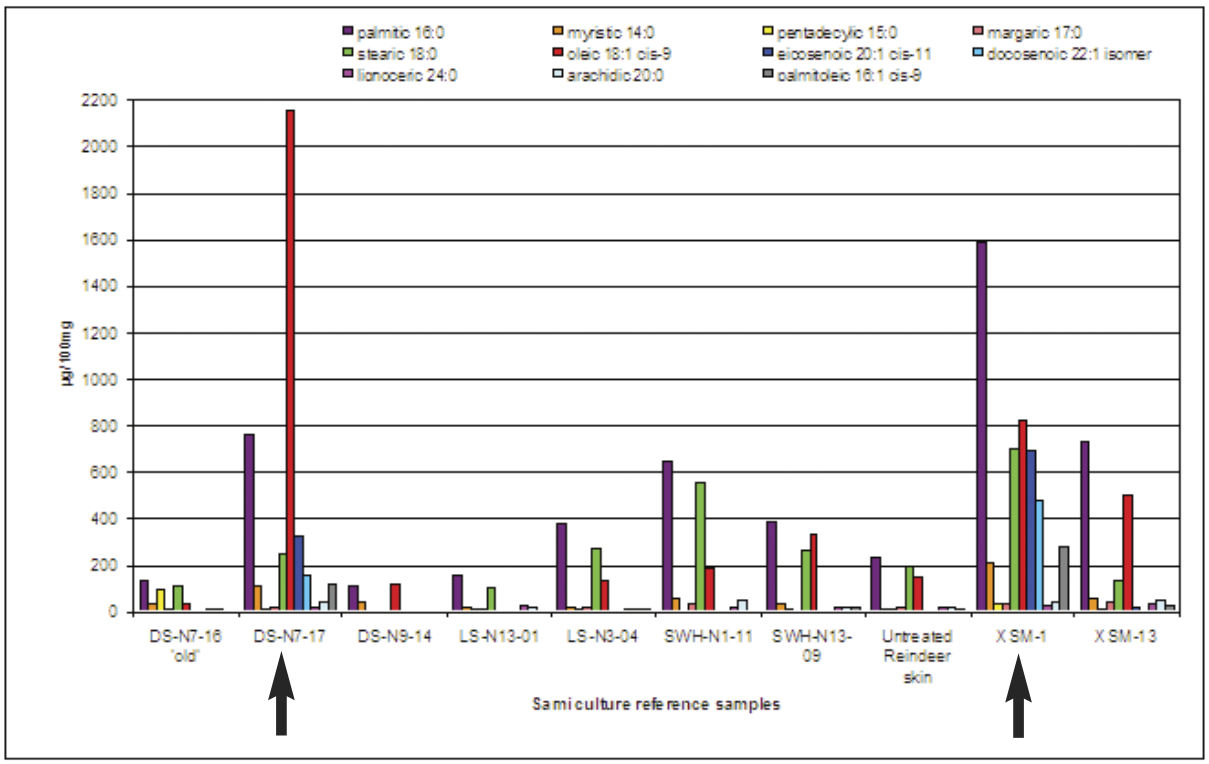


Fig. 5.48. Fatty acid distribution in Sámi culture reference samples and experimental samples. The samples DS-N7-17 and XSM-1, which possibly contain fish oils, are indicated with blue arrows.

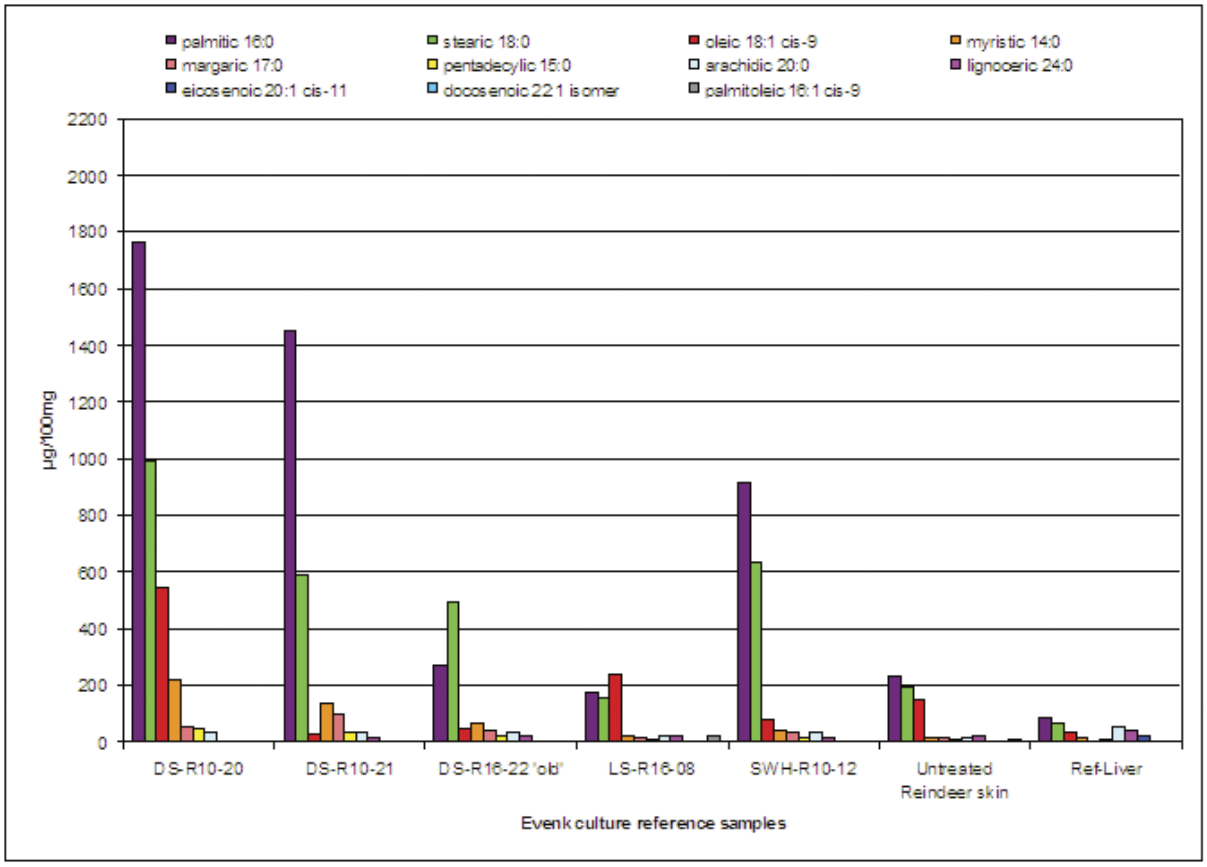


Fig. 5.49. Fatty acid distribution in Evenk culture reference samples. DS-R10-21 and SWH-R10-12 have according to the informant not been smoked.

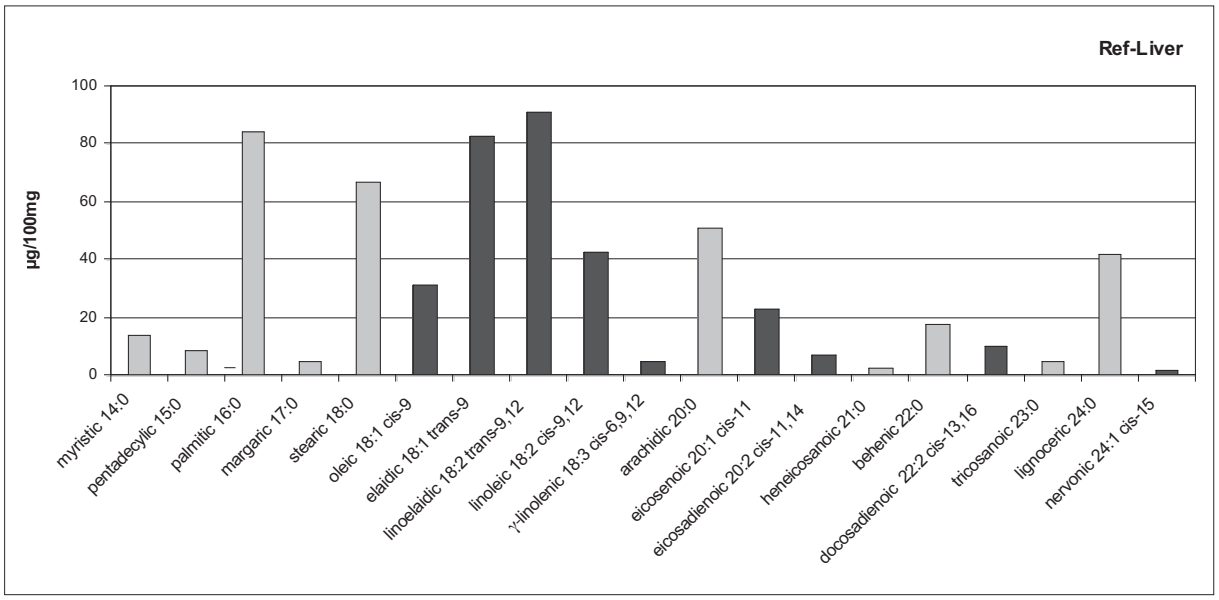


Fig. 5.50. Major fatty acids present in pure (unprocessed) reindeer liver, Ref-liver. The characteristic unsaturated fatty acids in the C18, C20, and C22 series are indicated as black columns. Note the scale difference in relation to the other illustrations.

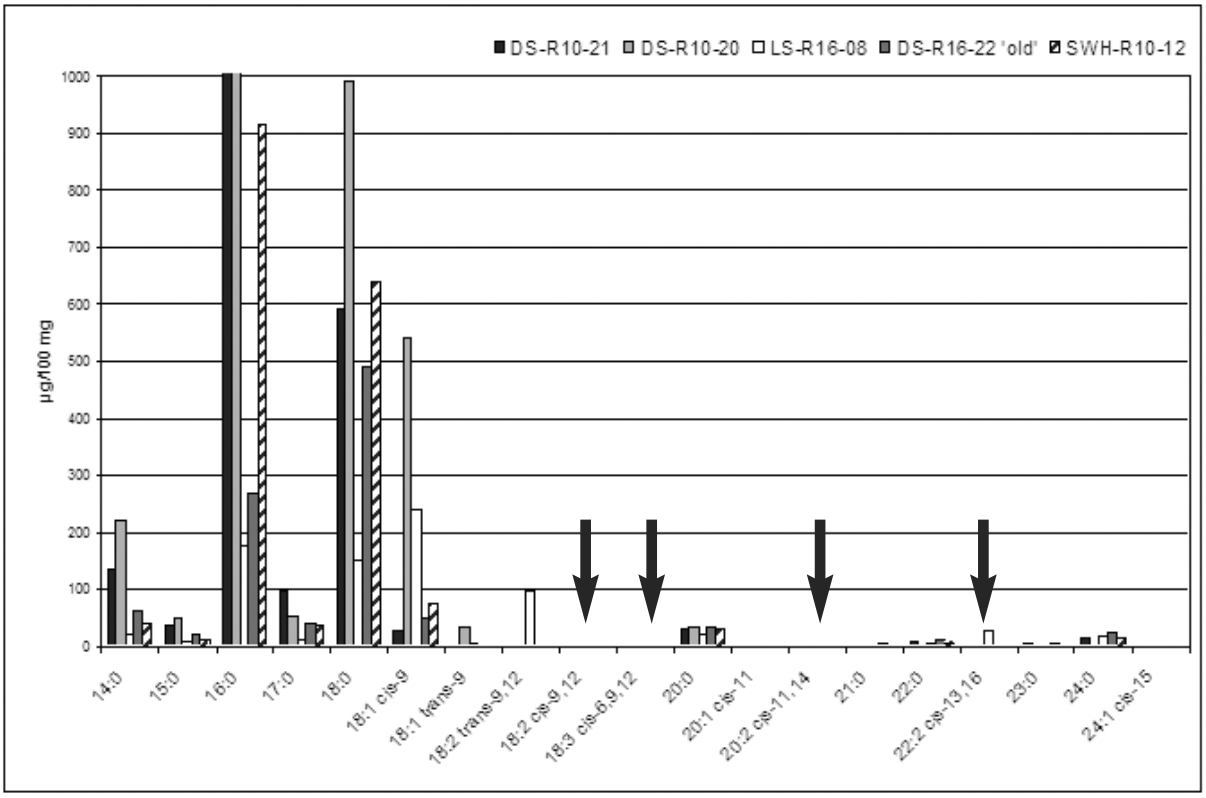


Fig. 5.51. Illustrating the lack of polyunsaturated fatty acids in the Evenk culture reference samples, indicated by arrows.

unexpected that only one reference sample possibly contains fish oil, as the informants today mostly use the locally bought skin processing oils and only occasionally use the home made cod liver oil.

It is expected that the Sámi culture reference samples vary in fatty acid composition because of the diverse composition of the skin processing oils used in these samples. The Evenk culture reference samples obtained in this study, however, only contain boiled reindeer liver as a fatty substance. This gives a fairly uniform representation of the fatty acids in the Evenk culture reference samples, even though the amounts differ (Fig. 5. 49). Liver lipids (unprocessed) are rich in unsaturated fatty acids in the C18 series and C20-C22 series and the saturated fatty acids are mainly comprised of palmitic acid (16:0) and stearic acid (18:0) up to 30-40 % of the total fatty acid content (Hilditch & Williams, 1964: 133-137; Padley *et al.,* 1994:198-199) (Fig. 5.50).

The major fatty acids present in the Evenk culture reference sample material are palmitic (16:0) and stearic acid (18:0), followed by oleic acid (18:1 *cis*-9), myristic acid (14:0) and smaller amounts of arachidic (20:0) and lignoceric (24:0) acid. Very few unsaturated fatty acids are present, with the exception of the monounsaturated fatty acids in the C18-series. The polyunsaturated fatty acids in the C18, C20 and the C22 series, which are observed in the pure sample of reindeer liver (Fig. 5.50), are not visible in the reference samples (Fig. 5.51). This confirms the rapid decomposition of polyunsaturated fatty acids occurring in the sample material.

5.4.5 Characterisation of historic sample material from the Evenk and Sámi culture

The main fatty acids present in the historic sample material are palmitic (16:0), stearic (18:0), oleic (18:1 *cis*-9), and myristic (14:0) acid. These are the predominant fatty acids present in land animal adipose tissue. They are also present in significant amounts in liver, brain and milk fats. Smaller amounts of pentadecylic (15:0) and margaric (17:0) acid and also arachidic (20:0) and palmitoleic (16:1 *cis*-9) acid is also found in the historic samples, although not in all and in various amounts. Palmitoleic (16:1 *cis*-9) acid is widely distributed in plant and animal fats as well as in fish oils. The odd numbered fatty acids pentadecylic (15:0) and margaric (17:0) acid, are in particular present in ruminant fats,

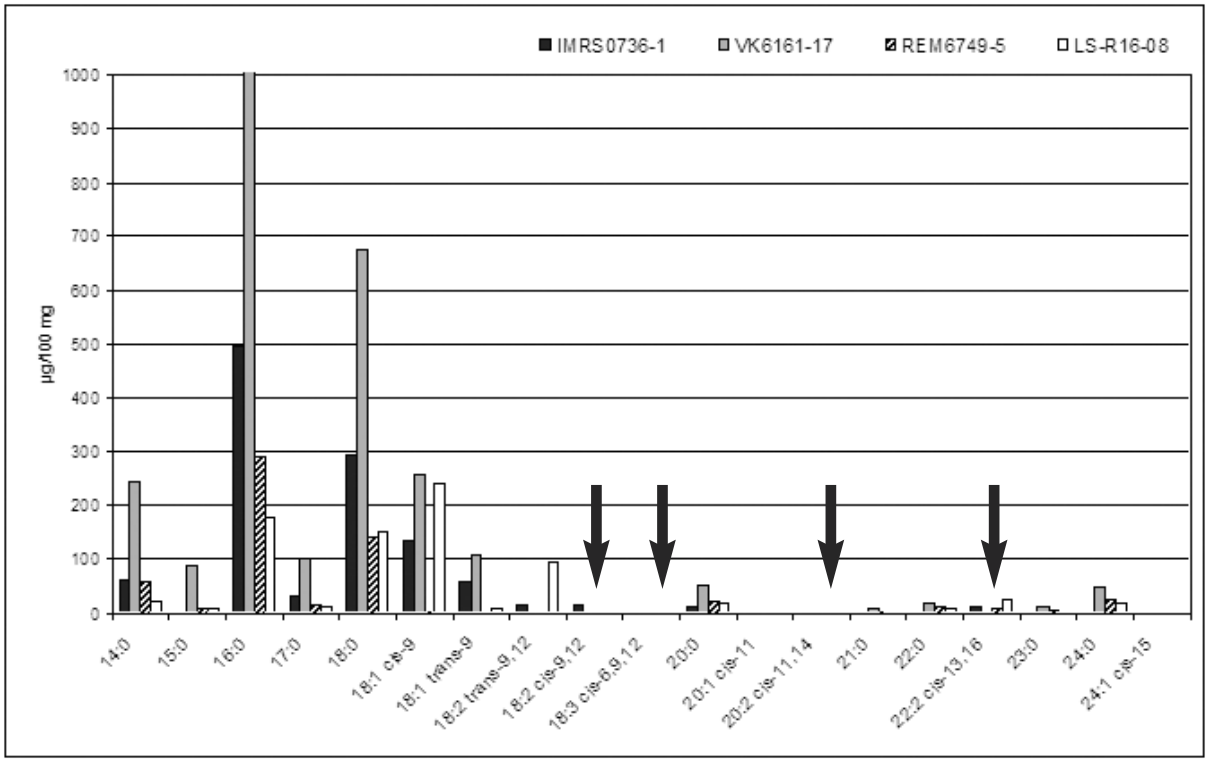


Fig. 5.52. Illustrating the lack of polyunsaturated fatty acids in selected Evenk culture historic samples. PUFA's which are only slightly or not present are indicated by arrows.

and have been identified in milk and butter fats. These fatty acids have, however, also been reported in hair fat, mutton fat and in shark liver oil (Morice & Shorland, 1955:455).

Generally, the content of fatty acids is higher in the Sámi culture historic samples than in the Evenk culture historic samples, as is shown in figure 5.45 and 5.46.

There are several groups of fats which may have been used in the processing of skin material in the Evenk culture in the last centuries. Reindeer liver, milk fats and fish oil are possibilities that can be considered. Vegetable oils may also have been used, although probably only in the last decades. As expected, the polyunsaturated fatty acids found in the pure reindeer liver sample, are not found in naturally aged historic samples from the Evenk culture (Fig. 5.52). The rapid decomposition of the polyunsaturated fatty acids is observed in the reference samples where reindeer liver is used as a fatty substance. The main fatty acids left in the samples are saturated fatty

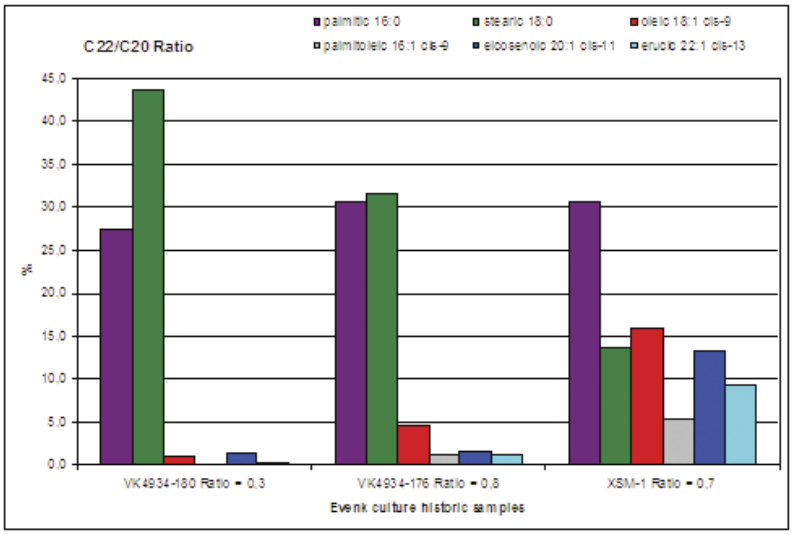


Fig. 5.53. The possible presence of fish oil in two Evenk culture historic samples; VK-4934-176 and VK-4934-180 using the C22/C20 ratio. The experimental sample XSM-1 which does contain cod liver oil is included for comparison.

acids and some proportion of monounsaturated fatty acids, which have a slower decomposition rate. This is generally observed in all samples, and illustrates that even though there may have been sharp distinctions in fatty acid composition when the historic material was originally processed, the natural ageing of lipids erases these distinctions.

The major difference in the Sámi and Evenk culture historic samples is the presence or absence of eicosenoic (20:1 *cis*-11) and docosenoic (22:1 isomer) acid. These fatty acids are used as indicators of the presence of fish oils, if at the same time oleic (18:1 *cis*-9) and palmitoleic (16:1 cis-9) acid are present in appreciable amounts. These fatty acids are present in some Sámi culture historic samples but virtually absent in the Evenk culture historic samples.

Fish and seal oils were used in skin processing in the Evenk culture in the 18th and 19th century (Georgi, 1775: 261; Erman, 1833:156 & 1838: 570), but there are no clear indications of this in the historic samples of this study. Using the C22/C20 ratio indicates that perhaps two historic samples from the Evenk culture: VK-4934-180 and VK-4934-176 may contain fish oil (Fig. 5.53). Using the same ratio for the Sámi culture historic samples yields 12 samples possibly containing fish oil (Fig. 5.54). The most convincing are the samples which in addition to having a C22/C20 ratio in the vicinity of the reference sample XSM-1 of 0.7, contain appreciable amounts of oleic and palmitoleic acid (Fig. 5.53 and 5.54).

Another difference in the Sámi and Evenk culture historic samples is the content of myristic (14:0) acid. Myristic (14:0) acid and other short chain fatty acids, such as caprylic (8:0), capric (10:0), and lauric (12:0) acid, are present in milk and butter fats. Myristic (14:0) acid is not only present in milk and butter fats, but also in marine oils. These short chain fatty acids are, however, not present in large amounts (Hilditch & Williams, 1964:146; Gunstone, 2004:19-20). They are also present in the historic sample material, with a slightly higher content in the Sámi culture samples than in the Evenk culture samples. The tradition of using milk fats in skin processing is presently stronger in the Sámi culture than in the Evenk culture. The Evenk culture has, however, used milk fats historically, at least in some areas (Georgi, 1775:261). Milk fats also contain significant amounts of oleic (18:1 *cis*-9) acid and small amounts of *trans* acids, mainly C16 and C18 monoene

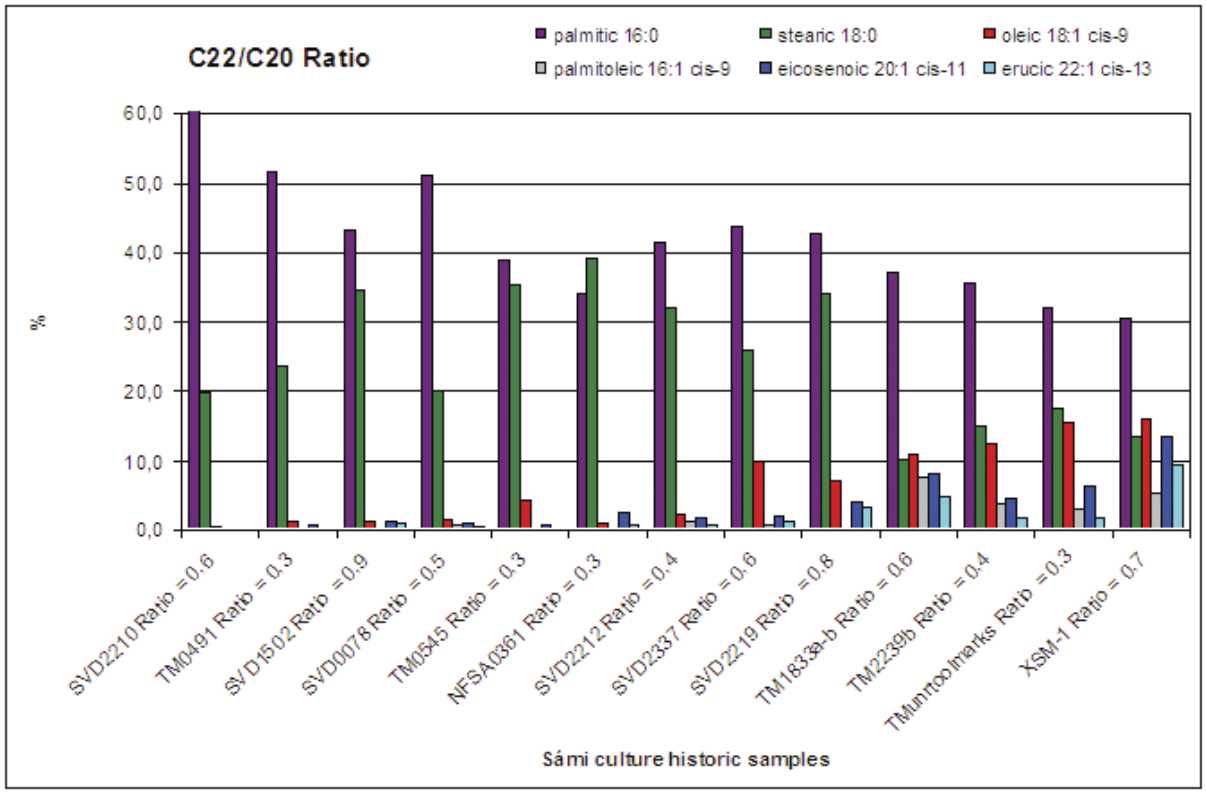


Fig. 5.54. The possible presence of fish oil in Sámi culture historic samples using the C22/C20 ratio. The experimental sample XSM-1 which does contain cod liver oil is included for comparison.

acids (Gunstone, 2004:19, 53). Studying the general FA composition in the Sámi and Evenk culture historic samples (Fig. 5.59 and 5.60), the Sámi culture sample population generally have a higher content of the short chain saturated fatty acids and the monounsaturated fatty acids.

Through the interviews, the informants both in the Sámi and Evenk culture expressed that vegetable oils were sometimes used in skin processing, something which is not mirrored in the fatty acid distribution of the historic samples. If vegetable oils are used, the presence of polyunsaturated fatty acids in the 18:2 and 18:3 series should be present, at least in the reference samples. The instability of polyunsaturated fatty acids reduces the expected existence of these acids and makes it difficult to suggest if they are used, or if they are not used. There is possibly one exception, and that is in the Sámi culture reference material. SWH-N13-09 contains palmitic, stearic and high amounts of oleic acid. In addition, this distribution confirms the presence of two polyunsaturated fatty acids linoelaidic (18:2 *trans*-8,12) and linoleic (18:2 *cis*-8,12) acid which occur in some plant oils, such as for example olive oil (Fig. 5.55).

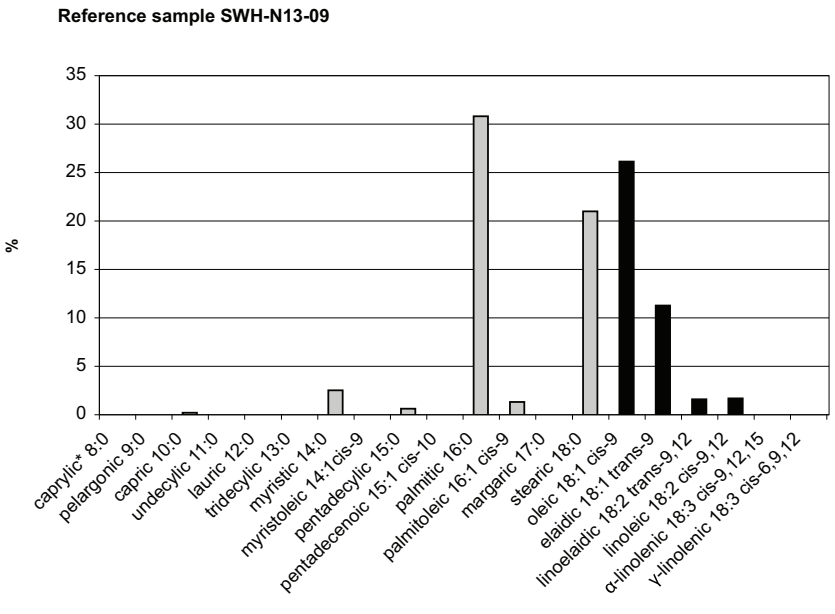


Fig. 5.55. Reference sample SWH-N13-09, possibly containing vegetable oil. The *cis* and *trans* isomer forms of the monounsaturated fatty acid 18:1 n-9 and linoelaidic (18:2 *trans*-8,12) and linoleic (18:2 *cis*-8,12) acid, which occurs in some plant oils, are indicated as black columns.

When studying the fatty acid composition over time, it is usually observed that the relative amount of saturated fatty acids (SFA) increases due to the decomposition of the unsaturated fatty acids (UFA) (Malainey *et al.*, 1999b: 95). This is also observed through the UFA/SFA ratio of the historic samples, using the reference samples' UFA/SFA ratio for comparison. As the relative amount of SFA increases, the ratio decreases. This feature has a serious disadvantage, which is that the fatty acid composition becomes less distinct and the similarity between groups of fats increases. This loss of long chain unsaturated fatty acids and the subsequent loss in distinction is also observed as fats are thermally manipulated (Malainey *et al.,* 1999b:100).

Thermal manipulation of fats used in skin processing is not unusual. In the Evenk culture the informants have described how brain substance and the fatty layer of fur skin animals are heated to obtain good quality oil used in skin processing. Reindeer liver is also boiled and mashed prior to application. The literature furthermore describes the use of warm fish oil being sprayed onto the skin (Erman, 1838:343). Thermal manipulation is not mentioned in the production of oils in the Sámi culture, apart from when the fatty substance which collects on the surface of broth, when boiling meat, is used. This solid fat and commercial fats such Boston leather fat may be heated to obtain the preferred viscosity before application (Eira Buljo, 2004, pers. comm.).

Figure 5.56 and 5.57 displays the UFA/SFA ratio of the historic samples and indicates that the fatty substances remaining in the sample chiefly are composed of saturated fatty acids. Very few samples have a ratio indicating the presence of fish oils or other drying oils, which are similar to the ratio found in experimental sample XSM-1. Examining the UFA/SFA ratio for indicating the presence of fish oil in the historic sample material is, however, problematic. Choosing samples from the Sámi, as well as from the Evenk culture sample population, which have UFA/SFA ratios above 0.4 (five samples in total) indicates that three of the five samples may contain fish oil similar to that observed

in the experimental sample XSM-1. These samples: TM-1833a-b, TM-2239 and TM-unr-toolmarks are all from the Sámi culture (Fig. 5.58) and the same three samples are also identified using the C22/C20 ratio (Fig. 5.54).

5.4.6 Summary

The amount of lipids present in the skin samples vary from very low lipid content to very high lipid content. This may be caused by the variability of fats applied to the skin, due to preference, skill and experience of the

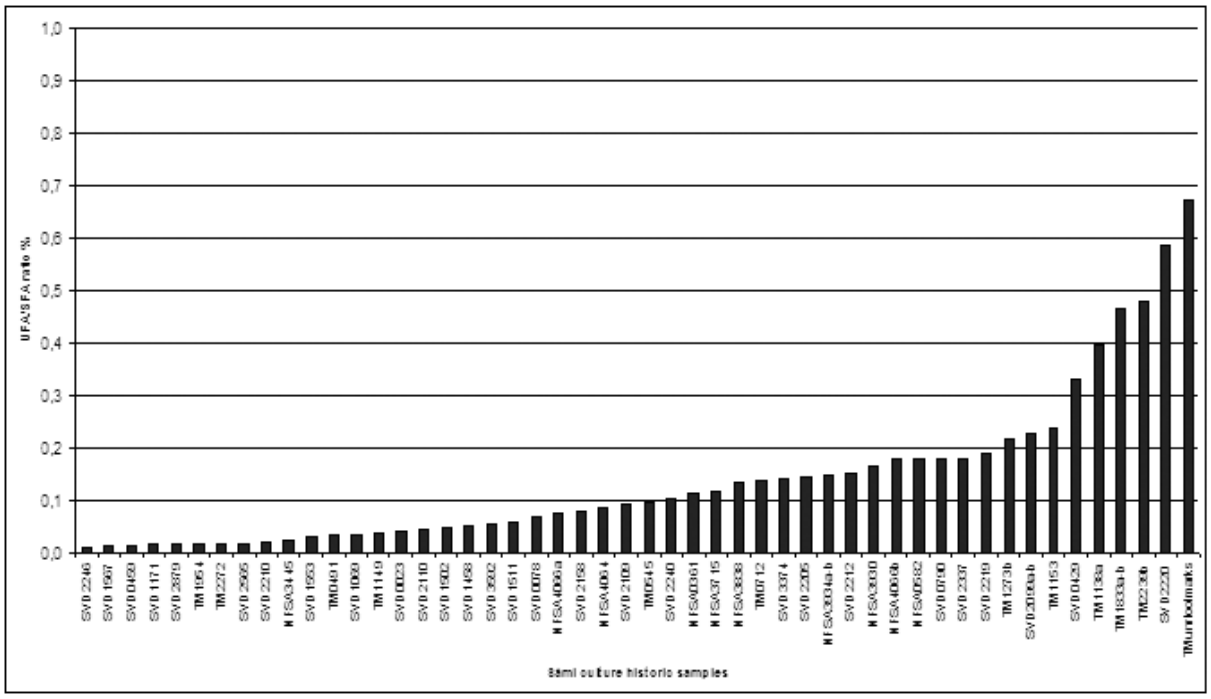


Fig. 5.56. UFA/SFA ratio of the Sámi culture historic samples.

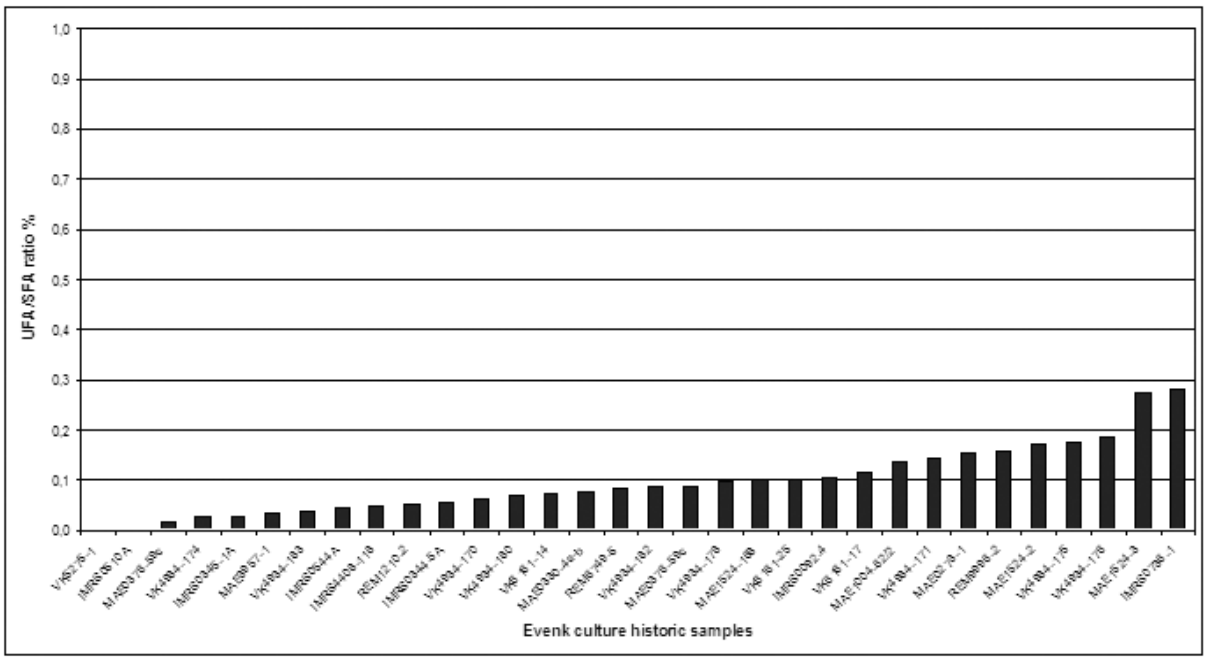


Fig. 5.57. UFA/SFA ratio of the Evenk culture historic samples.

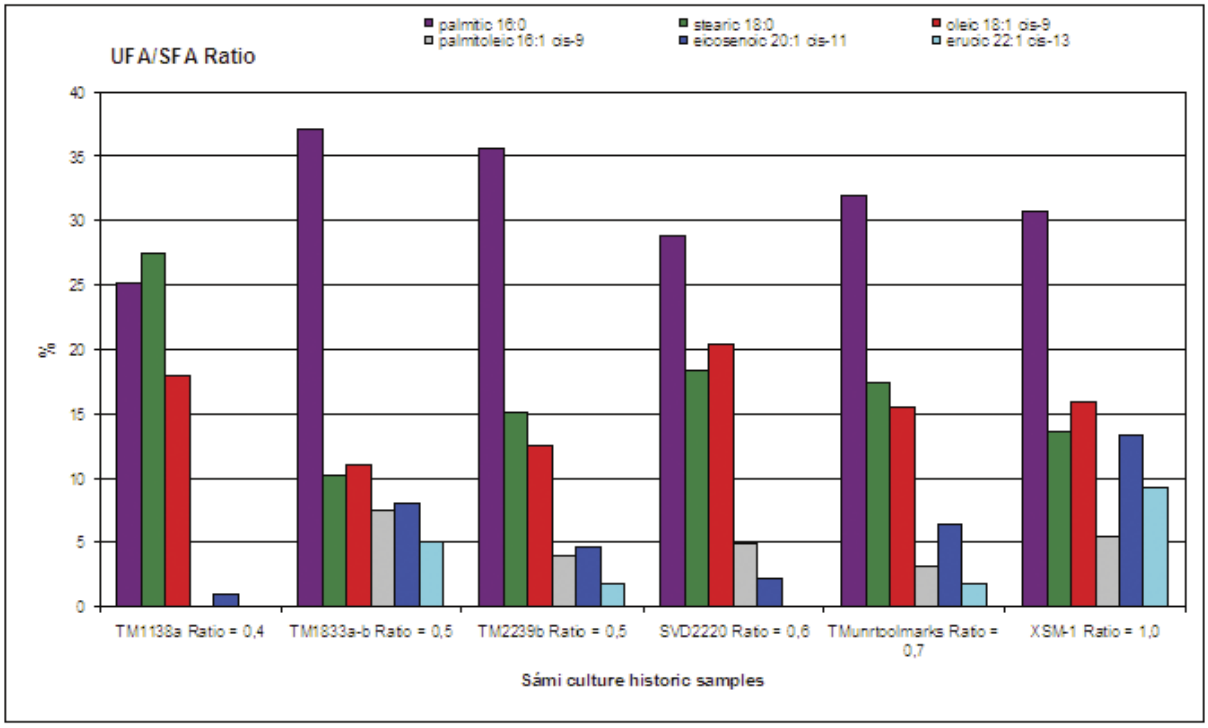


Fig. 5.58. The possible presence of fish oil in Sámi culture historic samples using UFA/SFA ratio.

performer, as well as by the type of skin produced. Little or no fat may be applied to materials which are used in arid and very cold climates, as opposed to materials which are to be used under humid or wet conditions. These considerations also apply to artefact type. An example from the Sámi culture is depilated skin bags used for food, a skin material which is not lubricated. On the other hand, if a depilated skin is to be used for summer boots, soles or summer leggings, fat is applied to obtain a skin which has water repellent qualities.

The considerable differences of lipid content may also have other causes, such as the possible contamination due to regular everyday activities when the artefact was in use, and the possible application of lubricants as part of a conservation process. The expected decrease in fatty substances in a skin material may not only be a result of the decomposition of the lipid molecules but also from a primary wear and tear, resulting in a wash-out of fatty substances from the artefact. In the interpretation of fatty acid content and distribution of historic skin sample material, it is therefore important that these contextual factors are included. The factors also include the information that exists regarding the historic and present use of fats and oils in the various cultures. To be able to narrow down the investigation into what fats that may have been used, the information from the informants is very important, as are also the available literature sources.

In this study it is shown that the variety of fats which are used in skin processing consist of four major fatty substance groups: dairy fat, fish fat, vegetable fat and mammal fat. In order to be able to distinguish between these four groups, the analytical scheme is extensive. This research can illustrate some tendencies, based on the available sample material.

Studying the content of each of the predominant fatty acids, in the reference samples and in the historic samples, demonstrates that the Sámi culture material generally contains more fat than the Evenk culture samples. It furthermore shows that the main fatty acids present in all the skin samples are palmitic (16:0) and stearic (18:0) acid. This is not unexpected as these are the main fatty acids in most fats and oils, and particularly in mammal fats. Mammal fats and also marine oils, and in particular cod liver oil, seem to be the main sources of fat historically used in skin processing technology in the Sámi and Evenk culture.

The fatty acids, apart from the saturated fatty acids (SFA) palmitic and stearic acid, found in the Evenk culture samples, include the monounsaturated fatty acid oleic (18:1 cis-9) acid, and saturated fatty acids,

such as myristic (14:0), margaric (17:0), and arachidic (20:0) acid.

The fatty acids, apart from palmitic and stearic acid, found in the Sámi culture samples are saturated fatty acids, such as myristic (14:0), margaric (17:0), and arachidic (20:0) acid. The content of eicosenoic (20:1 *cis*-11) and docosenoic (22:1 isomer) acid is significant in some of the Sámi culture samples, indicating the presence of fish oil. These same samples also contain an appreciable amount of palmitoleic acid (16:1 *cis*-9), also present in fish oil.

Furthermore, most samples from both the Sámi and the Evenk culture contain an appreciable amount of the monounsaturated acid, oleic (18:1 cis-9) acid, but not all. Even though the C22/C20 ratio and the UFA/SFA ratio may be useful in interpreting the fatty acid composition in the search for, for example, traces of fish oil, the decomposition of the fats, yielding lower numbers and lower amounts of polyunsaturated fatty acids, makes distinction problematic. A low amount of unsaturated fatty acids (UFA) generally yields a low UFA/SFA ratio, which is generally observed for a considerable part of the sample material. This is not unexpected, since the ratio decreases as the highly reactive unsaturated fatty acids decompose. Also, if the unsaturated fatty acid content originally is low due to the specific fats used, a further decomposition of the UFA will render the UFA/SFA ratio even lower.

Several of the samples which possibly contain fish oils, also contain appreciable amounts of myristic acid, which is present in milk fats. It is known that fermented milk, in the Sámi culture area, from the mid 1950 until today, was an important fatty substance. The C14:0 content and the presence of short chain fatty acids, in some of the samples may therefore be explained as residues of a dairy product. In general, the content of short chain saturated fatty acids is lower in the Evenk culture sample material (Fig. 5.59, 5.60), indicating that dairy products are not present.

The application of fatty substances from vegetable sources seems to be absent from the sample material. This is not unexpected, as the use of vegetable oils in skin processing technology primarily is of a more recent date.

Saturated fatty acids (SFA)

Common name	Systematic name	Short-hand	Other name	Molecular formula	Molecular weight	Melting point - ° C	Sources
Caprylic acid	n-octanoic acid	8:0	Methyl octanoat	$C_8H_{16}O_2$	144,12	16,7	Present in milk fats (Hilditch & Williams, 1964:143-162).
Pelargonic acid	n-nonanoic acid	9:0	Methyl nonanoat	$C_9H_{18}O_2$	158,23	12,5	Formed by oxidation of oleic acid (Markely, 1947:424-434).
Capric acid	n-decanoic acid	10:0	Methyl decanoat	$C_{10}H_{20}O_2$	172,26	31,6	Present in milk fats (Markley, 1947:23).
Undecylic acid	n-undecanoic acid	11:0	Methyl undecanoat	$C_{11}H_{22}O_2$		29,3	Ozonation of fish oil followed by hydrolysis gave undecanoic, undecanal, and azelaic acid (Markley, 1947:426).
Lauric acid	n-dodecanoic acid	12:0	Methyl laurat	$C_{12}H_{24}O_2$	200,31	44,2	One of the 3 most common found in nature. Seed fats in laurel fam. Seed fats of *Palmae*. In cows butter (4-8%) and in milk fats of other mammals.
Tridecylic acid	n-tridecanoic acid	13:0	Methyl tridecanoat	$C_{13}H_{26}O_2$	214,19	41-42	Traces in marine fish body oil. Small amounts in Palmae in ex. coconut oil. Small amounts also in animal depot and milk fats (Hilditch & Williams, 1964: 339, 585).
Myristic acid	n-tetradecanioc acid	14:0	Methyl myristat	$C_{14}H_{28}O_2$	228,36	53,9	Found in most animal and vegetable fats. Generally, 1-5 % of total fatty acids. In milk fats 8-12 % of the total acids.
Pentadecylic acid	n-pentadecanoic acid	15:0	Methyl pentade-canoat	$C_{15}H_{30}O_2$		52,3	Found in dairy products/milk fats (Lipomics, 2006). Found in mutton, hair and milk fats (Lipidbank.jp) and in shark liver oil (Morice & Shorland, 1955:455).
Palmitic acid	n-hexadecanoic acid	16:0	Methyl palmitat	$C_{16}H_{32}O_2$	256,42	62,0-63,5	In all animal and vegetable fat, but in low proportions - less than 5 % in the majority fats. Found in many vegetable oils (peanut, soybean, corn oils) and many fish and marine oils where it may comprise 10 % of total fatty acids. The most common in aquatic animal fats – 15 % of total fatty acids.
Margaric acid	n-heptadecanoic acid	17:0	Methyl heptade-canoat	$C_{17}H_{34}O_2$	270,45	60,8-61,5	Similarity in properties with palmitic acid and stearic acid may make identification difficult (Markley, 1947:15). Traces of odd numbered saturated fatty acids have been found in animal depot fats (Hilditch & Williams, 1964:585) and in shark liver oil (Morice & Shorland, 1955:455).

Common name	Systematic name	Short-hand	Other name	Molecular formula	Molecular weight	Melting point - ° C	Sources
Stearic acid	n-octadecanoic acid	18:0	Methyl stearat	$C_{18}H_{36}O_2$	284,47	69,2-70,5	Although in fewer species of plants and animals and often smaller proportion than palmitic - where the two occur together - it is of prime importance in commercial fats. Small amounts in marine oils and 5-15 % in milk fats. Predominant in animal body fats and 10-30 % of the fatty acids of lard and tallow.
Arachidic acid	n-eicosanoic acid	20:0	Methyl arachidat	$C_{20}H_{40}O_2$	312,30	75,3	Widely distributed, but minor component in most fats. Mainly in peanut oil and related seed plants. Also found in fish oil.
Heneicosanoic acid	n-heneicosanoic acid	21:0	Methyl heneicosanoat	$C_{21}H_{42}O_2$	326,32	74,3	Trace acids in animal depot and milk fats (Hilditch & Williams, 1964: 152-153, 585).
Behenic acid	n-docosanoic acid	22:0	Methyl behenat	$C_{22}H_{44}O_2$	340,57	80,0	Minor component in a few oils (peanut, rapeseed. Also in fats of some sharks and a few other marine animals (Markley, 1947:24).
Tricosanoic acid	n-tricosanoic acid	23:0	Methyl tricosanoat	$C_{23}H_{46}O_2$	354.62	79-80	Traces in milk fats (Hilditch &Williams, 1964: 585).
Lignoceric acid	n-tetracosanoic acid	24:0	Methyl lignocerat	$C_{24}H_{48}O_2$	368,6	84,2	Widely distributed in natural fats, but small amounts. Principally in seed oils and legume family.

Table 5.8. Saturated fatty acids found in the sample material.

Unsaturated fatty Acids (UFA)*

Common name	Systematic name	Short hand	Other name	Molecular formula	Molecular weight	Melting point °C	Sources
Monounsaturated fatty acids (MUFA), $C_nH_{2n-2}O_2$							
Myristoleic acid	9-tetradecenoic acid	14:1 *cis*-9	Methyl myristoleat	$C_{14}H_{26}O_2$	226,35	112,15	Traces found in depot fats of land animals (in butter), and up to 1 % in marine oils. Whale blubber, shark liver, antarctic whale and turtle, eel, milk fats (Lipomics, 2006).
Pentadecenoic acid	*cis*-10 pentadecenoic acid	15:1 *cis*-10	Methyl pentadecenoat	$C_{15}H_{30}O_2$			

Palmitoleic acid	9-hexadecenoic acid	16:1 (n-7) *cis*-9	Methyl palmitoleat	$C_{16}H_{30}O_2$	254,40	99,78	Widely distributed plants and animals. Marine animal oils 15-20 %, bird and mammalian liver fats 6-8 %, mammalian depot fats 3-4 %, milk fats 3-4% (Markley, 1947:27).
Oleic acid	*cis*-9-octadecenoic acid	18:1 (n-9) *cis*-9	Methyl oleat	$C_{18}H_{34}O_2$	282,45	14 - 16	Predominant fatty acid of natural fats. 50 % or more of total fatty acid. Seldom less than 10 % of total fatty acid. The saturated form is stearic acid (Wikipedia, 2006).
Elaidic acid	trans-9-octadecenoic acid	18:1 trans-9	Methyl elaidat	$C_{18}H_{34}O_2$		46.5	Traces in milk fats. Small amounts in ruminant depot fats (Hilditch &Williams, 1964: 110, 150) (*trans* form of *cis* oleic).
Eicosenoic acid	*cis*-11-eicosenoic acid	20:1 *cis*-11	Methyl eicosenoat Also: Gondoic Acid	$C_{20}H_{38}O_2$	310.52	25 - 32	The direct elongation product of oleic acid (18:1 n9). Seed oils of rape, mustard. Reported in oils of menhaden, Atlantic cod and beluga, or white whale blubber (Lipomics, 2006).
Erucic acid	13-docosenoic acid	22:1 (n-9) *cis*-13	Methyl erucat	$C_{22}H_{42}O_2$	338.56	33.8	Found in rapeseed, wallflower seed and mustard seed, up to 40-50 % (Wikipedia, 2006). Also found in cod liver oil (DeWitt, 1963:95).
Nervonic acid	15-tetracosenoic acid	24:1 (n-9) *cis*-15	Methyl nervonat	$C_{24}H_{46}O_2$	366.62	42 - 44	Found in seed oils (Gunstone, 2004:16, 55) and liver oil of spiny dogfish shark (Lipomics, 2006). Occurs in cerebrosides brain and other nerve tissue, especially the myelin sheath (medical-dictionary-freedictionary, 2006). An omega-9 fatty acid.

Polyunsaturated fatty acids (PUFA), $C_nH_{2n-4}O_2$

Linoleic acid	*cis*,*cis*-9,12-octadecadienoic acid	18:2 (n-6) cis-9,12	Methyl linoleat	$C_{18}H_{32}O_2$	280,44		Most important polyunsaturated fatty acid found in plant fats and oils. Follows oleic acid in vegetable fats. Not in marine animal oils (but a few). Characteristic fatty acid of drying oil (Markley, 1947:30).
Linoelaidic acid	trans-9,12-octadecadienoic acid	18:2 trans-9,12	Methyl linoelaidat	$C_{18}H_{32}O_2$	280.5		Linoelaidic acid is the trans fatty acid homolog of linoleic acid.
Eicosadienoic acid	11,14-eicosadienoic acid	20:2 *cis*-11,14	Methyl eicosadienoat	$C_{20}H_{36}O_2$			Found in herring and menhaden oils, cattle-liver, swine brain lipids, shark liver oil (Lipomics, 2006).

Common name	Systematic name	Short hand	Other name	Molecular formula	Molecular weight	Melting point °C	Sources
Docosadienoic acid	*cis*-13,16-docosa-dienoic acid	22:2 *cis*-13,16	Methyl docosa-dienoat	$C_{22}H_{40}O_2$	336.55		Exceedingly rare in all lipid classes (Lipomics, 08.2006). Seen accompanying erucic acid in small proportions in rapeseed oil (Hilditch & Williams, 1964: 630).
Linolenic acid (α) (ALA)	9,12,15-octadeca-trienoic acid	18:3 (n-3) *cis*-9,12,15	Methyl linolenat	$C_{18}H_{30}O_2$	278,42		Especially in vegetable oils, ex: linseed, soy bean, although in small quant. Improves drying capacity of oils (Markley, 1947:32).
γ-linolenic acid (GLA)	*cis*-6, 9, 12 oc-tadeca-trienoic acid	18:3 *cis*-6,9,12	Methyl gamma linolenat	$C_{18}H_{30}O_2$	278.43 -	11.3 to -11	Found in plant based oils (Lipid Bank for Web Database, 2006).
Dihomo-γ linolenic acid (DGLA)	*cis*-8,11,14-eicosatrienoic acid	20:3 *cis*-8,11,14	Methyl eicosatrienoat		306.2		Present in phospholipid classes, cholesterol esters and free fatty acids. Found in fish oils, phosphatides of liver and kidneys of land animals and of brain. In shark liver oil (Lipomics, 2006). Typically 1-2 % of the phospholipids fatty acids (Lipid Library, 2006).
Eicosatrienoic acid	*cis*-11,14,17-eicosatrienoic acid	20:3 *cis*-11,14,17	Methyl eicosatrienoat	$C_{20}H_{34}O_2$	306.48		Found in shark-liver and herring oil (Lipomics, 2006). Usually detected in the phospholipids of animal tissue but rarely at above 1 % of the total. Somewhat higher concentrations may be found in fish oils (The Lipid Library, 2006).
Arachidonic acid	5,8,11,14-eicosatetraenoic acid	20:4 (n-6) *cis*-5,8,11,14	Methyl arachidonat	$C_{20}H_{32}O_2$	304,46	333,50	Found in liver, brain and depot fats of animals, especially phosphatides. Found in herring and cod liver oil (Hilditch & Williams 1964: 641). An omega 6 fatty acid. Present in the phospholipids of membranes of the body's cells, and highly enriched in the brain (Wikipedia, 2006).
Docosadienoic acid	13, 16-Docosa-dienoic acid	22:2 (n-6)	Methyl docosa-dienoat	$C_{22}H_{40}O_2$	336.552		An omega 6 fatty acid.

Table 5.9. Monounsaturated (MUFA) and polyunsaturated (PUFA) fatty acids found in the sample material.

* The tables are comprised by information collected from the following sources:

Hilditch & Williams, 1964; Markley, 1947; Gunstone, 2004; Lipid bank: http://www.lipidbank.jp/; Lipomics: http://www.lipomics.com/ ; The Lipid Library: http://www.lipidlibrary.co.uk/; Cyberlipid: http://www.cyberlipid.org/; and Wikipedia: http://en.wikipedia.org/.

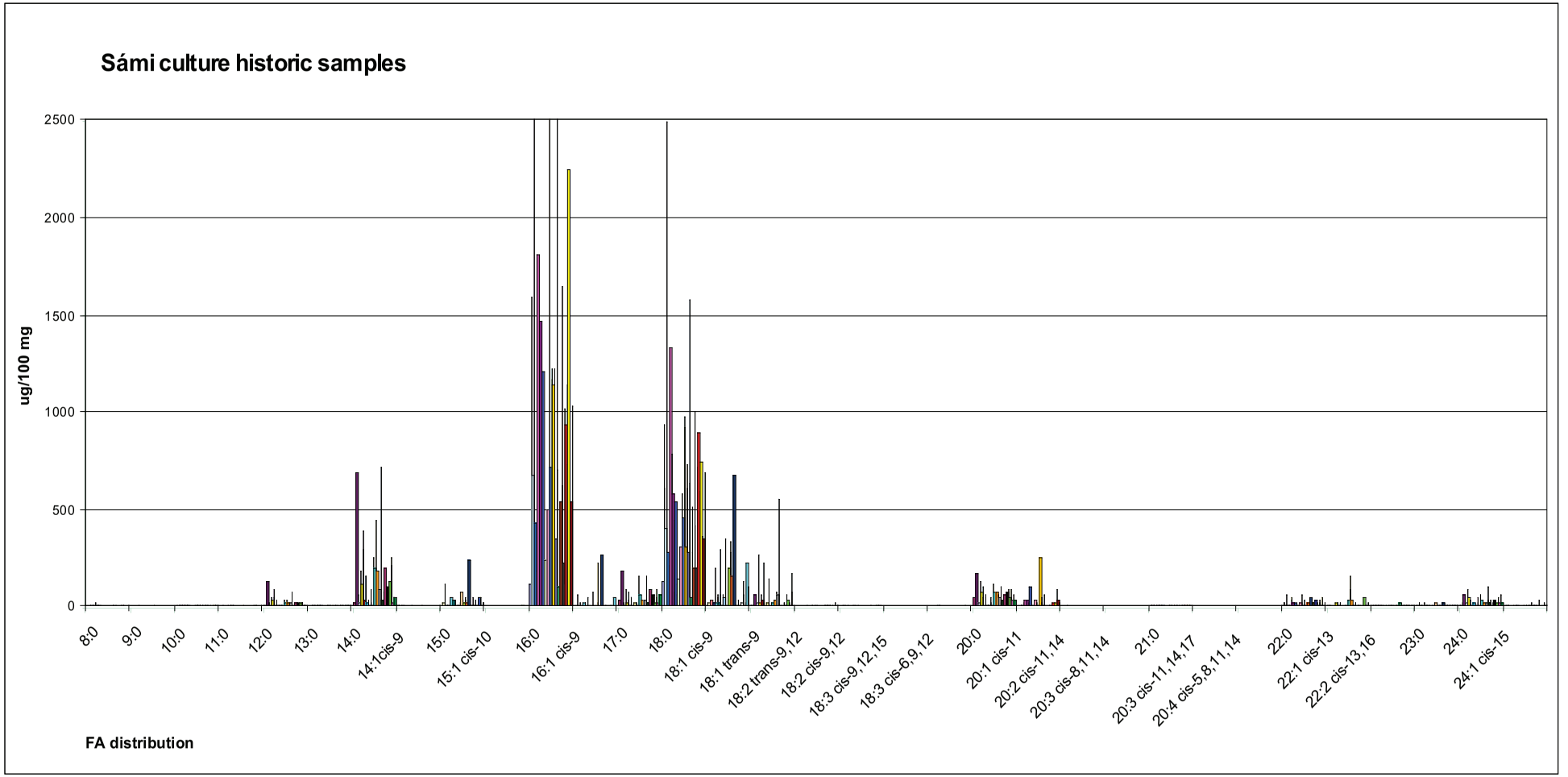


Fig. 5.59. Illustration of the general fatty acid distribution of all historic Sámi culture samples.

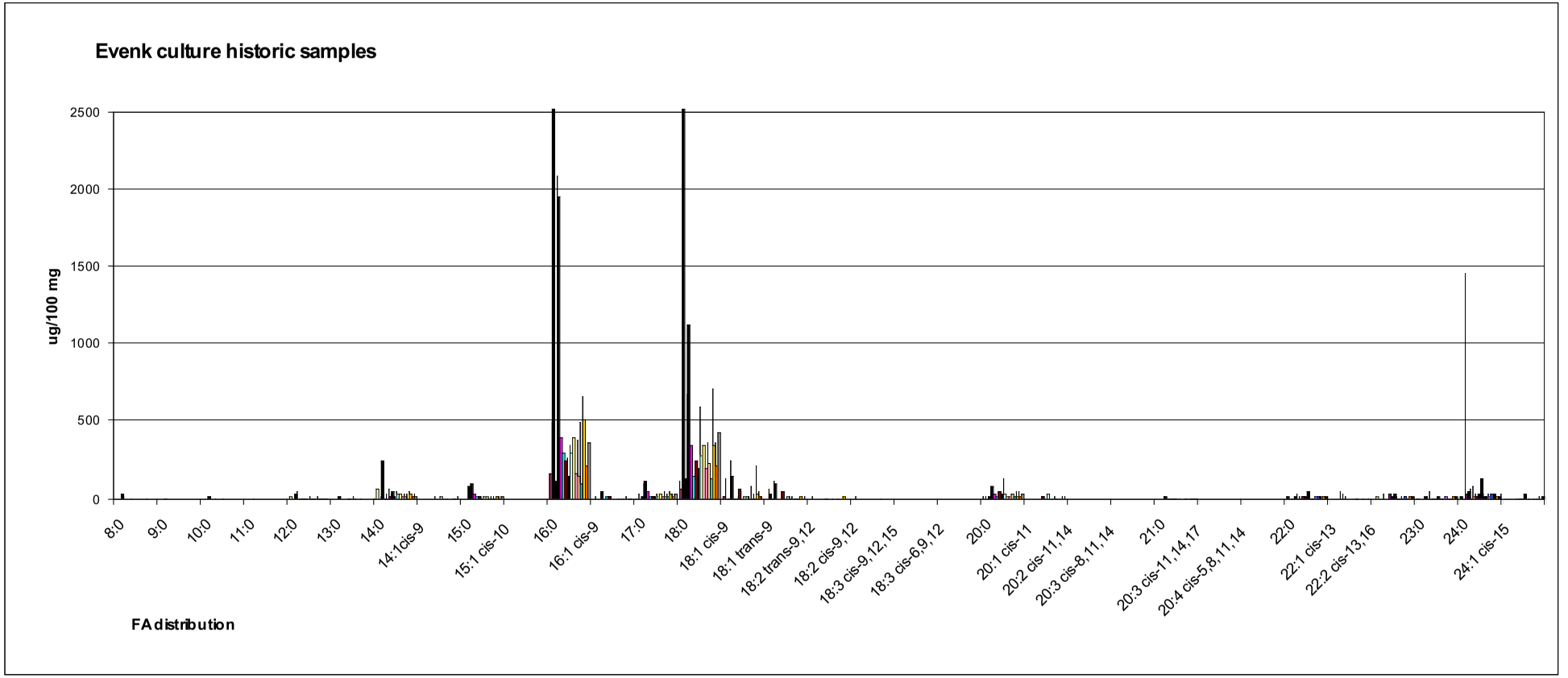


Fig. 5.60. Illustration of the general fatty acid distribution of all historic Evenk culture samples.

6 FIBRE CHARACTERISATION AND HYDROTHERMAL STABILITY ANALYSIS

As opposed to the visual assessment in chapter 4, based in the artefacts general appearance and characteristic features, this chapter goes a bit closer examining the collagen fibres which constitutes the basis for the well being of the artefact.

The objective of the fibre assessment is to search for patterns in the fibre characteristics, and possibly connecting these patterns to the condition of the fibre. In addition, the characteristics related to skin processing methods and substances used in skin processing, are explored. The basis of these investigations is the extensive work carried out in the STEP, ENVIRONMENT, and IDAP projects (see bibliography). The diverse nature of the sample material, however, indicated that the established criteria had to be modified in order to reflect this diversity, and a simpler methodology was chosen as an initial approach in assessing the fibre samples.

Fibre assessment and hydrothermal analysis may be performed on the same fibre sample. The minute fibre sample needed to perform these analyses agrees well with the precondition of all analysis performed on historic artefacts, that destructive sampling should be minimal.

This chapter starts with a brief description of the skins structure and main components, leading up to the fibre assessment criteria and the hydrothermal analysis.

In addition, the description and analysis of pH performed on the sample material, to investigate the acidic nature of the sample material, is included in this chapter.

6.1 The skin

The skin consists of mainly three layers; epidermis, dermis, and hypodermis. Dermis constitutes the largest part of the skin and is composed, as is also the epidermis (apart from it outermost keratinised layer), of collagen, elastin and reticulin based in an amorphous ground substance. Hypodermis constitutes the inner layer of the skin and is mainly composed of subcutaneous tissue, fat, and blood vessels which are removed in the initial phases of skin processing (Fig. 6.1). Hair follicles and hairs constitute a variable part of the skin's structure dependent on the animal species, the age of the animal and from which part of the skin the sample is taken.

6.1.1 Collagen

Collagen is a fibrous protein formed by approximately 20 naturally occurring amino acids. It is characterised

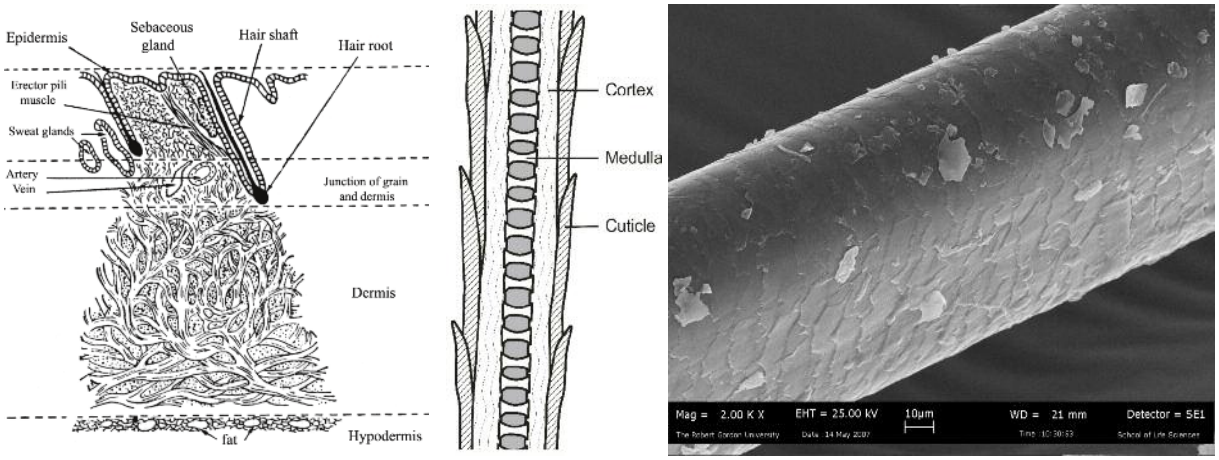


Fig. 6.1. On the left an illustration of the skin structure (modified from Sharphouse, 1995:21). In the middle an illustration of the structure of a mammal hair (modified from Adorjan & Kolenoski, 1969). On the right a SEM image of a reindeer leg skin hair. From I. Tough, The Robert Gordon University, Aberdeen.

by a high number of the amino acid glycine (33%), and the presence of proline and hydroxyproline and the primary structure is -GLY-X-Y- , where X is often proline and Y is often hydroxyproline (Stenzel *et al.*, 1974: 234; Wess & Nielsen, 2002:149; Hames & Hooper, 2005:56). Amino acids are difunctional and contain both a basic amino group —NH_2 and an acidic carboxyl group —CO_2H (Fig. 6.2). The amino acids have certain properties, and can be hydrophobic, hydrophilic, basic, or acidic, they can be charged or uncharged, aromatic, containing sulphur, small or large. Some of the side chains may have more than one of these properties. The hydrophobic amino acids, sometimes also called non polar amino acids, mainly reside in the interior of the protein, while hydrophilic amino acids, also called polar amino acids primarily reside on the exterior of the protein (Berg *et al.*, 2002; Hames & Hooper, 2005:43). Glycine (Gly) has the smallest side chain (H), and has high conformational flexibility, while proline, with a more complex side chain has low conformational flexibility (Fig. 6.3). Forces which stabilise the structures at the various levels of protein formation include van der Waals interaction between adjacent atoms; the hydrophobic forces, maintaining the hydrophobic residues in the core; electrostatic forces, such as salt bridges and hydrogen bonds (Berg *et al.*, 2002; Hames & Hooper, 2005:44-45).

Peptide chains are formed by peptide bonds between the —NH_2 of one amino acid and the —CO_2H of another amino acid. Glycine is characteristically positioned in the repeating sequence pattern, at every third residue. The residues (R) constitute the characteristic nature of the collagen molecule and their properties are a contributory factor in the formation of the three-dimensional structure of the protein (Berg *et al.*, 2002; Hames & Hooper, 2005:59). The next level is the formation of the triple helix, where three polypeptide strands of approximately 1000 residues, each being a left handed helix, are coiled together in a right-

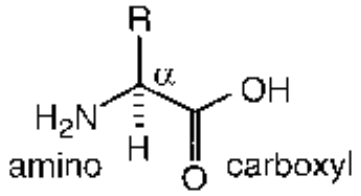


Fig. 6.2. Structure of α-amino acid. R (residues) is attached to the α-carbon, which is the carbon next to the carboxyl group.

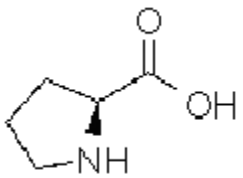


Fig. 6.3. Proline (Pro) is a neutral, hydrophilic amino acid.

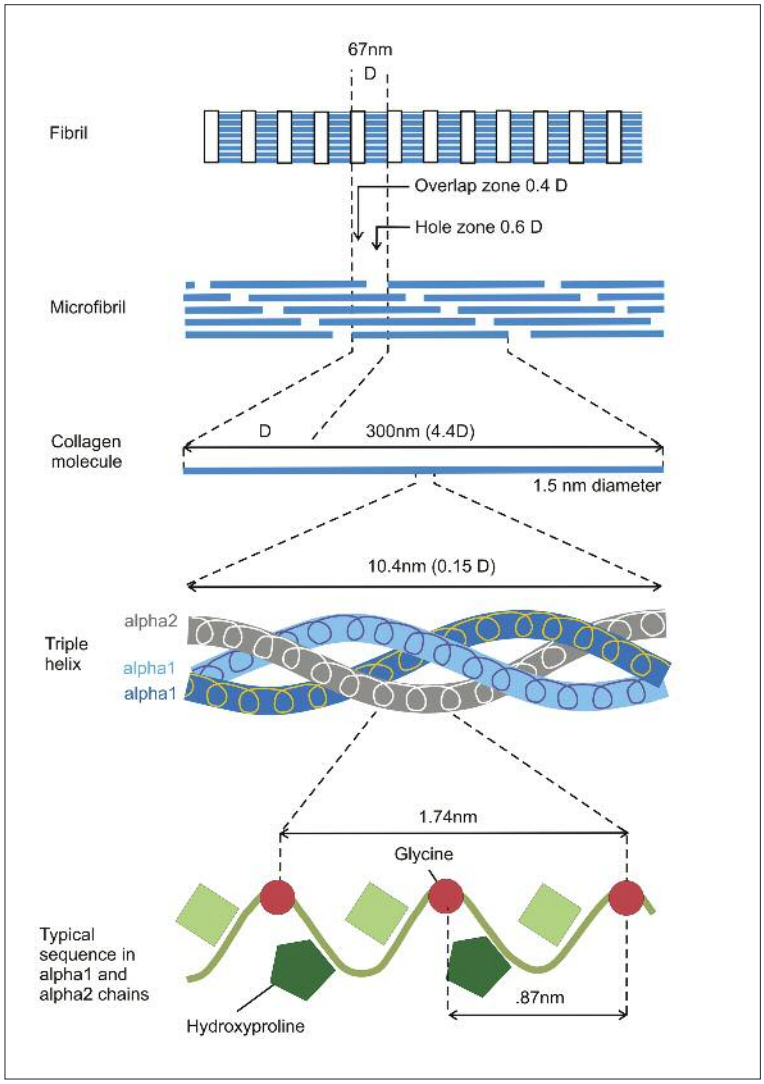


Fig 6.4. The formation of the collagen fibril, from the polypeptide strand through the triple helix to the microfibril and to the fibril, at each level illustrating the dimensions in the formation process (redrawn from Ross *et al.,* 1995).

handed way, forming the collagen molecule. The collagen molecules, each being 300 nm long, are aligned side by side in a staggered manner, with a periodic banding every 64-67 nm (Wess & Orgel, 2000:119,120; Parry, 2005:18; Fessas *et al.*, 2000:130) (Fig. 6.4). The collagen molecules are bundled together constituting the micro-fibril. A number of these microfibrils are again packed together forming the fibril. The fibrils are again bundled together forming the collagen fibres, which are finer in the grain layer (≤ 5 μm) and increase in diameter towards the dermis where the diameter, in bovine skin is ≈ 100 μm (O'Leary & Attenburrow, 1996:5677).

6.2 Fibre assessment

Fibre assessment is encompassed to indicate the physical nature of the sample material. Apart from the reference skin material where the sample size would be adequate for a number of established physical and chemical test methods, the historic sample material is very small, requiring the physical evaluation of characteristic features to be performed microscopically. As for all the analyses performed on the artefact material in this study, the representativity is limited to one small location on the artefact. This location is chosen for ethical and practical reasons. The assessment is qualitative, based on subjective observation of the fibre samples prior to hydrothermal analysis. Two to three samples from each artefact sample were analysed to determine their hydrothermal stability. The heterogeneity of the artefact material both in material type, skin processing technology and substance use, along with the multiple state of preservation of the artefacts, requires at this point a primary assessment, with limited details in feature variability. This means three to four levels in the description, such as strong, medium, weak, and yes/no options (Table 6.1). The fibres are separated on a glass slide with concavity, with the point of a scalpel, and are observed using a Nikon Labophot-2 microscope under 40 x and 100 x magnification.

6.2.1 Fibre assessment features

The main fibre assessment features are listed in table 6.1. The objective of applying these features is to contribute to the identification of the skin processing method and to the evaluation of the condition of the fibres.

Fibre coherence is a measurement of how well the fibres are physically attached in the skin structure. The point of a scalpel is used to remove fibres from the sample and the ease or difficulty of this procedure determines the level of coherence. This feature has been explored and systematically described for vegetable tanned book binding leather and for parchment (Larsen *et al.*, 1996b:113-115; DUPDA see: http://www.idap-parchment.dk/). The fibres in the first sample were separated in a dry state, and the fibres in the second sample were separated in a wet state. Wetting the fibres may either assist in the separation of the fibres or it may increase the force needed to separate the fibres. Strong coherence signifies a fibre in good condition and weak coherence of the fibres is a characteristic of a deteriorated fibre (Klokkernes, 1994:111; Larsen *et al.*, 1996c:196).

The fibre length was estimated by visual observation of the majority of the fibres on the sample slide. In most separated fibre samples there will be a mixture of sample lengths, due to how the sample is obtained and due to the nature and the condition of the fibre sample. The frailty of the fibres edges may give an idea whether

Fibre assessment features	**Feature variability**
Fibre coherence - dry	Strong, medium, weak
Fibre coherence - wet	Strong, medium, weak
Fibre length	Long, medium, short, fragmented
Fibre thickness	Thick, medium, thin
Fibre flexibility	Soft, medium flexible, stiff
Fibre colour	Uncoloured, slightly coloured, coloured
Fibre surface	Smooth, Slightly rough, rough
Residues on bottom of glass slide	Yes, no
Substance clinging to fibre surface	Yes, no
Absorbing water	Well, medium well, not well

Table 6.1. Fibre assessment features investigated prior to hydrothermal analysis.

the fibre is cut or not. Fibre length will also signify the state of deterioration, as long fibres are typically perceived as intact fibres and shorter or fragmented fibres are perceived as deteriorated fibres.

Fibre thickness may indicate the size of the skin or also what part of the animal's skin the sample is taken. This is not fully developed at this stage, but it seems that the fibre thickness or the ability to separate fibre bundles varies according to location. The inherent diameter variation from grain layer to dermis is an established issue, as is the variation in fibre thickness between a fawn skin and a mature reindeer skin. The possible divergent nature of the fibres in the leg skin of the reindeer remains to be further investigated.

Fibre flexibility is associated to the thickness of the fibres, as well as to the fibres condition. Short thick fibres are often perceived as less flexible than thin long fibres, and fibres are known to loose their flexibility upon ageing. As previously demonstrated for skin artefacts, fibre softness may signify both an advanced state of deterioration as well as a skin artefact in good condition (Klokkernes, 1994:77).

Fibre colour may indicate if a plant polyphenol tanning agent is used in the processing of the skin. If a plant polyphenol is used, most often a brownish/yellow or brownish/red colour is observed. However, this may not always be the case, as the colour may be too weak to be registered. A mixture of coloured and uncoloured fibres is observed as well, relating for example to surface tanned skin samples.

Observing characteristics on the fibre surface yield information on the condition of the skin fibres. A smooth fibre surface is suggested to indicate a fibre in a better condition than a rough fibre surface, or/and a fibre with frayed edges. If this feature also indicates the level of mechanical action applied to the skin, has so far not been established.

Substance clinging to the fibre surface may illustrate the use of tanning substances, although the origin of this substance may be unknown. This is also the case with residues that can be observed on the bottom of the glass slide. Observing substance clinging to the fibres surface and likewise observing residues on the bottom of the glass slide as water is added to the fibre sample, may aid in the identification of skin processing method and in the identification of the substance groups used in the process. In some of the samples in this study, a white cloud was sometimes observed as the fibre was immersed in water. Other observations indicated the use of fatty substances, as droplets were observed on the bottom of the glass slide. However, residues on the bottom of the glass slide may as well be fragments of the fibre itself, or dirt and other elements attaching itself to the artefacts while in use.

Whether a fibre absorbs water well or not well provides additional information on the fibres characteristics and condition. A fibre which absorbs water well may be more deteriorated that a fibre which do not absorb water well. However, there are exceptions to this. It is for example observed that a skin sample (XSM-13) treated with raw reindeer brain absorbs water well as the fibres are separated on the glass slide. On the other hand, a sample treated with cod liver oil (XSM-1) does not absorb water with the same ease. Both samples are manufactured for this study. The absorption may therefore be facilitated by some processing methods and not by others.

6.2.2 Fibre assessment of the reference samples from the Sámi and Evenk culture

The reference samples of the Sámi culture (Table 6.2) have medium to strong fibre coherence, which is expected for newly processed skin material. The naturally aged sample, DS-N7-16, has medium fibre coherence which is not unexpected. The experimental samples (XSM-samples) all have strong fibre coherence. The Evenk culture samples (Table 6.2), however, have much more diverse results. Here, the naturally aged sample DS-R16-22, have strong fibre coherence while the other samples have medium to weak coherence. It is possible that the naturally aged sample, which is obtained from an old boot, has been repeatedly smoked through usage, and is thereby being strengthened.

Apart from the naturally aged sample which exhibit medium length fibres, the Sámi culture samples all exhibit long fibres, with a medium thickness and medium flexibility. This is also observed in the experimental samples which all have primarily long fibres, and medium fibre thickness and flexibility. The impression is again more varied for the results of the Evenk culture samples. The fibre length is primarily long, but the thickness also contains examples of thin fibres, suggesting skins from younger animals. The flexibility of these samples is soft to medium flexible, which again suggest it coming from skins of younger animals. Other causes for these characteristics, is deterioration of the fibres, local variation in the skin and a softening of the fibre effectuated by the skin processing substances.

The fibre colour observed follows the known tanning methods of the reference sample material. DS (de-

pilated skin) samples from the Sámi culture are all coloured. The LS (leg skin) samples, which are primarily surface tanned/coloured, exhibit a pattern of mixed coloured and uncoloured fibres and the SWH (whole skin with hairs attached) samples, which do not contain vegetable tannins, exhibit uncoloured fibre samples. The same pattern of following the skin processing method is also observed in the Evenk culture reference samples, where only one sample is slightly coloured. This again also strengthens the impression that the brown rotted larch wood utilised in the processing of skins, merely has a slight colouring effect. The experimental samples exhibit the same results as the SWH samples from the Sámi culture.

Reference number	Fibre coherence - dry	Fibre coherence - wet	Fibre length	Fibre thickness	Fibre flexibility	Fibre colour	Fibre surface	Residues, bottom glass slide	Substance on fibre surface	Absorbing water
DS-N7-16 'old'	Medium	Medium	Medium	Medium	Medium	Coloured	Slightly Rough	Yes	Yes	Medium Well
DS-N9-14	Strong	Strong	Long	Medium	Medium	Coloured	Slightly Rough	Yes	Yes	Medium Well
SWH-N1-11	Medium	Medium	Long	Medium	Medium	Un-coloured	Smooth	No	No	Medium Well
SWH-N13-09	Strong	Strong	Long	Medium	Medium	Un-coloured	Slightly Rough	No	No	Medium Well
DS-R10-20	**Medium**	**Medium**	**Long**	**Thin**	**Soft**	**Un-coloured**	**Slightly Rough**	**No**	**No**	**Medium Well**
LS-R16-08	**Weak**	**Weak**	**Long**	**Medium**	**Soft**	**Slightly coloured**	**Smooth**	**No**	**No**	**Medium Well**
SWH-R10-12	**Medium**	**Medium**	**Long**	**Medium**	**Soft**	**Un-coloured**	**Slightly Rough**	**No**	**No**	**Medium Well**
XSM-1	*Strong*	*Strong*	*Long*	*Medium*	*Medium*	*Un-coloured*	*Smooth*	*No*	*No*	*Medium Well*
DS-N7-17	Strong	Strong	Long	Medium	Medium	Coloured	Slightly Rough	Yes	Yes	Not Well
LS-N3-04	Strong	Strong	Long	Medium	Medium	Mixed	Smooth	Yes	No	Not Well
DS-R10-21	**Weak**	**Weak**	**Medium**	**Thin**	**Medium**	**Un-coloured**	**Slightly Rough**	**No**	**No**	**Not Well**
DS-R16-22 'old'	**Strong**	**Strong**	**Long**	**Medium**	**Medium**	**Un-coloured**	**Slightly Rough**	**No**	**No**	**Not Well**
Untreated	Strong	Strong	Long	Medium	Medium	Un-coloured	Smooth	No	No	Not Well
LS-N13-01	Strong	Strong	Long	Medium	Medium	Mixed	Smooth	No	Yes	Well
XSM-13	*Strong*	*Strong*	*Long*	*Medium*	*Medium*	*Un-coloured*	*Smooth*	*No*	*No*	*Well*

Table 6.2. Fibre assessment results for the reference samples from the Sámi and Evenk culture. Grouped by how well the fibre absorbs water (last column). The Evenk culture samples are marked in bold.

The fibre samples demonstrate smooth to slightly rough surface characteristics both in the Sámi and the Evenk culture. The LS samples generally seem to have a more robust surface structure than the DS and SWH samples. Surface fibre structure may also be associated with the amount of mechanical action applied to the skin surface, in the manufacturing and through the maintenance of the artefact.

Although this is now at a very early stage in its investigation, these methods may become useful if explored further. The DS samples of the Sámi culture all exhibit substance clinging to the fibre surface as well as residues on the bottom of the glass slide. The LS samples show varying results. This is also expected as there may be fibres on the glass slide from both the raw streak as well as from the outer surface of the dermis of the leg skin sample. The experimental samples do not exhibit any residues or substances clinging to the surface.

The fibres' absorption of water is facilitated by the use of an emulsion based fatty substance in the processing method. This is indicated in the experimental sample XSM-13, where raw reindeer brain substance is used as a lubricant, and where the water absorbing ability is good. Referring to oil tanned skin, in particular wash skin (chamois) which is generally known for its highly absorptive qualities, the Sámi and Evenk culture skin materials should also exhibit slightly similar qualities if the oil tanning is properly effectuated. This is however not the case. Most newly made samples have low to medium low absorption abilities.

6.2.3 Fibre assessment of the historic samples from the Sámi and Evenk culture

The results of the fibre length and fibre flexibility assessment, as well as the results from the fibre coherence and the ability of the fibre to absorb water, are typically applied to investigate the condition of the fibres.

Museum number	Main material	Culture	Fibre coherence-Dry	Fiber coherence-Wet	Fibre length	Fiber thickness	Fiber flexibility	Absorbing water
TMunrtoolmarks	SWH	Sámi	Medium	Medium	Medium	Thick	Medium	Well
REM6749-5	**LS**	**Evenk**	**Weak**	**Weak**	**Medium**	**Medium**	**Medium**	**Well**
TM1833a-b	LS	Sámi	Weak	Weak	Medium	Medium	Medium	Well
SVD2158	DS	Sámi	Weak	Weak	Long	Thin	Medium	Well
SVD2219	LS	Sámi	Medium	Medium	Long	Thin	Soft	Well
MAE0376-59c	**DS**	**Evenk**	**Medium**	**Weak**	**Medium**	**Medium**	**Soft**	**Well**
NFSA3930	DS	Sámi	Weak	Weak	Medium	Thin	Soft	Well
MAE0330-4a-b	**DS**	**Evenk**	**Weak**	**Weak**	**Medium**	**Thin**	**Soft**	**Well**
REM1210-2	**DS**	**Evenk**	**Weak**	**Weak**	**Medium**	**Medium**	**Soft**	**Well**
TM1954	DS	Sámi	Weak	Weak	Medium	Thin	Soft	Well
TM0545	LS	Sámi	Weak	Weak	Medium	Medium	Soft	Well
IMRS0736-1	**DS**	**Evenk**	**Weak**	**Weak**	**Medium**	**Thin**	**Soft**	**Well**
MAE1524-168	**DS**	**Evenk**	**Weak**	**Weak**	**Medium**	**Thin**	**Soft**	**Well**
VK4934-178	**DS**	**Evenk**	**Weak**	**Weak**	**Long**	**Thin**	**Soft**	**Well**
IMRS0344-5A	**LS**	**Evenk**	**Weak**	**Weak**	**Medium**	**Thin**	**Soft**	**Well**
MAE0376-59c	**LS**	**Evenk**	**Weak**	**Weak**	**Medium**	**Medium**	**Soft**	**Well**
VK4934-175	**LS**	**Evenk**	**Weak**	**Weak**	**Medium**	**Medium**	**Soft**	**Well**
MAE0273-1	**SWH**	**Evenk**	**Weak**	**Weak**	**Medium**	**Medium**	**Soft**	**Well**
REM9996-2	**SWH**	**Evenk**	**Weak**	**Weak**	**Long**	**Thin**	**Soft**	**Well**

Table 6.3. The results of the fibre assessment, grouped by how well the fibre absorbs water: Well. The main tendency is marked in red letters. Evenk samples are marked in bold.

Museum number	Main material	Culture	Fibre coherence-Dry	Fiber coherence-Wet	Fibre length	Fiber thickness	Fiber flexibility	Absorbing water
SVD2879	LS	Sámi	Medium	Medium	Long	Medium	Medium	Medium Well
SVD2109	SWH	Sámi	Medium	Medium	Long	Medium	Medium	Medium Well
SVD2565	SWH	Sámi	Weak	Weak	Long	Medium	Medium	Medium Well
TM2272	SWH	Sámi	Medium	Medium	Medium	Medium	Medium	Medium Well
MAE1004-62/2	**LS**	**Evenk**	**Medium**	**Medium**	**Medium**	**Medium**	**Medium**	**Medium Well**
MAE1524-2	**LS**	**Evenk**	**Medium**	**Medium**	**Medium**	**Medium**	**Medium**	**Medium Well**
MAE3957-1	**SWH**	**Evenk**	**Medium**	**Medium**	**Medium**	**Medium**	**Medium**	**Medium Well**
NFSA0361	SWH	Sámi	Weak	Weak	Medium	Medium	Medium	Medium Well
IMRS0092-4	**DS**	**Evenk**	**Weak**	**Weak**	**Medium**	**Medium**	**Medium**	**Medium Well**
TM1273b	SWH	Sámi	Weak	Weak	Medium	Medium	Medium	Medium Well
IMRS0544A	**SWH**	**Evenk**	**Medium**	**Medium**	**Short**	**Medium**	**Medium**	**Medium Well**
VK4934-171	**SWH**	**Evenk**	**Weak**	**Medium**	**Medium**	**Thick**	**Medium**	**Medium Well**
TM0712	DS	Sámi	Medium	Medium	Medium	Thin	Medium	Medium Well
SVD1553	SWH	Sámi	Medium	Medium	Medium	Thin	Medium	Medium Well
MAE1524-3	**SWH**	**Evenk**	**Medium**	**Medium**	**Medium**	**Thin**	**Medium**	**Medium Well**
NFSA0582	SWH	Sámi	Weak	Weak	Medium	Thin	Medium	Medium Well
NFSA3445	DS	Sámi	Weak	Weak	Medium	Thin	Medium	Medium Well
TM0491	DS	Sámi	Weak	Weak	Short	Thin	Medium	Medium Well
NFSA4066b	DS	Sámi	Medium	Medium	Long	Medium	Soft	Medium Well
NFSA4066a	LS	Sámi	Weak	Weak	Long	Medium	Soft	Medium Well
VK6161-17	**DS**	**Evenk**	**Medium**	**Medium**	**Short**	**Medium**	**Soft**	**Medium Well**
SVD2110	SWH	Sámi	Weak	Weak	Long	Thin	Soft	Medium Well
VK4934-182	**SWH**	**Evenk**	**Weak**	**Weak**	**Long**	**Thin**	**Soft**	**Medium Well**
IMRS4408-118	**SWH**	**Evenk**	**Weak**	**Weak**	**Long**	**Thin**	**Soft**	**Medium Well**
IMRS0510A	**SWH**	**Evenk**	**Weak**	**Weak**	**Long**	**Thin**	**Soft**	**Medium Well**
SVD0429	DS	Sámi	Weak	Weak	Long	Thin	Soft	Medium Well
SVD2205	DS	Sámi	Weak	Weak	Long	Thin	Soft	Medium Well
TM1149	SWH	Sámi	Medium	Medium	Medium	Thin	Soft	Medium Well
VK4934-180	**SWH**	**Evenk**	**Medium**	**Medium**	**Medium**	**Thin**	**Soft**	**Medium Well**
VK6161-14	**SWH**	**Evenk**	**Weak**	**Medium**	**Medium**	**Thin**	**Soft**	**Medium Well**
IMRS0345-1A	**SWH**	**Evenk**	**Weak**	**Medium**	**Medium**	**Thin**	**Soft**	**Medium Well**
TM1153	DS	Sámi	Weak	Weak	Medium	Thin	Soft	Medium Well
SVD2212	LS	Sámi	Weak	Weak	Medium	Thin	Soft	Medium Well
VK5275-1	**SWH**	**Evenk**	**Medium**	**Medium**	**Short**	**Thin**	**Soft**	**Medium Well**
SVD2337	LS	Sámi	Medium	Medium	Short	Medium	Stiff	Medium Well
VK4934-183	**DS**	**Evenk**	**Medium**	**Weak**	**Short**	**Thick**	**Stiff**	**Medium Well**

Table 6.4. The results of the fibre assessment, grouped by how well the fibre absorbs water: Medium well. Evenk samples are marked in bold.

Museum number	Main material	Culture	Fibre coherence-Dry	Fiber coherence-Wet	Fibre length	Fiber thickness	Fiber flexibility	Absorbing water
SVD1502	LS	Sámi	Strong	Strong	Short	Thick	Medium	Not Well
NFSA4064	SWH	Sámi	Medium	Strong	Medium	Medium	Medium	Not Well
SVD2099a-b	LS	Sámi	Medium	Medium	Long	Medium	Medium	Not Well
NFSA3715	SWH	Sámi	Medium	Medium	Short	Thin	Medium	Not Well
SVD1069	LS	Sámi	Weak	Medium	Medium	Thin	Medium	Not Well
SVD2246	SWH	Sámi	Strong	Strong	Long	Thin	Soft	Not Well
SVD2240	SWH	Sámi	Medium	Medium	Long	Medium	Soft	Not Well
TM2239b	DS	Sámi	Medium	Medium	Short	Thin	Soft	Not Well
NFSA3838	SWH	Sámi	Weak	Weak	Long	Thin	Soft	Not Well
SVD1458	DS	Sámi	Strong	Strong	Short	Medium	Stiff	Not Well
SVD1511	DS	Sámi	Strong	Strong	Short	Thick	Stiff	Not Well
SVD0790	LS	Sámi	Strong	Strong	Short	Thick	Stiff	Not Well
VK6161-25	**LS**	**Evenk**	**Strong**	**Strong**	**Medium**	**Thin**	**Stiff**	**Not Well**
SVD0023	DS	Sámi	Medium	Medium	Short	Medium	Stiff	Not Well
SVD0078	DS	Sámi	Medium	Medium	Short	Thin	Stiff	Not Well
SVD0459	DS	Sámi	Medium	Medium	Short	Medium	Stiff	Not Well
SVD1171	DS	Sámi	Medium	Medium	Short	Medium	Stiff	Not Well
NFSA3934a-b	LS	Sámi	Medium	Medium	Short	Medium	Stiff	Not Well
SVD2220	LS	Sámi	Medium	Medium	Medium	Medium	Stiff	Not Well
VK4934-174	**DS**	**Evenk**	**Medium**	**Medium**	**Short**	**Thick**	**Stiff**	**Not Well**
VK4934-176	**LS**	**Evenk**	**Medium**	**Medium**	**Medium**	**Thick**	**Stiff**	**Not Well**
SVD2210	SWH	Sámi	Medium	Medium	Long	Medium	Stiff	Not Well
TM1138a	LS	Sámi	Medium	Medium	Short	Medium	Stiff	Not Well
VK4934-170	**SWH**	**Evenk**	**Medium**	**Medium**	**Medium**	**Thick**	**Stiff**	**Not Well**
SVD1567	SWH	Sámi	Weak	Medium	Medium	Thick	Stiff	Not Well
SVD3374	LS	Sámi	Weak	Weak	Short	Thick	Stiff	Not Well
SVD3592	LS	Sámi	Weak	Weak	Short	Thick	Stiff	Not Well

Table 6.5. The results of the fibre assessment, grouped by how well the fibre absorbs water: Not well. The main tendency is marked in red letters. Evenk samples are marked in bold.

It is generally assumed that fibres break, become fragmented and looses flexibility as the samples age and deteriorate, and that the fibre coherence decreases and water absorption ability increases. It is furthermore reasonable to assume that these features are also depend on the nature and the condition of the substances added in the skin processing of the various material types. Earlier studies also show that although a fibre may become less flexible as it ages, the opposite may also occur, yielding a very soft fibre with excellent water absorption abilities (Klokkernes, 1994:93-94).

The historic samples typically exhibit medium to weak fibre coherence both in a dry and in a wetted state. Nine out of ten times when a fibre has weak coherence in the dry state it also has weak coherence in a wetted state, and in one out of ten times, the fibre coherence goes from weak to medium when the fibres are wetted. This tendency is less apparent for the fibres

which exhibit medium coherence. These fibres generally have the same fibre coherence in the wetted state. This is also the case for the fibres with strong fibre coherence, even though there are very few samples exhibiting strong fibre coherence, in both the Evenk and the Sámi culture historic sample material.

The water absorption ability depends on the condition of the fibre, but also the substances added to the fibre structure during its manufacture. Investigating the proposed correlation between weak coherence in dry and wetted state to good water absorption ability of the fibre, show that this assumption is confirmed for the Evenk culture samples in particular. Fibres with weak coherence both in the dry and wet state, will in most cases absorb water well, whereas the samples which do not absorb water well generally lie within the strong coherence to medium coherence group. The tendency is not as evident in the Sámi culture samples, were the general tendency shows a 'medium well' to 'not well' ability to absorb water. However, the few samples that do absorb water well, also exhibit weak fibre coherence.

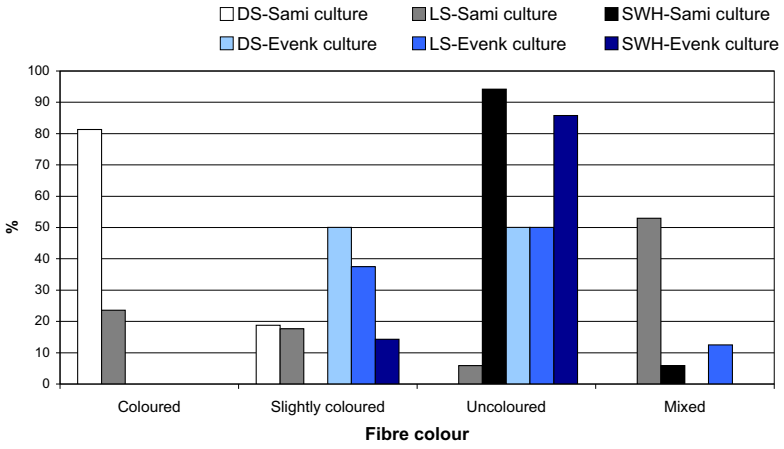


Fig. 6.5. Results of observations of fibre colour during the fibre assessment analysis.

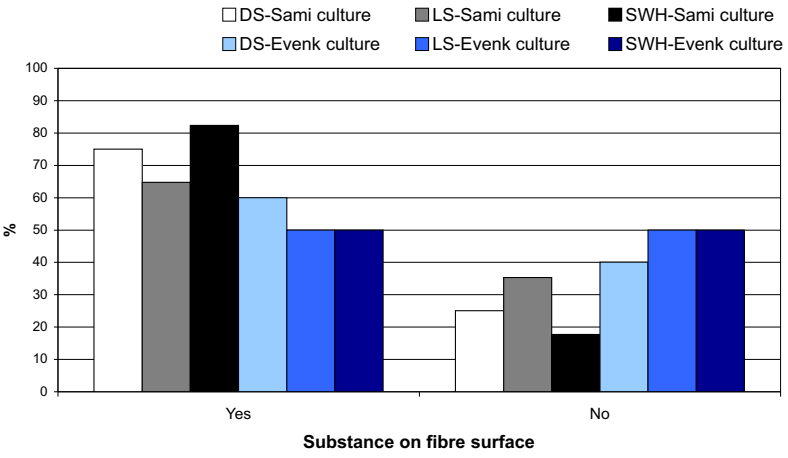


Fig. 6.6. Results of observations of substances clinging to the fibre surface during the fibre assessment analysis.

Investigating the correlation of the samples that absorb water well and at the same time exhibits weak coherence in the dry and wetted state with fibre length, fibre thickness and fibre flexibility demonstrates that the fibres within this group primarily are thin and soft. The fibre lengths are mainly medium thick. In this group, the Evenk culture sample material dominates (Table 6.3). In the group that does not absorb water well (Table 6.5); the fibre flexibility mainly consists of stiff fibres and the fibre thickness shows medium to thick fibres. This is also the group where all the historic fibre samples with a strong coherence, both in the dry and in the wetted state, lie. This group is dominated by the Sámi culture samples. The group that absorbs water medium well (Table 6.4) has a mixture of results, although no samples exhibit strong fibre coherence. The amount of samples which can be characterised as having thick, stiff and short fibres is furthermore very low in this group.

There is a clear distinction in fibre colour between the various material groups and between the two cultures (Table. 4.1). The majority of the Sámi DS samples are recorded as coloured. This is expected due to the vegetable tanning agent typically used for DS material in the Sámi culture. Other samples which typically exhibit the use of a vegetable tanning agent are the LS samples, also from the Sámi culture. This material type, with surface tanning or colouring, as well as a raw streak, will therefore display a mixture of uncoloured and coloured fibres when sample fibres are separated on the glass slide (Fig. 6.5). The Sámi cul-

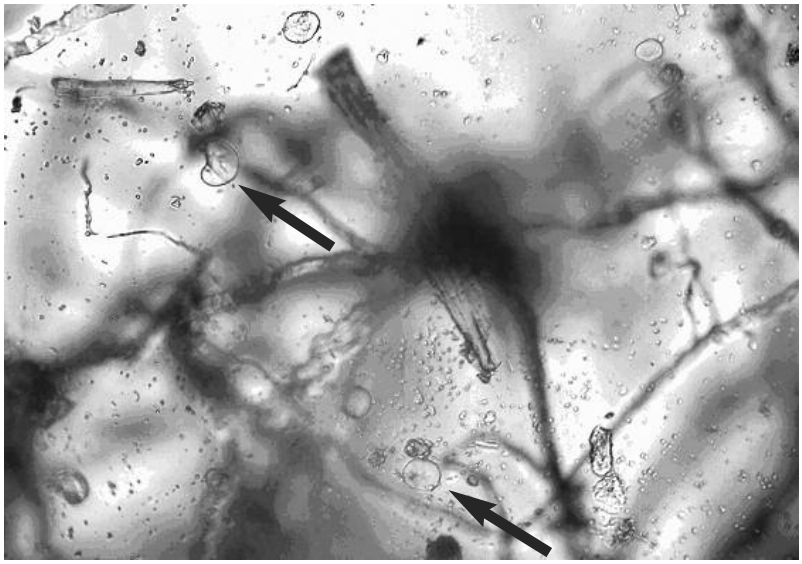


Fig. 6.7. Residues visible on the glass slide as the fibres are separated. Possible starch granules marked by arrows. Magnification ~ 200x.

ture SWH samples also seems to exhibit the tanning method applied to the skin, which yields very little colour to the fibres. Most samples from the Sámi culture, as well as most samples from the Evenk culture are found within this sample group. A few of the Evenk culture samples exhibit slight colouring, which is illustrated in figure 6.5.

Observing potential substances clinging to the fibre surface originates from fatty substances or a combination of vegetable tannins and fatty substances, as well as substances from when the artefacts were in use, and thereby accumulated over many years. Figure 6.6 demonstrates that this feature can be equally observed in the sample material from both cultures, however slightly more in the Sámi culture samples. Residues which collect on the bottom of the glass slide originates from tanning substances, but may also be fragments of deteriorated fibres and accumulated material from daily activities (Fig. 6.7). In this initial trial; fat residues, vegetable tannins, starch granules, and fibre fragments are the main groups of residues that have been observed.

6.2.4 Summary

The major difference in characteristics between the reference samples and the historic samples is the fibre coherence properties. The reference samples exhibit strong to medium strong fibre coherence properties, while the historic samples primarily exhibit medium to weak fibre coherence properties. The reference material also exhibits medium well to not well characteristics concerning the fibres' ability to absorb water, and the fibres observed on the glass slide generally contained long fibres of a medium thickness. The historic samples are different and show more varied results, which also confirms that changes do occur in the fibre over time. The results are categorised according to the fibres water absorption ability, and this yields information also concerning differences between the fibre samples of the two cultures. The main observation in the historic sample material is that weak coherence and excellent water absorption abilities are often followed by, thin, medium length, and soft fibres, and the opposite, that strong fibre coherence and not very good water absorption abilities are followed by thick, short, and stiff fibres. The Evenk culture fibre samples dominate the first group, with weak fibre coherence and good water absorption abilities, and the Sámi culture dominate the category where the samples do not absorb water well, and where the fibres are stiff, short and medium to strong concerning fibre coherence. The features, which are used to explore and identify substances applied to the skin in the processing stages, indicated a variation in processing technology. Fibre samples recorded as coloured are typically related to a vegetable tanning process. It furthermore confirms, through the observation of coloured and uncoloured fibres, the impression that Sámi culture leg skin is only surface tanned or coloured. The lack of colour is also observed in the Evenk culture sample material. Even though the use of tannins originating from brown rotted larch wood and also through smoking of the skin yields a noticeable colour to the skins surface, this colouring is too weak to be registered in this investigation.

6.3 Analysis of hydrothermal stability - shrinkage temperature of collagen fibres

Measuring the hydrothermal stability of the collagen fibres has several purposes. The measurement can be used as an estimate of the stability/condition of the

collagen fibre and it can indicate the tanning material that has been used in the skin processing method (Fig. 6.8). Raw collagen, or rather, dried skin that has received no pre-tanning treatment, has a shrinkage temperature (T_s) of approximately 60-65 °C. The shrinkage temperatures indicated in figure 6.8 show a range in which the fibre sample may shrink when it is heated in water. The values depend upon the tanning method employed, the degree of tanning, and should only be used as general guidelines (Reed, 1972:318).

Oil tanned	50 – 63 °C
Formaldehyde tanned	63 – 73 °C
Vegetable tanned	75 – 85 °C
Hydrolysable	75 – 80 °C
Condensed	80 – 85 °C
Alum tawed	50 – 63 °C
Basic aluminium	81 – 90 °C
Basic chromium	95 – 105 °C

Fig. 6.8 Examples of shrinkage temperatures of tanned skin (Sykes, 1991:10).

Measuring the shrinkage temperature of historic artefacts made from skin materials in the arctic and sub arctic have shown that deteriorated skin material may have very low shrinkage temperatures (Schmidt, 1991; Klokkernes, 1994). Deterioration may be due to oxidation, caused by the influence of light, heat and oxidative pollutants, or by hydrolysis, which is mainly caused by acid pollutants, such as sulphur dioxide or nitrogen oxides (Larsen, 1995:36). The shrinkage activity of collagen fibres is a complex matter affected not only by the condition of the collagen fibres, the pre tanning and tanning agents utilised, and the possible conservation methods applied to the skin material, but also by the structure of the collagen molecule. This makes the interpretation of the measured shrinkage temperature in an artefact material a complex task, involving many interrelated factors. In the hydrothermal reaction consisting of water, heat, and collagen fibres the hydrogen bonds in collagen structure are broken (Fig. 6.9), which cause the collagen fibre to irreversibly shrink (Larsen *et al.,* 1993:151). It is not fully understood why skin collagen tanned with different tanning agents represent different shrinkage temperatures, but it is presumed that it is a combination of several factors including the presence of cooperating units (Covington, 2006:23). The shrinkage temperature is dependent partly on these cooperating units which are formed between some of the 20 amino acids, and between the collagen molecules, and also at higher levels at the micro fibril and fibril level. The shrinkage activity may be stabilised by the inter-molecular hydrogen bonds and by salt bonds between amino acids side chains. The nature of the amino acids side chains furthermore play a part in the hydrothermal stability of the collagen fibre. The hydrophobic part (with units such as Gly, Ala, Pro etc.) may have higher shrinkage stability than the hydrophilic part of the molecule (with units like Asp, Glu, Lys, Arg etc.) and may, in addition to, or together with cross link formation explain why some deteriorated fibers/fragments or part of fibers may have relative high or very high shrinkage temperature (Larsen, 2007).

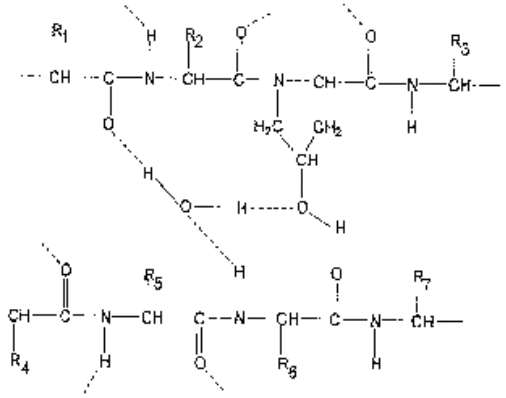


Fig. 6.9. Hydrogen bonding in collagen (Covington *et al.,* 1998:110).

6.3.1 Experimental

The instrument used is a Mettler Toledo FP90 Central processor with a hot stage unit, FP 82 HT, attached. The skin fibre sample is finely separated and placed on a microscope slide with a concavity, covered with distilled water and left to soak for ten minutes or until the fibres are fully soaked, but not exceeding one hour. A cover slip is placed on the slide and sample and the slide is placed in the hot stage unit. The hot stage unit is placed on the microscope stage (Nikon Labophot 2 microscope) and the shrinkage process is observed at 40 x magnification. The temperature is gradually increased at a rate of 2 °C per minute. The accuracy of the shrinkage measurement is +/- 2 °C. The shrinkage intervals are recorded by manually activating a handheld unit connected to the central processor and the results from each shrinkage sequence are printed on an OKI black and white ink printer.

Prior to analysis the processor is calibrated using Mettler Toledo calibration substance, benzoic acid, with a melting point of 122.4 °C +/- 0.2 °C and Mettler Toledo calibration substance benzophenone with a melting point of 48.0 °C +/- 0.2 °C.

The shrinkage sequence is divided into five intervals:

Interval A_1: Individual fibres shrink sporadically and not continuously
Interval B_1: Individual fibres shrink continuously
Interval C: Two or more fibres shrink at the same time and continuously
Interval B_2: As for interval B_1
Interval A_2: As for interval A_1

The start temperature for interval C, the main shrinkage interval, is called T_s. This value is registered as the shrinkage temperature of the fibre. The length of the main interval is called ΔT (B_2 - C) and illustrates the interval where the major part of the shrinkage activity occurs. Interval B_2 and A_2 is not always be observed. The start of A_1 is called T_{first} and the last shrinkage activity observed in the A_2 interval is called T_{last}. The total shrinkage range from T_{first} to T_{last} is called ΔT_{total} (Larsen *et al.*, 1993:151).

As the temperature is raised the shrinkage of the fibres takes place in this sequence:

No activity → A_1 → B_1 → C → B_2 → A_2 → complete shrinkage

The advantage of using this method is that only a very small sample is needed. As the user gains experience, the recommended sample weight of 0.3 mg may be even further reduced. However, the samples representativity will be lessened as the sample size is reduced (Larsen, *et al.,* 2002a:55). Figure 6.10 illustrates a typical initial observation of T_{first} (A_1 interval) in this study and figure 6.11 illustrates a typical observation of T_{last} (A_2 interval).

Issues in the analysis of hydrothermal stability of collagen fibres

The shrinkage temperatures observed in the sample material, based on the information obtained from informants and from the literature, would be expected to be: 80-85 °C as in skin tanned with condensed plant polyphenols; 63-73 °C as in aldehyde tanned skin and; 50-63 °C as in oil tanned skin. This is based on the general overview of suggested shrinkage temperatures, shown in figure 6.7. A well tanned skin sample which is considered to be in a good condition, and which is tanned with condensed tannins, would typically have a high T_{first} (A_1) in the vicinity of 75-80 °C. T_s would lie between 80-85 °C and the main shrinkage interval would be short, in the vicinity of 5-6 °C. The main shrinkage interval ΔT, and ΔT_{total}, would also be short, approximately 5-10 °C and 15-20 °C respectively. However, there are factors affecting the length of these various intervals, which do not only signify a reduced stability of collagen fibres, but perhaps rather an effect of the tanning procedure, such as heterogeneous tanning of the fibres, the use of multiple tanning materials, the properties of the tanning bath, an also changeable sample removal and sample preparation conditions.

A feature which must be included in the interpretation of the results is the possible variation in shrinkage temperature depending on where on the skin the sample is taken. It has been shown that the shrinkage temperature may vary two to three degrees depending on location (Larsen *et al.*, 2002a: 59). This issue was investigated on dried, untreated reindeer skin (SWH) where T_s were measured in ten different locations. The

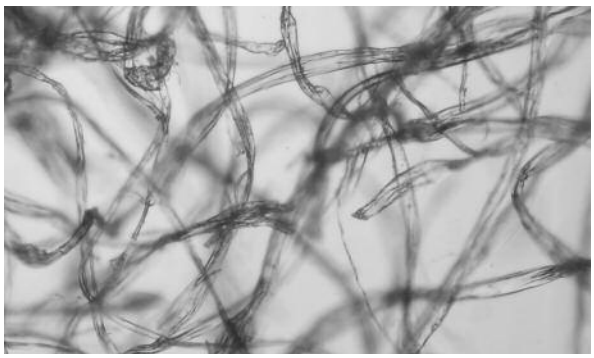


Fig. 6.10. T_{first} in the A_1 interval. Museum number: TM-unr-toolmark. Tromsø Museum, Norway.

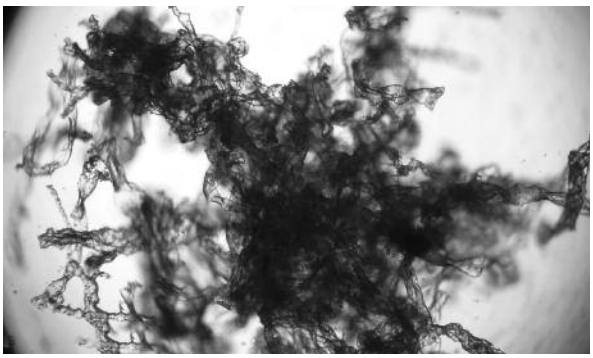


Fig. 6.11. T_{last} in the A_2 interval. Museum number: TM-unr-toolmark. Tromsø Museum, Norway.

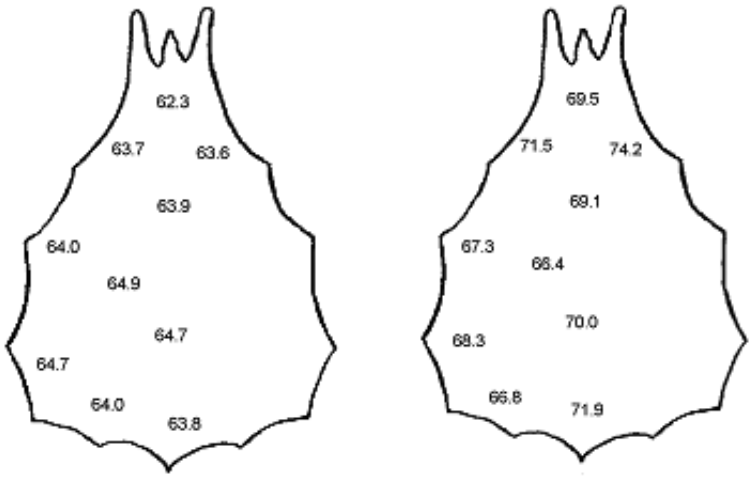


Fig. 6.12. Measurements of shrinkage temperature (T_s) on dried, untreated reindeer skin (left), and on depilated skin (SNF) tanned with willow bark extract (right).

analysis showed a difference of 2.6 °C from the lowest to the highest temperature. The lowest T_s were measured to 62.3 °C and the highest value was measured to 64.9 °C (Fig. 6.12). There does not seem to be a general pattern in the differences measured in the skin, although the shrinkage temperature is slightly elevated towards the lower back of the skin. The same investigations were made on a depilated reindeer skin manually tanned with willow bark extract (SNF) (Fig. 6.12) and to a manually tanned skin where willow bark extract and a locally purchased skin processing oil (emulsion) was applied (SWF). The SNF skin exhibited a greater variation of T_s in these measurements than in dried untreated skin. The lowest value was measured to 66.4 °C and the highest value was measured to 74.2 °C. This is a T_s difference of 7.8 °C. For the SWF skin, the T_s difference is lower; 3.5 °C (Table 6.6).

Measuring the hydrothermal stability of collagen fibres generally involves removing as much as possible of the fatty substances from the collagen fibres prior to analysis. Fibres containing fatty substances will absorb humidity at a slower rate, as opposed to defatted fibres, and generally yield a higher shrinkage temperature (T_s). Removing the fat will provide a more correct representation of the collagen fibres' condition, but will not to the same degree mirror the artefacts general reaction rate. How fast the water penetrates the collagen fibres varies significantly from artefact to artefact, depending on the amount of fat in the fibre structure, the possible cross linking of lipid molecules and collagen, the condition of the fibres, and the efficacy of the defatting procedure. Defatting procedures for selected samples were conducted to investigate this issue. The samples were chosen from the amount of fatty acids (FA) calculated in the sample, based on the GC-MS analysis. Samples with different FA content were selected (Table 6.7). Skin fibres from two reference samples and four historic samples were separated and left in petroleum ether (boiling point 40-60 °C) for 24 hours. The samples were repeatedly stirred. After removal from the solvent, the fibres were rinsed three times, each time in fresh solvent and air dried, before the fibres were rewetted and the shrinkage activity was registered. This procedure removes most of the fatty substances in the skin sample. The objective to characterise and identify substances used in skin processing, involves a visual description of the fibres prior to hydrothermal analysis, such as a description of residues or other elements observed as the skin fibres are physically separated in water. This also involves observing

Sample	**T_s**	**ΔT**	**T_{first}**	**T_{last}**	**ΔT_{total}**	**Ts difference**
SWH dried untreated	63,9	3,8	61,2	71,8	10,6	2,6
SNF (DS with willow bark extract)	69,5	8,0	65,6	82,5	16,9	7,8
SWF (DS with willow bark extract and fat (F5))	77,0	8,7	72,7	88,3	15,6	3,5

Table 6.6. Average shrinkage activity and the Ts difference between different locations on manually tanned skin materials.

Museum number	Age	Material type	FA content %	T_s difference
IMRS-0510-A	100	SWH	14.8	0.5
SVD-0429	Unknown	DS	3.0	1.3
TM-unr-toolmarks	Unknown	SWH	1.4	3.5
MAE-3957-1	75	SWH	0.4	1.6
DS-N7-17	Reference	DS	5.0	7.0
DS-R10-21	Reference	DS	2.4	2.4

Table 6.7. The T_s difference of skin fibre samples after defatting.

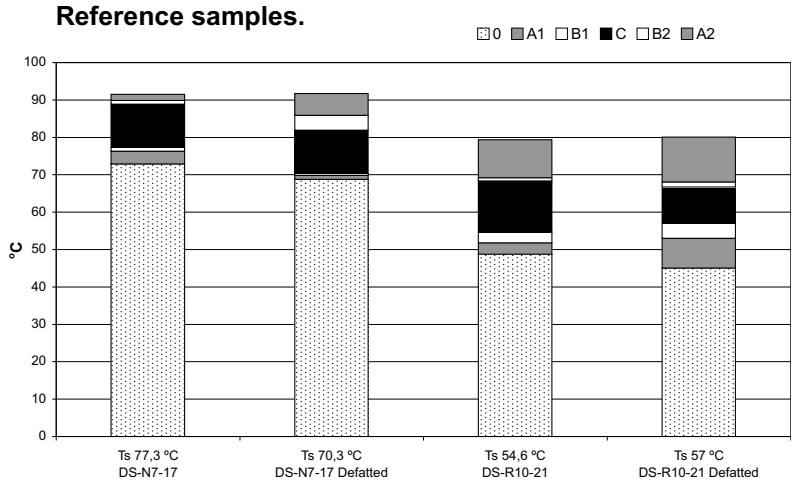


Fig. 6.13. Shrinkage activity of reference samples before and after defatting.

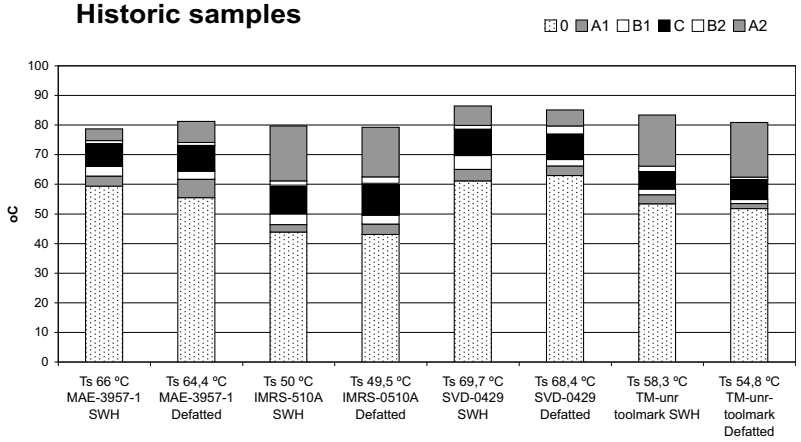


Fig. 6.14. Shrinkage activity of the historic samples before and after defatting.

substances clinging to the fibres' surface. Residues of possibly fatty substances could be observed in the separation of the fibres for some samples, although the fatty acid (FA) content in % of total sample size does not necessarily reflect the residue observations. This means that even if fat droplets were observed on the glass slide, the FA content in the sample could still be quite low.

Investigating the difference of the shrinkage temperature of the sample before and after defatting showed a very varied result (Fig. 6.13, 6.14). The main difference between defatted and not defatted samples appears in the reference samples. However, only two samples are investigated. The reference sample are; DS-N7-17 with a FA content of 5.0 % and DS-R10-21 with a FA content of 2.4 %, yielding a T_s difference of 7.0 °C and 2.4 °C respectively. The four historic samples, chosen for their varied FA content, exhibit a lower and more even T_s difference. Again, the FA content of the sample does not reflect the T_s difference, as can be observed in table 6.7 below.

6.3.3 Analysis of hydrothermal stability of the reference samples from the Sámi and Evenk culture

Depilated skin (DS) samples generally exhibit a higher shrinkage temperature (T_s) than the samples from whole skin with hairs attached (SWH) and leg skin (LS) (Fig. 6.15, table 6.11). This is concurrent with the information on the tanning substances added to the material, which is willow bark extract and locally bought skin processing oils. The shrinkage temperature of the DS samples ranges from 77.3 °C to 82.4 °C. The sample with the highest T_s: DS-N9-14 (82.4 °C), is at the same time evaluated to contain condensed tannins, illustrated by a high tannin content measured as OD/100mg (Table 5.2). The naturally aged sample DS-N7-16 has lower T_s (63.4 °C), indicating that deterioration of the collagen fibres has taken place. One of the substances added to this sample is possibly cod liver oil (CLO) which may cause a slight oil tannage effect on the material. This is also the case for DS-N7-17 which possibly also contains CLO. A low tanning degree and the application a fatty substance may be an additional reason for a lower shrinkage temperature observed in these samples.

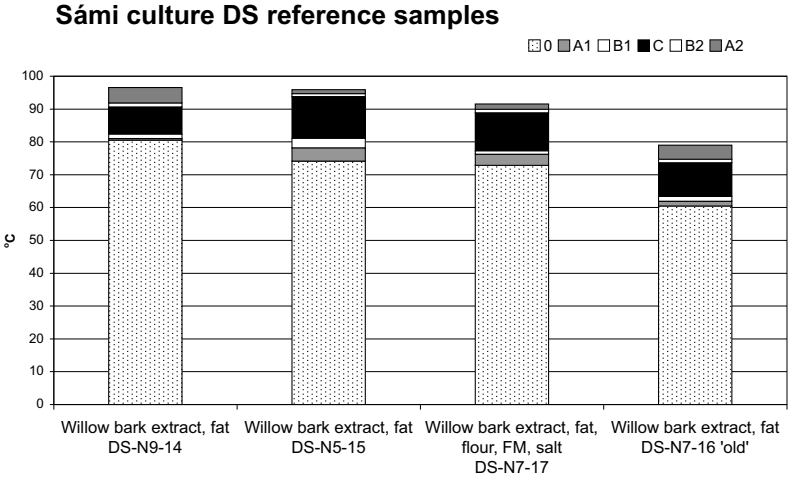


Fig. 6.15. The results of the hydrothermal analysis of the Sámi culture DS reference samples.

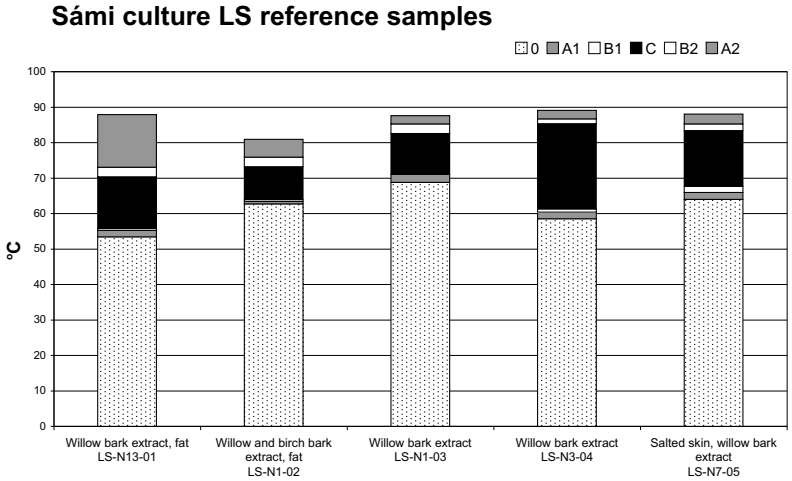


Fig. 6.16. The results of the hydrothermal analysis of the Sámi culture LS reference samples.

The length of the main shrinkage interval, ΔT, for the DS references samples range from 8 °C to 12 °C. The sample with the highest T_s (DS-N9-14) has the lowest ΔT, indicating reasonable homogeneous fibre strength. A high T_{first} furthermore indicates a well tanned skin in good condition, yielding a total shrinkage range only slightly longer than that for untreated skin.

The leg skin (LS) samples have generally lower T_s compared to the DS samples (Fig. 6.16, table 6.11). All samples have been tanned with willow bark extract, but probably only as a surface tannage and/or colouring. Based on the visual analysis of tannin penetration, the samples typically consist of tanned and untanned collagen fibres. This results in a heterogeneous assembly of fibre qualities and consequently for some samples a very long ΔT, up to 24 °C. The T_s of the LS samples range from 55.8 °C to 70.2 °C. The application of a condensed plant polyphenol does not seem to have caused significantly elevated shrinkage temperatures in the material. The fatty substances, if they have been applied to the skin, come in various forms, but most likely in these samples as locally purchased tanning oils. The effect of these fats are not an actual oil tannage, but rather a fat liquoring resulting in a T_s value close to raw skin. LS samples showing slightly higher T_s (67.7 °C and 70.2 °C) may consist of a fibre mixture on the glass slide consisting of more tanned than untanned fibres. The total shrinkage range (ΔT_{total}) is generally

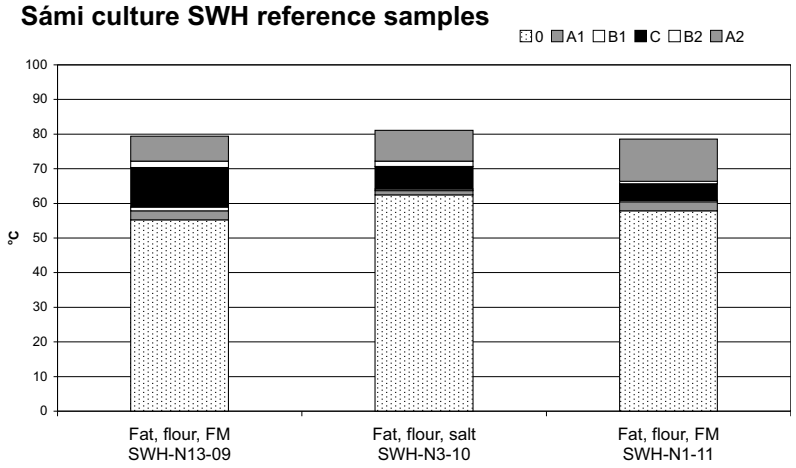


Fig. 6.17. The results of the hydrothermal analysis of the Sámi culture SWH reference samples.

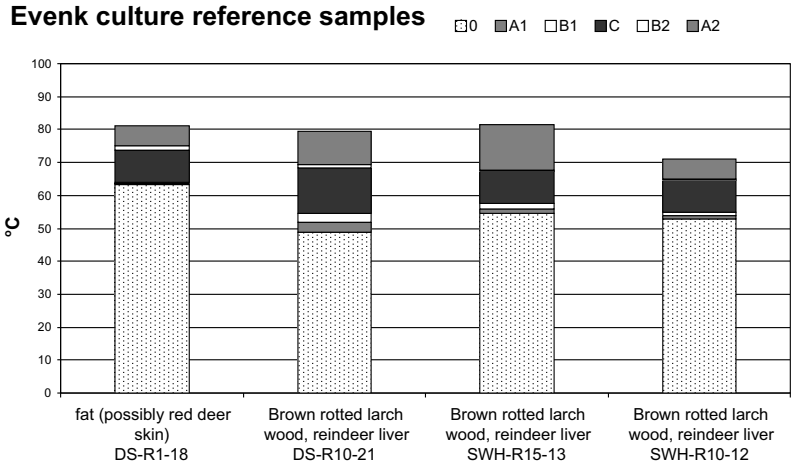


Fig. 6.18. The results of the hydrothermal analysis of the Evenk culture reference samples which have not been smoked as part of the tanning process.

very long for the LS samples, between 17 °C and 34 °C. This is expected, due to the diverse fibre characteristics.

The samples from whole skin with hairs attached (SWH) have a T_s ranging from 58.9 °C to 64.1 °C (Fig. 6.17, table 6.11). This is significantly lower than the DS samples and fairly similar to the LS samples. The SWH samples have not been tanned with a plant polyphenol. A willow bark solution may have been used as humidification prior to the removal of the subcutaneous tissue, and also as a fluid supplement to the pasty tanning formula, but not as a regular tanning agent on its own. This is reflected in the results from the hydrothermal analysis. The values range around the T_s of untreated skin, which indicate the use of a fatty substance. At the same time a reduced T_s may signify a beginning deterioration of the sample material. This is not very likely in these fairly new reference samples, although the sample with the lowest T_s (SWH-N13-09) also exhibits a fairly high amount of monomers (gallic acid) from decomposition of plant polyphenols observed in the vegetable tannin analysis (HPLC) (Table 5.2). The ΔT of the SWH samples is short, from 4.9 °C to 11.4 °C. This indicates a fairly even tanning of the skin and a fairly uniform condition of the fibres. Yet, the SWH samples generally have long total shrinkage ranges, from 18 °C to 24 °C, due to the fairly long A_2 interval. A longer A_2 interval suggests that there is a tendency towards varying tanning qualities also in these, in other wise, homogenous fibre groups.

In the Evenk culture reference samples there are two main patterns in the shrinkage activity. One pattern describing the shrinkage activity of skin samples which have been treated with a fatty substance and another pattern describing the activity in samples which, in addition to have been treated with fatty substances, also have been smoked. The T_s of the reference samples treated with brown rotted larch wood do not come close to the suggested values for skin tanned with condensed tannins, between 80- 85 °C.

The samples, where only a fatty substance has been applied (in addition to brown rotted larch wood), generally have a T_s ranging from 52.8-57.6 °C (Fig. 6.18, table 6.11). This is concurrent within the shrinkage temperature range suggested for oil tanned skin. The results of the analysis of defatted fibre sample showed, that the T_s may even be slightly lower due to delayed water absorption of the fibres. This implies, if the brown rotted larch wood is assumed to have little effect on the shrinkage temperature, that there is little

reduction in fibre stability due to deterioration. The ΔT interval of the samples treated with a fatty substance supports this impression, as the main shrinkage interval is fairly short, ranging from 9.6-13.8 °C. The samples have short initial shrinkage intervals A_1 and B_1. This again strengthens the impression that the main part of the reference samples is not significantly deteriorated. The ΔT_{total} of the samples varies from 18.2-30.7 °C, indicating a certain variety in tanning quality, and that some fibres have a higher degree of tannage than others.

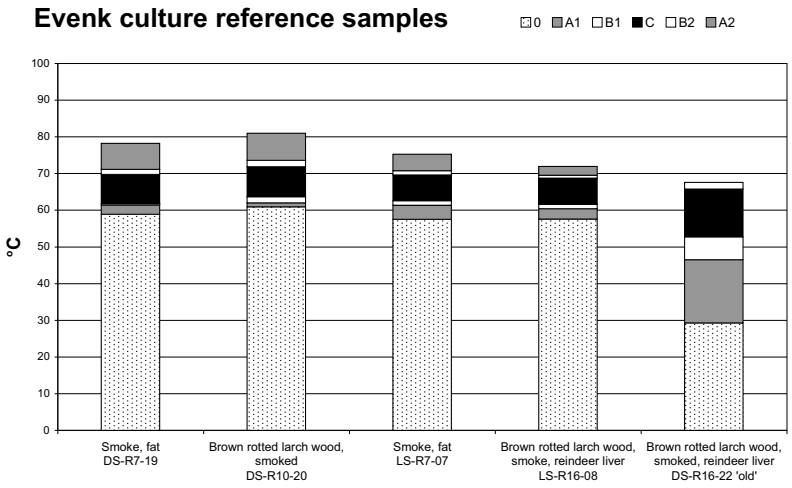


Fig. 6.19. The results of the hydrothermal analysis of the Evenk culture reference samples which have been smoked as part of the tanning process.

The samples that have been smoked, in addition to being treated with fatty substances, have slightly elevated shrinkage temperatures than the sample that have not been smoked (Fig. 6.19, table 6.11). Some of these samples have also been treated with brown rotted larch wood, but with no obvious effect to the shrinkage temperature. The T_s of these sample lie between 61.6 °C and 63.7 °C. ΔT lies between 7.1 °C and 8.2 °C and ΔT_{total} from 14.3-20.1 °C. This is very even values, showing a uniform tannage. The shrinkage temperature of an aldehyde tannage effect due to smoking is not known to increase the shrinkage temperatures of the skin. The ΔT_{total} ranges are fairly short, indicating a uniform tanning quality of the samples. The range is slightly longer than for untreated skin sample, but not significantly longer. All samples that have been smoked, have short initial intervals, A_1 and B_1, indicating that the samples have not noticeably deteriorated. This does not apply to the naturally aged sample DS-R16-22, which has a very long A_1 interval and a very low T_{first} value. This skin sample is approximately 20 years old, and comes from a boot which was discarded and is now used as patching material. Although this sample has a very low T_{first}, the shrinkage temperature is not significantly low. However, compared to the smoked skin samples the T_s has fallen by almost 10 degrees.

There are important distinctions between the Evenk and Sámi culture reference samples, both in the choice of tanning substances and application methods for each material type. In the Evenk culture samples the substances and processes are independent of the material types: DS, SWH, and LS, whereas the Sámi culture samples indicate a use of different tanning methods and substances for each material type. This is reflected in the shrinkage temperature. The results of the analysis of hydrothermal stability of the Evenk culture reference samples, exhibit a more homogenous material, based on one main methods; the application of a fatty substance, and as a sub group, the presence or absence of a smoking procedure.

The Sámi culture DS samples stand out in the overall T_s measurements. This material type exhibits the characteristics of a vegetable tanned skin. Even thought the Sámi culture LS samples also are treated with the same condensed tannin, this group exhibits a very different result. This strengthens the interpretation that the colouring effect of the plant polyphenols and the attainment of a raw streak in the processing of LS skin material, perhaps are more important than the tanning effect. Generally in the Sámi culture sample material there is a greater variability also in the length of the main shrinkage interval, ΔT. This confirms the impression that the methodological individuality is greater in the Sámi culture samples than in the Evenk culture samples, where ΔT is generally shorter and more homogenous.

6.3.4 Analysis of hydrothermal stability of historic samples from the Sámi and Evenk culture

It is expected that deterioration has occurred in the artefact material over the last century. Most of the Evenk culture samples are between 80 to 120 years old, while most of the Sámi culture samples are younger, between 30-70 years, with a few exceptions (NFSA-

samples) which are approximately 100 years old. The conditions under which the artefacts have been stored and exhibited are not fully known, but a variety of conditions must be expected. The interpretation of the shrinkage activity is based on the substances and processes which have been used in the reference samples and furthermore substances based on information from the informants, and from the investigation of processing methods and materials used in indigenous culture in the sub arctic and arctic area. This predominantly consists of; plant polyphenols (mainly CT); fatty substances; smoking and combinations of these substances. As for the reference sample material, individual differences in tanning quality must be expected also in the historic artefact material.

The Sámi culture DS samples (Fig. 6.20, table 6.9) vary in T_s from 48.4 °C to 69.7 °C. If it is assumed that condensed tannins are used in the historic sample material, the decrease from the original T_s is extensive. For this to be considered an extensive drop in temperature, the original T_s should lie in the vicinity of 80 °C to 85 °C. However, as observed in the reference samples and the experimental samples, depilated skin from the Sámi culture tanned with condensed tannins, may be as low as 70 °C (table 6.6). It is therefore difficult to use T_s as a measurement for identification of vegetable tannins in this research material.

The span of 21.3 °C from the lowest to the highest T_s, indicate that the stability of the collagen fibres vary significantly. This is further supported by the long A_1 intervals for most of the samples. The main shrinkage interval (ΔT) indicates by its length the general condition of the fibres in the sample. A short ΔT will in most cases indicate a well tanned skin and at the same time that the fibres are of similar condition. A long ΔT may indicate that the fibres are unevenly tanned and that tanned and untanned fibres shrink at different intervals (sub intervals). The length of the main shrinkage interval (ΔT) varies from 7.5 °C to 17.7 °C for the DS samples. The short intervals, in most cases, follow higher shrinkage temperatures. The condition of the collagen fibres may be either good or poor, depending on how high the T_s is. A high T_s and a short ΔT indicates high stability for the collagen fibres, whereas low T_s and a short ΔT, indicates similar and deteriorated fibres.

The T_s for all Sámi culture SWH samples (Fig. 6.21, table 6.9) lie within a span of 8.4 °C (from 50.3 °C to 58.7 °C). This is remarkably alike for artefacts with a variable age and from different locations, and may indicate that a similar processing method has been used, and that the deterioration of this material follows the same pattern. The T_s of these samples, from 50.3 °C to 58.7 °C suggests that a fatty substance have been applied as a tanning agent. The initial shrinkage activity, T_{first}, for some of the samples is very low, starting at

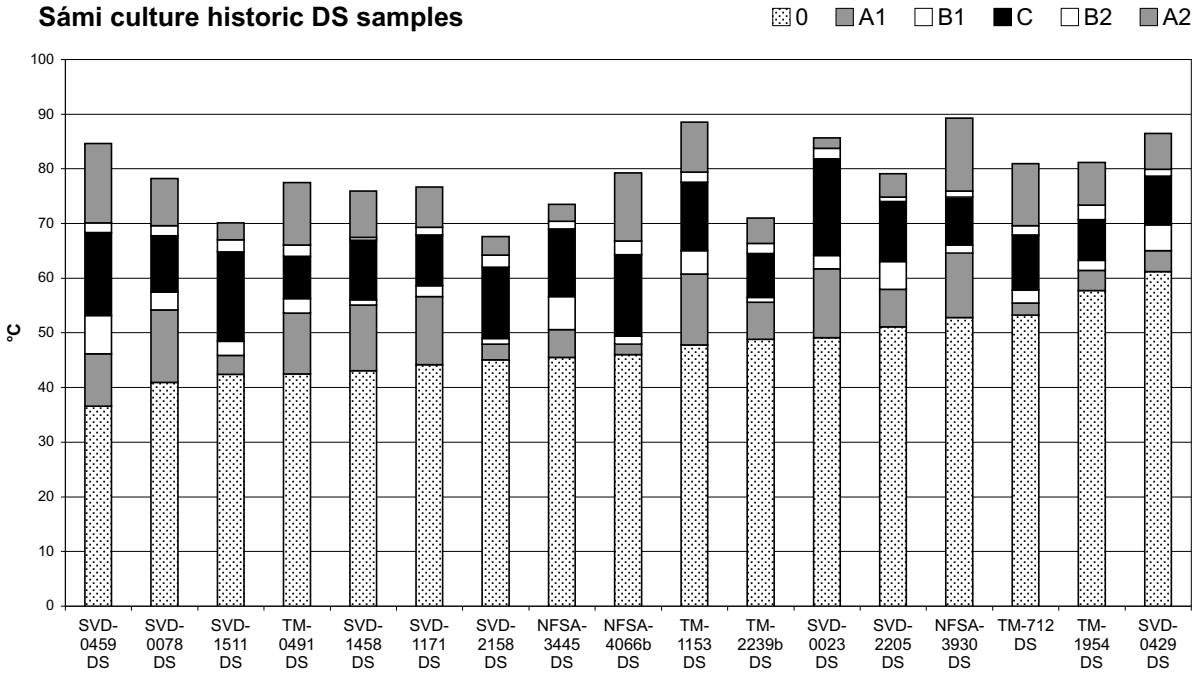


Fig. 6.20. The results of the hydrothermal analysis of the Sámi culture historic DS samples.

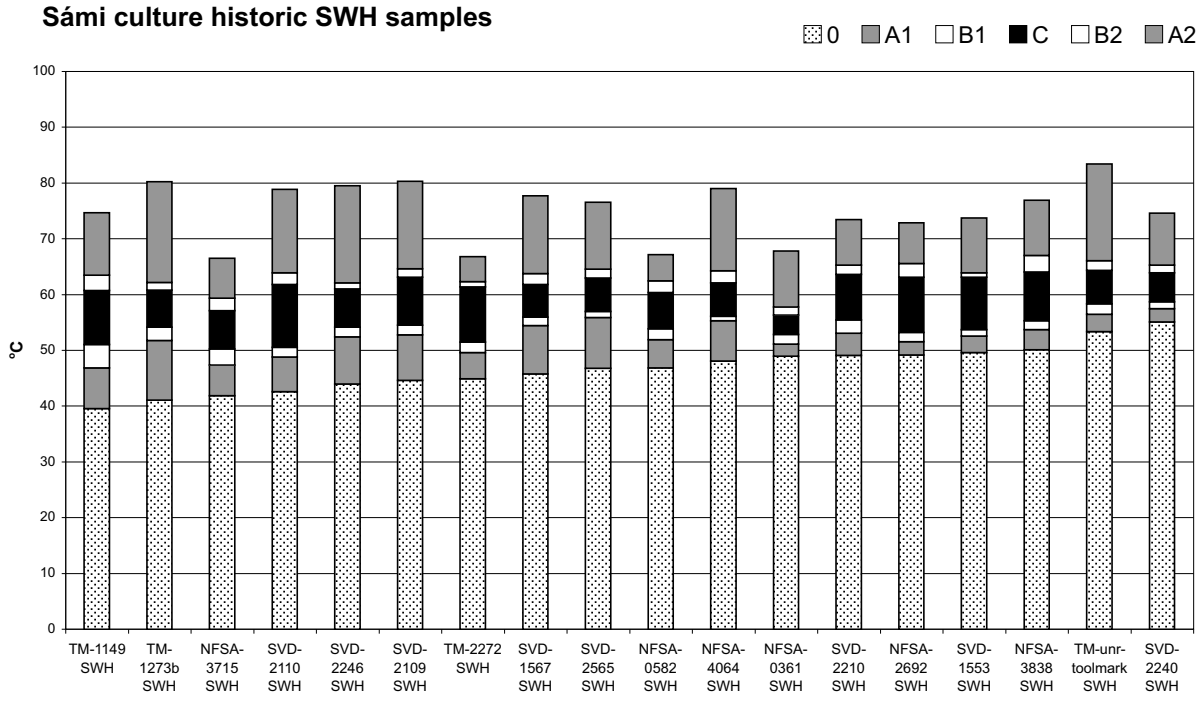


Fig. 6.21. The results of the hydrothermal analysis of the Sámi culture historic SWH samples.

39.6 °C, suggesting instability in the fibres and that deterioration has occurred (Table 6.9). Comparing these results to the results from the Sámi culture SWH reference samples and to the experimental samples, T_s has decreased. The main shrinkage intervals (ΔT) lie within a range of 3.5 °C to 11.3 °C, with an average of 7.5 °C. This indicates a fairly homogenous nature of the collagen fibres from these samples.

The Sámi culture LS samples (Fig. 6.22, Table 6.9) show a variety in shrinkage activity as is also observed in the LS reference samples. The nature of this material type, where keeping a raw streak in the material is important for the properties of the material, also indicates that both tanned and untanned fibres are present during the shrinkage intervals, yielding high values for the main shrinkage interval, the A_2 interval, and in the end for the ΔT_{total}. The fairly long A_1 intervals indicate and uneven condition of the fibres in the sample and the T_s lie between 48.0 °C and 72.5 °C, although the main part of the sample material has shrinkage temperatures above 60 °C. These variations reflect that some of the samples show deterioration features, but also that the surface tanning observed in the samples yields both tanned and untanned fibres.

The Evenk culture samples show a slightly different shrinkage activity pattern which seems unrelated to material types (Table 6.9). This is also observed in the reference samples. There is, furthermore, a strong tendency that the artefacts within one institution have similar shrinkage activity patterns, or more precisely, that the shrinkage temperatures (T_s) from artefacts within one museum institution have similar values, independent of material type. For example: the average T_s for the samples marked IMRS is 49.3 °C (DS: 49.4 °C, LS: 49.1 °C, and SWH: 49.3 °C). The average T_s for the samples marked MAE is 64.9 °C (DS: 66.1 °C, LS: 63.4 °C, and SWH: 65.1 °C). When examining the shrinkage temperatures for one material type (for example SWH) from all institutions together, the variety is significant (Fig. 6.23), but if samples from the individual institutions are extracted and viewed separately, the shrinkage temperatures are located within a limited range for all the samples from the same institution (Fig. 6.24, 6.25). This is observed in artefact collections where the artefacts are of a similar age. The main shrinkage interval (ΔT) values exhibit the same tendency as the T_s, that ΔT is located within a limited range within the same institution. This is a general trend, although exceptions occur.

The deterioration of the collagen fibres is also measured by when shrinkage of the individual fibres starts (T_{first}) as well as by when the last individual fibre shrink (T_{last}). In this respect, the Evenk culture samples show significant variations. This feature is also

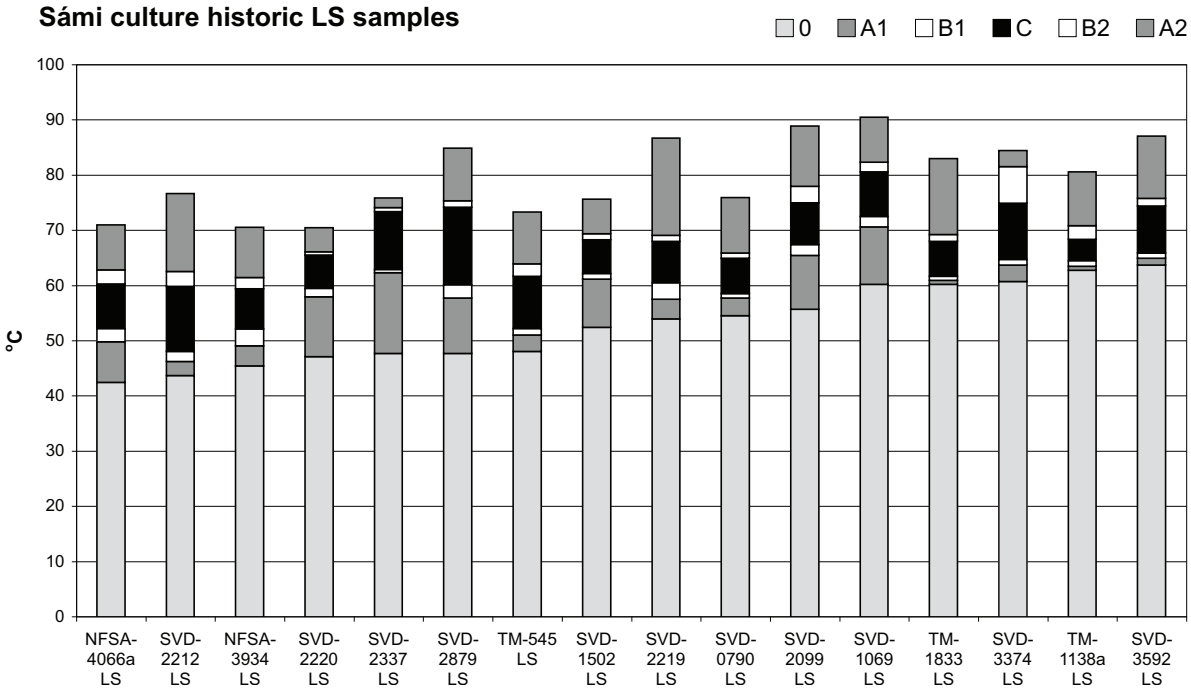


Fig. 6.22. The results of the hydrothermal analysis of the Sámi culture historic SWH samples.

measured by the ΔT_{total}, which generally is high for most samples, ranging from 19.4 °C to 47.5 °C. The younger samples, such as VK-6161-17, VK-6161-25, and VK-6161-14, which are approximately 15 years old and MAE-3957-1 and REM-9996-2, which are 75 and 30 years respectively, generally have lower ΔT_{total}

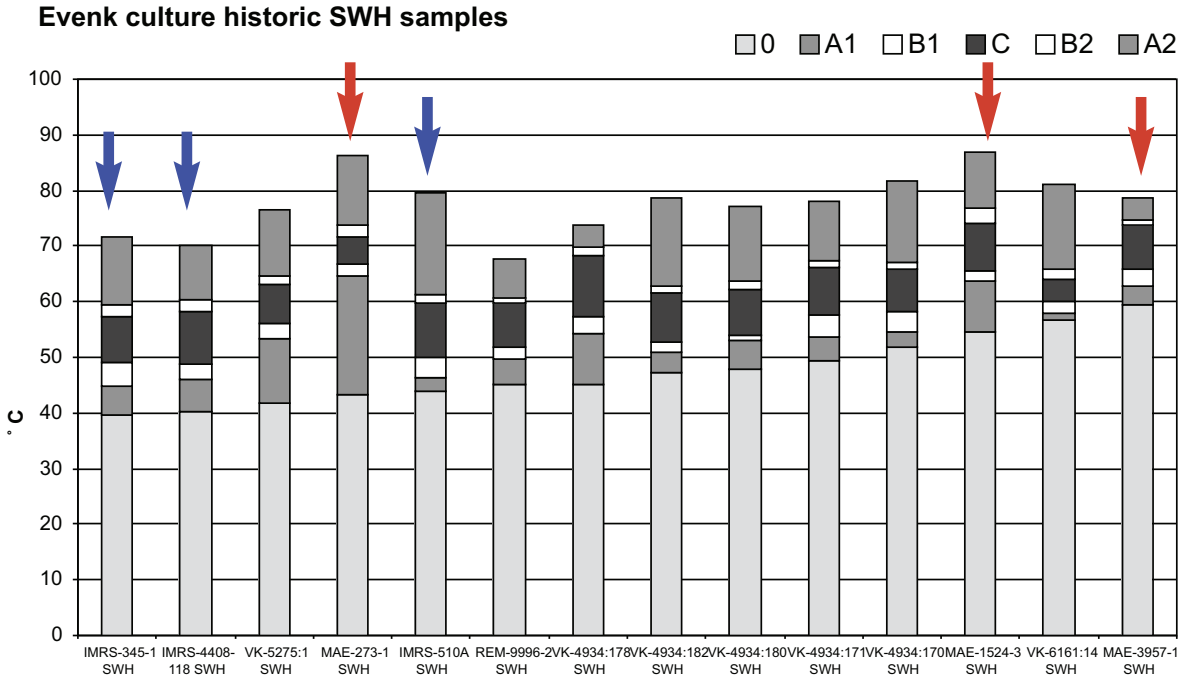


Fig. 6.23. Shrinkage activity for SWH samples from all museums included in this study. Results from MAE, marked with red arrows, is extracted and can be viewed in figure 6.24. Results from IMRS marked with blue arrows are extracted and can be viewed in figure 6.25.

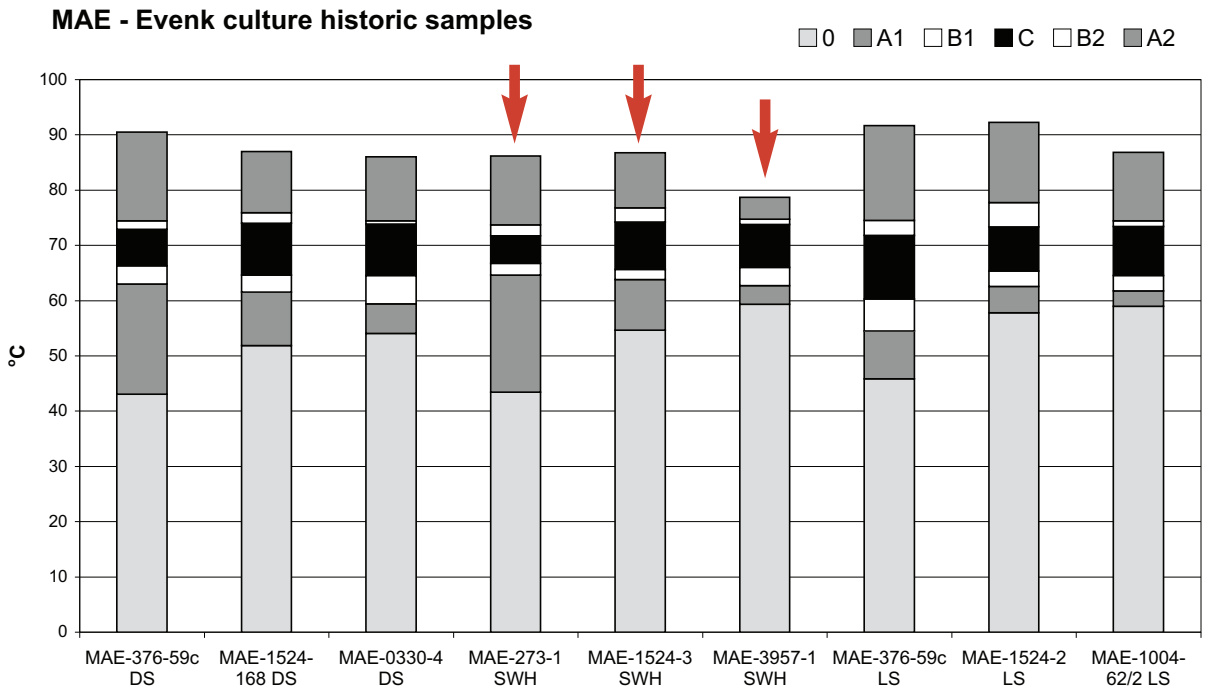


Fig. 6.24. Shrinkage activity for SWH samples from MAE, including the results marked in red arrows in figure 6.23, indicating that the main shrinkage interval is located within a certain range.

values, 29.7 °C, 27.8 °C, 24.4 °C, 19.4 °C, and 22.6 °C respectively, than the other samples in their respective institutions, which typically have ΔT_{total} values between 30 °C and 45 °C.

6.3.5 Summary

The Sámi and Evenk culture reference samples and historic samples exhibit varied shrinkage patterns, which mainly seem to divide the samples in two skin processing groups. One being the vegetable tanned DS material and the other being the skin material where fatty substances have been applied. In addition, the surface tanning applied to Sámi culture LS material and smoking of the Evenk culture skin materials, can be seen as subgroups as there are deviations and overlaps in the characteristics in and between the processing groups.

This division is furthermore based on the observations that brown rotted larch wood used in the tanning of the Evenk culture skin material does not affect the shrinkage temperature (T_s) to a significant degree. None of the Evenk culture reference samples treated with brown rotted larch wood, have T_s values above 70 °C, and consistently, none of the Evenk culture historic samples have T_s values above 70 °C, although a few samples have a T_s close to this value.

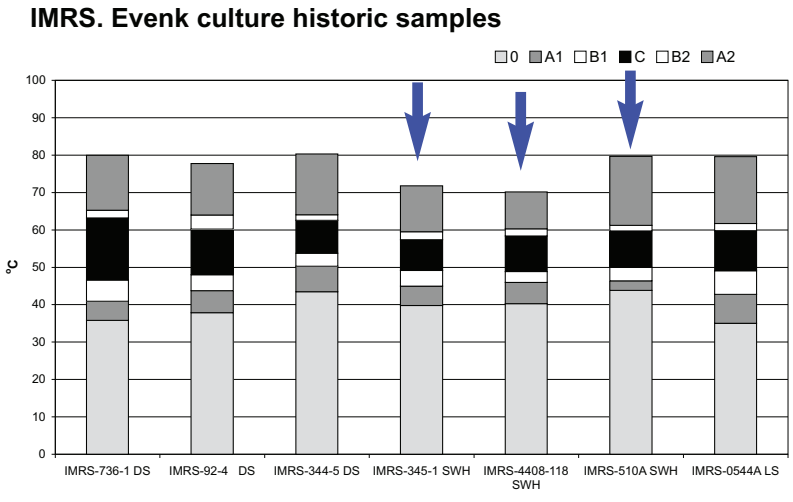


Fig. 6.25. Shrinkage activity for SWH samples from IMRS, including the results marked in blue arrows in figure 6.23, indicating that the main shrinkage interval is located within a certain range.

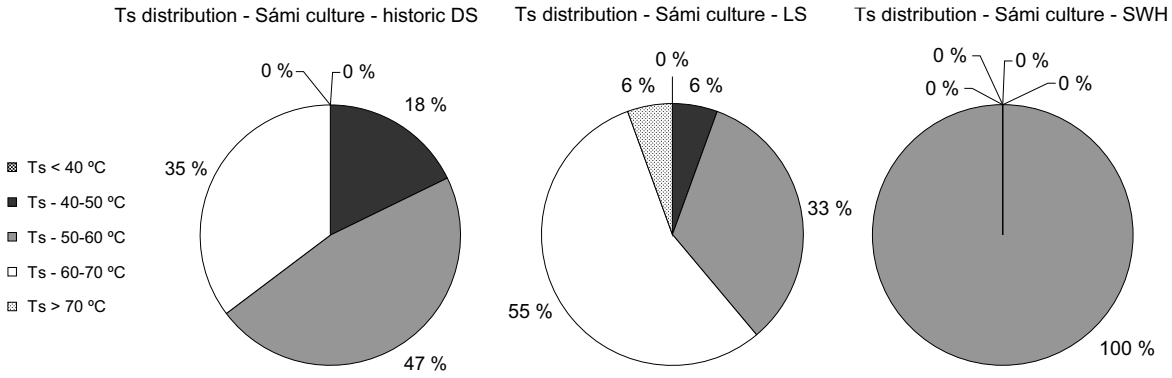


Fig. 6.26. Distribution of artefacts in the various condition categories for shrinkage temperature (T_s) in Sámi culture historic DS and LS artefact samples.

The Sámi culture reference DS samples and the experimental samples show that even though a skin is tanned with known vegetable tannins of a condensed type, the T_s may be fairly low compared to the general guidelines, and exhibits T_s value from 69.5-82.4 °C and furthermore that the variation in T_s within a skin may be significant (Fig. 6.12). The historic DS and LS samples of the Sámi culture, do not exhibit T_s values above 70 °C, indicating a low tanning degree, and an ongoing deterioration of the skin. In addition, the analyses of the vegetable tanned Sámi culture DS samples show that individual tanning procedures are reflected in the skin material. A raw streak in vegetable tanned DS material is not unusual, and would yield longer intervals as the tanning degree would vary within the fibre sample group. The same phenomenon is observed in Sámi culture leg skin (LS), although the use of vegetable tannins here seems to be mostly superficial. The LS samples also exhibit the same individuality in the processing method, resulting in a very varied shrinkage pattern, where the shrinkage temperatures range from 55.8-70.7 °C in the reference material, and from 48.0-72.5 °C in the historic sample material. The presence of a tanned and untanned fibres, results in shrinkage intervals of varying lengths.

Vegetable tanned (CT) and surface tanned sample material with an obtained shrinkage temperature > 60 °C, will regarding hydrothermal stability, be evaluated as in a good condition. For samples with T_s between 50 °C and 60 °C, the condition will be suggested as fairly good, and for samples where the T_s lies between 40 °C and 50 °C the condition will be regarded as fairly poor. Samples with a shrinkage temperature < 40 °C the condition will be considered in a poor condition. The Sámi culture LS samples, which is regarded as a sub group of the vegetable tanned material, exhibits shrinkage temperatures within the same range as the DS material. Furthermore, the percentage of artefacts sample with T_s above 60 °C is considerable higher in the LS sample group than in the DS sample group (Fig. 6.26), indicating that the LS material generally is in a better condition that the DS material. The SWH samples from the Sámi culture have a very characteristic pattern, where all samples are located within the condition category 'fairly good', with T_s between 50-60 °C. This may be an illustration of uniform tanning effect obtained by the SWH samples by the method which have been employed and possibly an expression of an even deterioration pattern (Fig. 6.26).

Applying these condition categories to the artefact sample material of this study shows that none of the vegetable tanned samples have a T_s below 40 °C. It is furthermore observed that the group of artefacts in the 'fairly poor' condition category (T_s between 40-50 °C) are larger in the DS sample group than in the LS sample group, indicating the vegetable tanned (CT) DS materials generally are more deteriorated than the LS artefact samples.

Even though the process of using fatty substances in the tanning of Evenk culture skin material, as well as in Sámi culture artefact SWH material, should be insufficient in creating a fully oil tanned skin, the shrinkage activity still indicates that an effect is obtained. The Evenk culture reference samples and the Sámi culture SWH reference samples exhibit shrinkage activity which supports this, exhibiting a decrease in the T_s in skins where a fatty substance has been applied. The reference samples have shrinkage temperatures ranging from 54.6-63.7 °C (Table 6.8).

Smoking, as in obtaining a slight aldehyde tanning effect, which may be indicated from the results of the

Sample number	Substance	Material type	T_s - °C	ΔT - °C	T_{first} - °C
DS-R10-21	Brown rotted larch wood, reindeer liver	DS	54,6	13,8	48,7
SWH-R10-12	Brown rotted larch wood, reindeer liver	SWH	54,9	9,6	51,6
SWH-R15-13	Brown rotted larch wood, reindeer liver	SWH	57,6	9,7	54,4
SWH-N13-09	Willow bark extract, fat, flour	SWH	58,9	11,4	56,8
SWH-N1-11	Fat, flour, FM	SWH	60,8	4,9	57,7
LS-R16-08	Brown rotted larch wood, reindeer liver, smoke	LS	61,6	7,1	56,2
DS-R7-19	Fat, smoke	DS	61,8	8,0	58,9
LS-R7-07	Reindeer liver, smoke	LS	62,2	7,1	57,5
DS-R10-20	Brown rotted larch wood, smoke	DS	63,7	8,2	60,6
Dried reindeer skin	Untreated	SWH	63.9	3.8	61.2

Table 6.8. Results from the analyses of hydrothermal stability for the SWH references samples from the Sámi culture, as well as the DS, SWH, and LS samples from the Evenk culture. The samples that are treated with a fatty substance, and which in addition are smoked, show a slight increase in hydrothermal stability.

reference samples, seems to raise the T_s of the fat tanned skin material by a few degrees (Table 6.8). This assumption is however based on a small sample material.

Observations of the shrinkage temperature of the sample material tanned with a fatty substance confirm the similarity in processing method for all material types (Fig. 6.27). The condition categories are the same as for the vegetable tanned material, but may be interpreted slightly different, as the T_s starting point would be different. The T_s starting point of these skin materials will on the basis of the reference sample, be assumed to lie within a range from 60 °C to 65 °C. If this is assumed, the Evenk culture sample material show a lower average drop in shrinkage temperature, than the vegetable tanned skin materials. For these skins, where a fatty substance and possibly smoke is

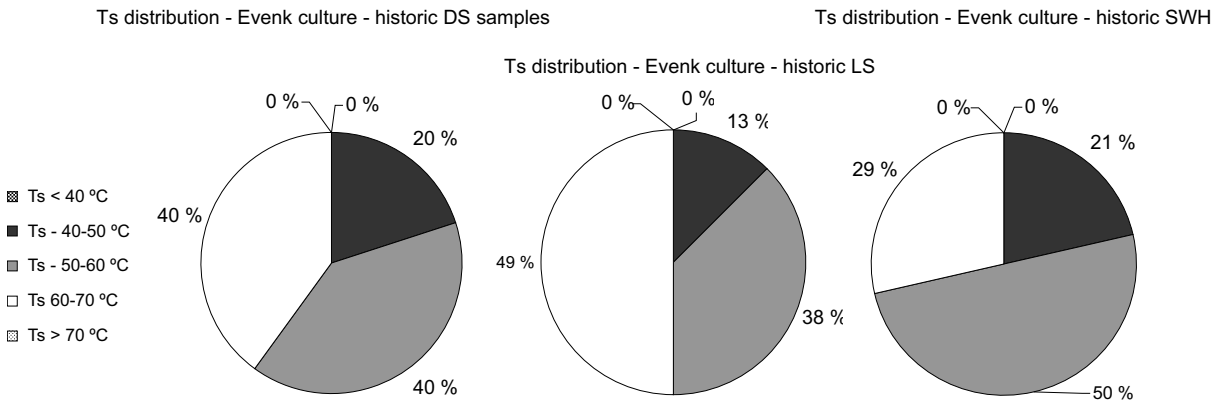


Fig. 6.27. Distribution of artefact samples in the respective condition categories for shrinkage temperature (T_s) in Evenk culture historic DS, LS, and SWH artefact samples.

used in the tanning process, and furthermore, if a shrinkage temperature of 65 °C is set as the starting point, the average drop in T_s is 10.7 °C for the Sámi culture SWH samples and 8.1 °C for the Evenk culture sample material. The average drop in T_s for the Evenk culture samples are lower than for the Sámi culture SWH samples, seeing that six of the Evenk culture samples have a shrinkage temperatures above 65 °C. If these six samples with a T_s from 65.4 °C to 66.7 °C are omitted from the calculation, the average drop is 10.6 °C, close to the average drop value of the Sámi culture SWH samples.

For the vegetable tanned skins the average drop in shrinkage temperature is considerably higher. If a shrinkage temperature of 75 °C is set as the T_s starting point, average drop in shrinkage temperature is 16.8 °C for the DS material type and 14.9 °C for the LS material type. This again indicates on a general basis that the DS material is more deteriorated than the LS material.

Table 6.9. Shrinkage activity for historic sample material sorted by material type: DS, LS and SWH.

Museum No.	Material type	A_1 - T_{first}	B_1	C - T_s	ΔT	B_2	A_2	T_{last}	ΔT_{total}
SVD-1511	DS	42.4	45.9	48.4	16.4	64.8	67.0	70.1	27.7
SVD-2158	DS	45.0	47.9	49.0	13.0	62.0	64.2	67.6	22.6
NFSA-4066 b	DS	46.0	47.9	49.4	14.9	64.3	66.8	79.2	33.3
SVD-0459	DS	36.6	46.1	53.2	15.3	68.3	70.1	84.6	48.1
SVD-1458	DS	43.0	55.1	56.0	10.9	66.9	67.4	75.9	32.9
TM-0491	DS	42.5	53.6	56.3	7.7	64.0	66.1	77.5	35.0
TM-2239b	DS	48.8	55.6	56.5	8.1	64.5	66.3	71.0	22.2
NFSA 3445	DS	45.5	50.6	56.6	12.4	69.0	70.4	73.5	28.0
SVD-0078	DS	40.9	54.2	57.4	10.3	67.7	69.5	78.2	37.3
TM-712	DS	53.2	55.5	57.8	10.2	67.9	69.6	80.9	27.7
SVD-1171	DS	44.2	56.6	58.6	9.3	67.9	69.3	76.7	32.5
SVD-2205	DS	51.1	57.9	63.0	10.9	74.0	74.8	79.1	28.0
TM-1954	DS	57.7	61.4	63.2	7.5	70.7	73.3	81.2	23.5
SVD-0023	DS	49.1	61.7	64.1	17.7	81.8	83.7	85.6	36.5
TM-1153	DS	47.8	60.7	65.0	12.5	77.5	79.4	88.5	40.8
NFSA-3930	DS	52.8	64.6	66.0	8.8	74.8	75.9	89.3	36.5
SVD-0429	DS	61.2	65.0	69.7	8.9	78.6	79.9	86.5	25.3
Average	**All DS**			**58.2**	**11.4**				**31.6**
SVD-2212	LS	43.7	46.3	48.0	11.8	59.8	62.5	76.7	33.0
NFSA-3934	LS	45.4	49.1	52.1	7.3	59.4	61.4	70.6	25.2
TM-545	LS	48.0	51.0	52.2	9.5	61.7	63.9	73.3	25.3
NFSA-4066 a	LS	42.5	49.8	52.2	8.1	60.3	62.8	71.0	28.5
SVD-0790	LS	54.5	57.7	58.6	6.4	64.9	65.9	75.9	21.4
SVD-2220	LS	47.1	57.9	59.4	6.1	65.5	66.1	70.4	23.3
SVD-2879	LS	47.7	57.8	60.1	14.1	74.2	75.4	84.9	37.2
SVD-2219	LS	53.9	57.5	60.5	7.5	68.0	69.1	86.7	32.8
TM-1833	LS	60.2	61.0	61.7	6.4	68.0	69.3	83.0	22.8

SVD-1502	LS	52.4	61.1	62.1	6.1	68.3	69.4	75.6	23.2
SVD-2337	LS	47.7	62.3	62.9	10.5	73.4	74.1	75.9	28.2
TM-1138a	LS	62.7	63.5	64.5	3.8	68.3	70.8	80.6	17.8
SVD-3374	LS	60.7	63.7	64.7	10.2	74.9	81.5	84.5	23.8
SVD-3592	LS	63.7	64.9	65.9	8.5	74.4	75.8	87.1	23.4
SVD-2099	LS	55.7	65.4	67.4	7.6	75.0	78.0	88.9	33.3
SVD-1069	LS	60.2	70.6	72.5	8.1	80.6	82.4	90.5	30.3
Average	**All LS**			**60.3**	**8.2**				**26.8**
NFSA 3715	SWH	41.8	47.4	50.3	6.9	57.1	59.4	66.5	24.7
SVD-2110	SWH	42.6	48.8	50.5	11.3	61.8	63.9	78.8	36.3
TM-1149	SWH	39.6	46.8	51.0	9.7	60.7	63.5	74.7	35.1
TM-2272	SWH	44.9	49.6	51.5	9.9	61.4	62.3	66.8	21.9
NFSA 0361	SWH	49.0	51.1	52.8	3.5	56.3	57.8	67.8	18.9
NFSA 2692	SWH	49.1	51.6	53.2	9.9	63.1	65.5	72.8	23.7
SVD-1553	SWH	49.6	52.5	53.7	9.4	63.1	63.9	73.7	24.1
NFSA 0582	SWH	46.9	51.9	53.8	6.5	60.3	62.4	67.2	20.3
TM-1273b	SWH	41.0	51.7	54.1	6.7	60.8	62.2	80.2	39.1
SVD-2246	SWH	44.0	52.4	54.2	6.8	61.0	62.1	79.5	35.6
SVD-2109	SWH	44.6	52.8	54.5	8.6	63.1	64.6	80.3	35.7
NFSA 3838	SWH	50.1	53.7	55.3	8.7	64.0	67.0	76.9	26.9
SVD-2210	SWH	49.1	53.0	55.5	8.1	63.6	65.3	73.4	24.4
SVD-1567	SWH	45.8	54.4	55.9	5.9	61.8	63.7	77.7	32.0
NFSA 4064	SWH	48.1	55.3	56.1	6.0	62.1	64.3	79.0	31.3
SVD-2565	SWH	46.8	55.9	56.9	6.0	62.9	64.5	76.5	29.7
TM-unr toolmark	SWH	53.4	56.5	58.3	6.0	64.3	66.1	83.4	30.0
SVD-2240	SWH	55.1	57.5	58.7	5.3	63.9	65.3	74.6	19.6
Average	**All SWH**			**54.2**	**7.5**				**28.3**
Museum No.	**Material type**	**A_1 - T_{first}**	**B_1**	**C - T_s**	**ΔT**	**B_2**	**A_2**	**T_{last}**	**ΔT_{total}**
IMRS-736-1	DS	35.8	40.9	46.6	16.6	63.2	65.3	80.0	44.2
IMRS-92-4	DS	37.9	43.7	48.0	12.2	60.2	64.0	77.7	39.9
VK-4934:183	DS	41.8	50.7	53.5	7.1	60.6	62.0	77.5	35.7
IMRS-344-5	DS	43.5	50.3	53.7	8.8	62.5	64.1	80.3	36.9
VK-6161:17	DS	47.9	55.2	58.1	8.4	66.7	67.5	77.5	29.7
MAE-0330-4	DS	54.1	59.4	64.5	9.2	73.8	74.4	86.0	32.0
MAE-1524-168	DS	51.9	61.5	64.6	9.7	74.0	75.9	87.0	35.1
MAE-376-59c	DS	43.1	63.0	66.3	6.7	72.9	74.4	90.5	47.5
REM-1210-2	DS	55.8	65.3	66.4	7.0	73.4	75.5	90.5	34.7

Average	**All DS**			**57.9**	**9.5**				**37.3**
VK-4934:175	LS	34.8	41.1	43.3	15.3	58.5	60.6	77.9	43.1
IMRS-0544 A	LS	35.0	42.8	49.1	10.7	59.8	61.7	79.6	44.6
REM-6749-5	LS	46.4	52.9	55.3	8.5	63.7	66.4	79.7	33.3
VK-4934:174	LS	44.7	50.4	57.0	9.1	66.0	67.1	81.6	36.9
VK-6161:25	LS	47.6	54.8	59.3	5.1	64.4	65.9	75.4	27.8
MAE-376-59c	LS	45.9	54.5	60.3	11.6	71.8	74.5	91.7	45.8
VK-4934:176	LS	49.3	58.2	60.5	6.0	66.5	67.0	75.6	26.3
MAE-1004-62/2	LS	59.0	61.7	64.6	8.9	73.4	74.4	86.8	27.9
MAE-1524-2	LS	57.8	62.6	65.4	8.0	73.3	77.7	92.3	34.5
Average	**All LS**			**57.2**	**9.2**				**35.6**
IMRS-4408-118	SWH	40.3	46.0	48.9	9.7	58.4	60.3	70.2	29.9
IMRS-345-1	SWH	39.7	44.9	49.1	8.3	57.4	59.5	71.7	32.0
IMRS-510A	SWH	43.8	46.4	50.0	9.7	59.7	61.2	79.7	35.9
REM-9996-2	SWH	45.1	49.7	51.9	8.1	59.9	60.6	67.7	22.6
VK-4934:182	SWH	47.4	50.9	52.8	8.2	61.5	62.9	78.8	31.4
VK-4934:180	SWH	47.8	52.9	54.1	8.2	62.3	63.8	77.0	29.2
VK-5275:1	SWH	41.8	53.4	56.0	7.2	63.2	64.7	76.7	34.9
VK-4934:178	SWH	45.3	54.4	57.4	10.8	68.2	69.9	73.7	28.4
VK-4934:171	SWH	49.4	53.6	57.6	8.5	66.1	67.4	78.2	28.9
VK-4934:170	SWH	51.9	54.7	58.1	8.0	65.9	67.2	81.9	30.0
VK-6161:14	SWH	56.9	58.1	60.2	3.9	64.0	65.9	81.3	24.4
MAE-1524-3	SWH	54.6	63.8	65.6	8.6	74.2	76.8	86.8	32.2
MAE-3957-1	SWH	59.3	62.7	66.0	7.7	73.8	74.7	78.7	19.4
MAE-273-1	SWH	43.4	64.6	66.7	5.0	71.7	73.7	86.2	42.8
Average	**All SWH**			**56.7**	**8.0**				**30.1**

Table 6.9. Shrinkage activity for historic sample material from the Sámi and Evenk culture, sorted by material type: DS, LS and SWH.

Table 6.10. Shrinkage activity for historic skin samples, sorted by museum

Age	Museum No.	Material type	A_1 - T_{first}	B_1 -	C - T_s	ΔT	B_2	A_2	T_{last}	ΔT_{total}
15	VK-6161:17	DS	47.9	55.2	58.1	8.4	66.7	67.5	77.5	29.7
95	VK-4934:183	DS	41.8	50.7	53.5	7.1	60.6	62.0	77.5	35.7
95	VK-4934:176	LS	49.3	58.2	60.5	6.0	66.5	67.0	75.6	26.3
15	VK-6161:25	LS	47.6	54.8	59.3	5.1	64.4	65.9	75.4	27.8
95	VK-4934:174	LS	44.7	50.4	57.0	9.1	66.0	67.1	81.6	36.9
95	VK-4934:175	LS	34.8	41.1	43.3	15.3	58.5	60.6	77.9	43.1
15	VK-6161:14	SWH	56.9	58.1	60.2	3.9	64.0	65.9	81.3	24.4
95	VK-4934:178	SWH	45.3	54.4	57.4	10.8	68.2	69.9	73.7	28.4
95	VK-4934:171	SWH	49.4	53.6	57.6	8.5	66.1	67.4	78.2	28.9
95	VK-4934:180	SWH	47.8	52.9	54.1	8.2	62.3	63.8	77.0	29.2
95	VK-4934:170	SWH	51.9	54.7	58.1	8.0	65.9	67.2	81.9	30.0
95	VK-4934:182	SWH	47.4	50.9	52.8	8.2	61.5	62.9	78.8	31.4
85	VK-5275:1	SWH	41.8	53.4	56.0	7.2	63.2	64.7	76.7	34.9
	Average	DS			55.8	7.8				32.7
	Average	LS			55.0	8.9				33.5
	Average	SWH			56.6	7.8				29.6
	Average	All			56.0	8.1				31.3
Age	**Museum No.**	**Material type**	**A_1 - T_{first}**	**B_1**	**C - T_s**	**ΔT**	**B_2**	**A_2**	**T_{last}**	**ΔT_{total}**
110	MAE-0330-4	DS	54.1	59.4	64.5	9.2	73.8	74.4	86.0	32.0
100	MAE-1524-168	DS	51.9	61.5	64.6	9.7	74.0	75.9	87.0	35.1
115	MAE-376-59c	DS	43.1	63.0	66.3	6.7	72.9	74.4	90.5	47.5
100	MAE-1004-62/2	LS	59.0	61.7	64.6	8.9	73.4	74.4	86.8	27.9
100	MAE-1524-2	LS	57.8	62.6	65.4	8.0	73.3	77.7	92.3	34.5
115	MAE-376-59c	LS	45.9	54.5	60.3	11.6	71.8	74.5	91.7	45.8
75	MAE-3957-1	SWH	59.3	62.7	66.0	7.7	73.8	74.7	78.7	19.4
100	MAE-1524-3	SWH	54.6	63.8	65.6	8.6	74.2	76.8	86.8	32.2
110	MAE-273-1	SWH	43.4	64.6	66.7	5.0	71.7	73.7	86.2	42.8
	Average	DS			66.1	8.5				38.2
	Average	LS			63.4	9.5				36.1
	Average	SWH			65.1	7.1				31.4
	Average	All			64.9	8.4				35.2
Age	**Museum No.**	**Material type**	**A_1 - T_{first}**	**B_1**	**C - T_s**	**ΔT**	**B_2**	**A_2**	**T_{last}**	**ΔT_{total}**
100	IMRS-344-5	DS	43.5	50.3	53.7	8.8	62.5	64.1	80.3	36.9
120	IMRS-92-4	DS	37.9	43.7	48.0	12.2	60.2	64.0	77.7	39.9
120	IMRS-736-1	DS	35.8	40.9	46.6	16.6	63.2	65.3	80.0	44.2

100	IMRS-0544 A	LS	35.0	42.8	49.1	10.7	59.8	61.7	79.6	44.6
110	IMRS-4408-118	SWH	40.3	46.0	48.9	9.7	58.4	60.3	70.2	29.9
100	IMRS-345-1	SWH	39.7	44.9	49.1	8.3	57.4	59.5	71.7	32.0
100	IMRS-510A	SWH	43.8	46.4	50.0	9.7	59.7	61.2	79.7	35.9
	Average	DS			49.4	12.5				40.3
	Average	LS			49.1	10.7				44.6
	Average	SWH			49.3	9.2				32.6
	Average	All			49,3	10,8				37,6
Age	**Museum No.**	**Material type**	**A_1 - T_{first}**	**B_1**	**C - T_s**	**ΔT**	**B_2**	**A_2**	**T_{last}**	**ΔT_{total}**
100	REM-1210-2	DS	55.8	65.3	66.4	7.0	73.4	75.5	90.5	34.7
75	REM-6749-5	LS	46.4	52.9	55.3	8.5	63.7	66.4	79.7	33.3
30	REM-9996-2	SWH	45.1	49.7	51.9	8.1	59.9	60.6	67.7	22.6
	Average	DS			66.4	7				34.7
	Average	LS			55.3	8.5				33.3
	Average	SWH			51.9	8.1				22.6
	Average	All			57.8	7.8				30.2
Age	**Museum No.**	**Material type**	**A_1 -T_{first}**	**B_1 -**	**C - T_s**	**ΔT**	**B_2**	**A_2**	**T_{last}**	**ΔT_{total}**
un	TM-2239b	DS	48.8	55.6	56.5	8.1	64.5	66.3	71.0	22.2
30	TM-1954	DS	57.7	61.4	63.2	7.5	70.7	73.3	81.2	23.5
un	TM-712	DS	53.2	55.5	57.8	10.2	67.9	69.6	80.9	27.7
55	TM-0491	DS	42.5	53.6	56.3	7.7	64.0	66.1	77.5	35.0
55	TM-1153	DS	47.8	60.7	65.0	12.5	77.5	79.4	88.5	40.8
55	TM-1138a	LS	62.7	63.5	64.5	3.8	68.3	70.8	80.6	17.8
55	TM-1833	LS	60.2	61.0	61.7	6.4	68.0	69.3	83.0	22.8
55	TM-545	LS	48.0	51.0	52.2	9.5	61.7	63.9	73.3	25.3
30	TM-2272	SWH	44.9	49.6	51.5	9.9	61.4	62.3	66.8	21.9
un	TM-unr toolmark	SWH	53.4	56.5	58.3	6.0	64.3	66.1	83.4	30.0
65	TM-1149	SWH	39.6	46.8	51.0	9.7	60.7	63.5	74.7	35.1
40	TM-1273b	SWH	41.0	51.7	54.1	6.7	60.8	62.2	80.2	39.1
	Average	DS			59.7	9.2				29.82
	Average	LS			59.4	6.6				22.0
	Average	SWH			53.7	8.1				31.5
	Average	All			57.7	8.2				28.4
Age	**Museum No.**	**Material type**	**A_1 - T_{first}**	**B_1**	**C - T_s**	**ΔT**	**B_2**	**A_2**	**T_{last}**	**ΔT_{total}**
30	SVD-2158	DS	45.0	47.9	49.0	13.0	62.0	64.2	67.6	22.6
un	SVD-0429	DS	61.2	65.0	69.7	8.9	78.6	79.9	86.5	25.3

un	SVD-1511	DS	42.4	45.9	48.4	16.4	64.8	67.0	70.1	27.7
un	SVD-2205	DS	51.1	57.9	63.0	10.9	74.0	74.8	79.1	28.0
un	SVD-1171	DS	44.2	56.6	58.6	9.3	67.9	69.3	76.7	32.5
un	SVD-1458	DS	43.0	55.1	56.0	10.9	66.9	67.4	75.9	32.9
un	SVD-0023	DS	49.1	61.7	64.1	17.7	81.8	83.7	85.6	36.5
un	SVD-0078	DS	40.9	54.2	57.4	10.3	67.7	69.5	78.2	37.3
un	SVD-0459	DS	36.6	46.1	53.2	15.3	68.3	70.1	84.6	48.1
un	SVD-0790	LS	54.5	57.7	58.6	6.4	64.9	65.9	75.9	21.4
un	SVD-1502	LS	52.4	61.1	62.1	6.1	68.3	69.4	75.6	23.2
30	SVD-2220	LS	47.1	57.9	59.4	6.1	65.5	66.1	70.4	23.3
un	SVD-3592	LS	63.7	64.9	65.9	8.5	74.4	75.8	87.1	23.4
un	SVD-3374	LS	60.7	63.7	64.7	10.2	74.9	81.5	84.5	23.8
un	SVD-2337	LS	47.7	62.3	62.9	10.5	73.4	74.1	75.9	28.2
un	SVD-1069	LS	60.2	70.6	72.5	8.1	80.6	82.4	90.5	30.3
un	SVD-2219	LS	53.9	57.5	60.5	7.5	68.0	69.1	86.7	32.8
un	SVD-2212	LS	43.7	46.3	48.0	11.8	59.8	62.5	76.7	33.0
un	SVD-2099	LS	55.7	65.4	67.4	7.6	75.0	78.0	88.9	33.3
un	SVD-2879	LS	47.7	57.8	60.1	14.1	74.2	75.4	84.9	37.2
un	SVD-2240	SWH	55.1	57.5	58.7	5.3	63.9	65.3	74.6	19.6
un	SVD-1553	SWH	49.6	52.5	53.7	9.4	63.1	63.9	73.7	24.1
un	SVD-2210	SWH	49.1	53.0	55.5	8.1	63.6	65.3	73.4	24.4
un	SVD-2565	SWH	46.8	55.9	56.9	6.0	62.9	64.5	76.5	29.7
un	SVD-1567	SWH	45.8	54.4	55.9	5.9	61.8	63.7	77.7	32.0
un	SVD-2246	SWH	44.0	52.4	54.2	6.8	61.0	62.1	79.5	35.6
65	SVD-2109	SWH	44.6	52.8	54.5	8.6	63.1	64.6	80.3	35.7
65	SVD-2110	SWH	42.6	48.8	50.5	11.3	61.8	63.9	78.8	36.3
	Average	DS			57.7	12.5				32.3
	Average	LS			62.0	8.8				28.2
	Average	SWH			55.0	7.7				29.7
	Average	All			58.6	9.7				29.9
Age	**Museum No.**	**Material type**	**A_1 - T_{first}**	**B_1**	**C - T_s**	**ΔT**	**B_2**	**A_2**	**T_{last}**	**ΔT_{total}**
100	NFSA 3445	DS	45.5	50.6	56.6	12.4	69.0	70.4	73.5	28.0
100	NFSA-4066 b	DS	46.0	47.9	49.4	14.9	64.3	66.8	79.2	33.3
100	NFSA-3934	LS	45.4	49.1	52.1	7.3	59.4	61.4	70.6	25.2
100	NFSA-4066 a	LS	42.5	49.8	52.2	8.1	60.3	62.8	71.0	28.5
100	NFSA 0361	SWH	49.0	51.1	52.8	3.5	56.3	57.8	67.8	18.9
100	NFSA 0582	SWH	46.9	51.9	53.8	6.5	60.3	62.4	67.2	20.3
100	NFSA 2692	SWH	49.1	51.6	53.2	9.9	63.1	65.5	72.8	23.7

un	NFSA 3715	SWH	41.8	47.4	50.3	6.9	57.1	59.4	66.5	24.7
un	NFSA 3838	SWH	50.1	53.7	55.3	8.7	64.0	67.0	76.9	26.9
100	NFSA 4064	SWH	48.1	55.3	56.1	6.0	62.1	64.3	79.0	31.3
	Average	DS			53.0	13.6				30.6
	Average	LS			52.2	7.7				26.8
	Average	SWH			53.6	6.9				24.3
	Average	All			53.2	8.4				26.1

Table 6.10. Shrinkage activity for historic sample material from the Sámi and Evenk culture, sorted by owning institution.

Shrinkage temperature - reference samples and experimental samples of the Sámi and Evenk culture

Sample number	Substance	Material type	T_s	ΔT,	T_{first},	T_{last},	ΔT_{total}
LS-N13-01	Willow bark extract, fat	LS	55.8	14.6	53.2	92.7	34.5
LS-N3-04	Willow bark extract	LS	61.3	24.1	57.9	89.4	30.6
LS-R16-08	Brown rotted larch wood, smoke, reindeer liver	LS	61.6	7.1	56.2	72.5	14.3
SWH-N13-09	Willow bark extract, fat, flour	SWH	58.9	11.4	56.8	79.1	24.1
SWH-N1-11	Fat, flour, FM	SWH	60.8	4.85	57.7	78.5	20.7
SWH-R10-12	Brown rotted larch wood, reindeer liver	SWH	54.9	9.6	51.6	70.5	18.2
DS-N9-14	Willow bark extract, fat	DS	82.4	8.3	81.1	96.5	16.1
DS-N7-16	Willow, fat (old)	DS	63.4	10.3	59.4	78.4	18.55
DS-N7-17	Willow bark extract, flour, FM, salt	DS	77.3	11.6	72.5	91.5	18.7
DS-R10-20	Brown rotted larch wood, smoked	DS	63.7	8.2	60.6	81.8	20.05
DS-R10-21	Brown rotted larch wood, reindeer liver	DS	54.6	13.8	33.9	80.0	44.9
DS-R16-22	Brown rotted larch wood, smoked, reindeer liver	DS	52.8	12.6	28.5	65.4	38.3
Untreated	Untreated reindeer skin	SWH	63.9	3.8	61.2	71.8	10.6
SNF	Willow bark extract, no fat	DS	69.5	8.0	65.6	82.5	16.9
SWF	Willow bark extract, with fat (F5)	DS	77.0	8.7	72.7	88.3	15.6
XSM-1	CLO (F4), FM, wheat flour, salt	SWH	61.3	4.9	60.1	71.3	11.9
XSM-2	Oil (F3), FM, wheat flour, salt	SWH	60.6	5.0	57.9	70.6	12.7
XSM-3	Oil (F2), FM, wheat flour, salt	SWH	60.4	5.1	59.2	68.1	8.0
XSM-7	CLO (F4)	SWH	63.5	5.1	61.4	72.3	10.25
XSM-9	Willow bark extract, CLO (F4), wheat flour	SWH	63.6	5.5	61.5	73.5	10.9
XSM-10	CLO (F4), water, FM, wheat flour	SWH	62.2	5.8	59.8	69.4	10.6
XSM-11	Whitish pink oil (F5)	SWH	61.8	3.8	61.6	68.9	11.0
XSM-13	Raw reindeer brain	SWH	62.0	5.0	60.8	68.5	7.4

Table 6.11. Shrinkage activity for reference samples and experimental samples from the Sámi and Evenk culture.

6.4 pH measurements of Sámi and Evenk culture skin material

The pH which develops over time in the historic sample material has been influenced by a number of factors. These include the pre-tanning and tanning treatment, daily use and activity, and the environmental conditions which the artefacts have been exposed to as a museum artefact. In skins tanned with condensed tannins, red rot may for example develop providing that the artefact has been subjected to acidic environments, especially sulphuric acid. This has been observed in sulphate analysis of historic vegetable tanned book binding leather (Wouters *et al.*, 1996:106).

Measurements of pH are typically carried out to indicate the presence and the amount of strong acids in a historic artefact material. If the pH is measured to a value below 4, the pH difference may be calculated. If this value lies between 0.7 and 1.0, it indicates the presence of a strong acid which may be harmful to the skin material (Larsen *et al.*, 1996c: 201). However, this must be stated with care, as a conversion to possibly ammonium sulphite may have occurred (Wouters *et al.*, 1996:106). pH measurements is therefore only one of several analytical methods which should be used in an analytical array to indicate the skins present condition. A pH value cannot be used as a single measurement to determine the presence or absence of strong acids in skin materials. It has been demonstrated that sulphuric acid in time may be converted to non-acid compounds, such as ammonium sulphate, and as a consequence the measured pH would not give a reliable result concerning the deterioration taken place due to atmospheric pollutants (Wouters & Clayes, 1996:90).

The pH of the reference samples and the experimental samples is included in this study to illustrate the effect various tanning substances have on the skin materials. The pH measurements of the historic samples from the Sámi and Evenk culture will be interpreted on the basis of these results.

6.4.1 Experimental

In determining the pH of skin materials it is recommended that a fixed ratio of water/skin fibres is used. The result depends upon the concentration of ions in the extract which again is determined by the amount of water versus the amount of skin fibre. The recommended ratio is 1 g of skin fibre to 50 ml of distilled water. The sample weight may be reduced, but the ratio should be maintained.

In the analysis of reference samples, experimental samples, and historic samples; 5 mg of skin fibre to 0.25 ml distilled water is used. In using such small amounts of collagen fibres, it is recommended that plastic test tubes are used, so as not to cause ion contamination from contact between electrode and glass in a glass test tube (Larsen *et al.*, 1996c:201).

The finely cut sample and distilled water is placed in 0.5 ml thermo tube with flat cap, and is shaken. The sample is shaken regularly in the 24 hours before the analysis is performed. The analysis is carried out using an Orion Research EA-920 pH meter with a micro combination electrode, Orion Micro 9803BN, small length PKGD. The combination electrode is calibrated at pH 4.01 and 7.0 before the analysis and after every tenth samples, as is also the temperature. The temperature is set by the temperature in the sample solution.

To measure the pH difference the solution is diluted 10 fold and the difference between the two pH values are calculated.

6.4.2 pH measurements of reference and experimental samples

The pH value of the tanning solutions plays an important role in the tanning of skin materials. Typically, tanning with plant polyphenols takes place between pH 3-5 on the acidic side of the isoelectric point of the collagen (pH 5). Tannin fixation of the vegetable tannin in hide powder, although this cannot fully be compared to compact fibrous skin, is at its best on the acidic side but also on the slightly alkaline side of the isoelectric point of the collagen. This is partly due to swelling of the fibre structure which eases the tannins' fixation in the collagen structure (Gustavson, 1956:157,158). The fixation has been measured over a two week tanning period, but also over a 24 hour period (Fig. 6.28), which would correspond fairly well to the tanning period often experienced in manually tanned depilated skin in the Sámi culture. The swelling of the skin is particularly important in the initial phases of the tanning, and it has been shown that secondary tanning with vegetable tannins is more independent of the pH in the solution (Gustavson, 1956:158). This indicates that the initial tannin bath in the Sámi culture tanning of depilated skin is important in relation to the final quality of the skin. In the willow bark extract used in the Sámi culture, the pH is measured to 5.5. This may indicate that the solution is not acidic enough to obtain a limited swelling and subsequent optimal tanning of a depilated skin in the first tannin bath.

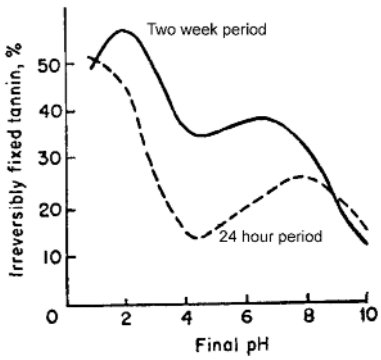


Fig. 6.28. Irreversible tannin fixation in hide powder in relation to pH and time (From Gustavson, 1956:157).

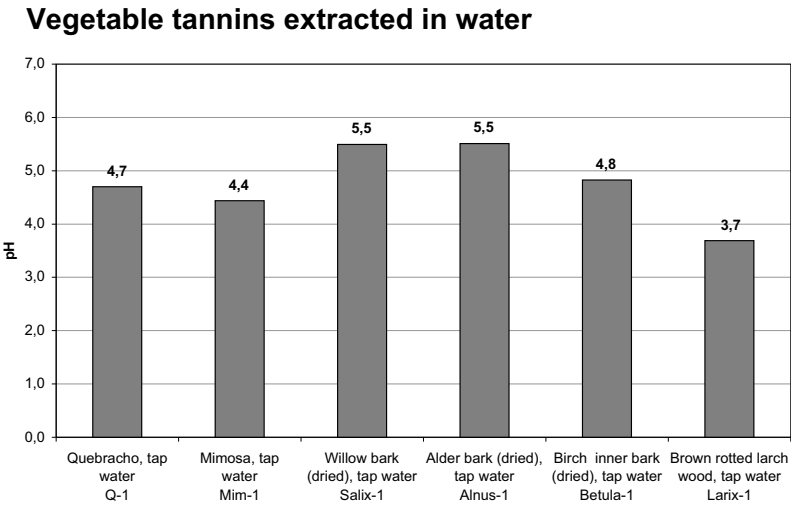


Fig. 6.29. pH measured in pure vegetable tannins extracted in tap water.

Measuring the pH of the vegetable tannins used in the Sámi and Evenk culture shows that the tannin solution of willow bark extract, alder bark extract and birch inner bark extract lies in the pH range of 4.8 to 5.5. Extract of brown rotted larch wood, however, has a lower pH of 3.7. The locally purchased tannin powders, available in the Sámi culture areas, such as quebracho and mimosa, have a pH of 4.7 and 4.4 respectively, and are slightly more acidic than willow, alder and birch bark extract (Fig. 6.29, Table 6.11).

In the oil tannage process carried out in the leather industry the skin is typically swelled at pH 6.5-10 before tanning commences. Swelling is performed to clean and remove excess fat from the skin, to ease the penetration of the tanning oil, and the skins are brought back to a slightly acidic state (pH 5.5) before the oil is applied (Sharphouse, 1995:72). The skin treated with fatty substances in the Sámi and Evenk culture is not brought to a certain pH level prior to the application of the fat. Experimental reindeer skin samples (Fig. 6.30) treated with cod liver oil (F4), as one of the applied substances, has a pH of 4.9. The sample where willow bark extract is added has a slightly higher pH, at 5.2.

The pH lies within a range from 4.5 to 6.5 for all the skin samples treated with fatty substances. A pure sample of the locally purchased emulsion, F5 has a pH of 6.6, and seems to create a skin material with a higher pH. This is observed in XSM-11, where the pH is measured to 6.5. The results from this analysis indicate that, apart from the F5 emulsion, the applied skin processing fats slightly lower the pH of the skin.

Untreated reindeer skin sample is measured to a pH of 6.3.

Alum (pH in aqueous solution is 3.5-4.5) is sometimes used in the pre-treatment of skin in the Sámi culture. It is used in a mixture with salt (NaCl). A slight swelling occurs, with the skin becoming thicker when the alum/salt mixture is applied (Kemi Eira, 2004, pers. comm.). This pre-treatment of the skin possibly leads to a slight alum tanning effect, as well as to prepare the skin for the subsequent vegetable tannin application, by opening up the fibre structure.

The pH measurements from the Sámi and Evenk culture reference samples can be observed in figure 6.31, 6.32, and table 6.11. The samples from the Sámi culture have values from pH 4.1 to pH 6.3, slightly on the acidic side. The Evenk culture samples have values from pH 4.7 to pH 6.3, slightly higher than some of the Sámi culture samples. The naturally aged samples DS-N7-16 and DS-R16-22 have pH values that fall within the range for both the Sámi and the Evenk references.

6.4.3 Sámi and Evenk culture historic samples

The historic sample material has values from pH 3.0 to pH 5.9 (Table 6.12, 6.13). The majority of the samples lie within a range from pH 4.5 to pH 5.5, which corresponds to the value of the reference samples. This is also the case for the Evenk culture samples which all have values between pH 4.1 to 5.9.

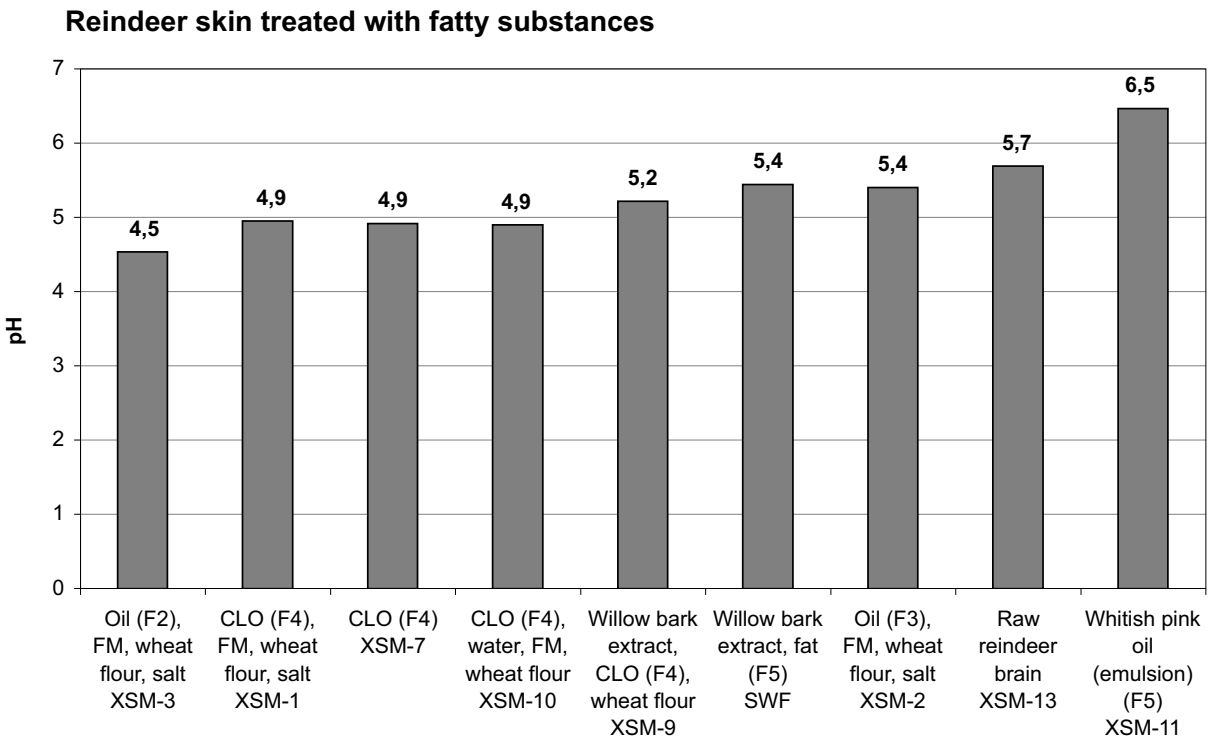


Fig. 6.30. Reindeer skin experimental samples treated with fatty substances.

There are eight samples with a low pH of 3.0 to 3.9 (Fig. 6.33, 6.34, 6.35). These samples all come from the Sámi culture collections, and are mainly found in the depilated skin sample groups from two institutions, SVD and NFSA. Measuring the pH difference from the samples with pH values below 4.0 indicates that six of the eight samples contain strong acids, which may be harmful to the skin. Of the two samples with pH difference values below 0.7, one is a LS and the other a SWH sample.

None of the samples with a high pH difference value, or the pH values in general seem to be associated with the age of the samples. The lacking association with the age of the sample corresponds to the result from the reference samples, where the naturally aged samples have pH values within the range of values in the younger samples.

The Evenk culture samples all have pH values from 4.1 to 5.9 (Fig. 6.36). The sample with the lowest value is a chestpiece, REM-6749-5, which has been heavily attacked by insects (Fig. 4.36). The pH values of the rest of the samples show no significant characteristics and lie within the range measured in the reference samples.

6.4.4 Summary

The pH analyses of the total sample population show that few samples exhibit the presence of strong acids. The DS samples of the Sámi culture stand out with respect to the presence of strong acids, with five of the

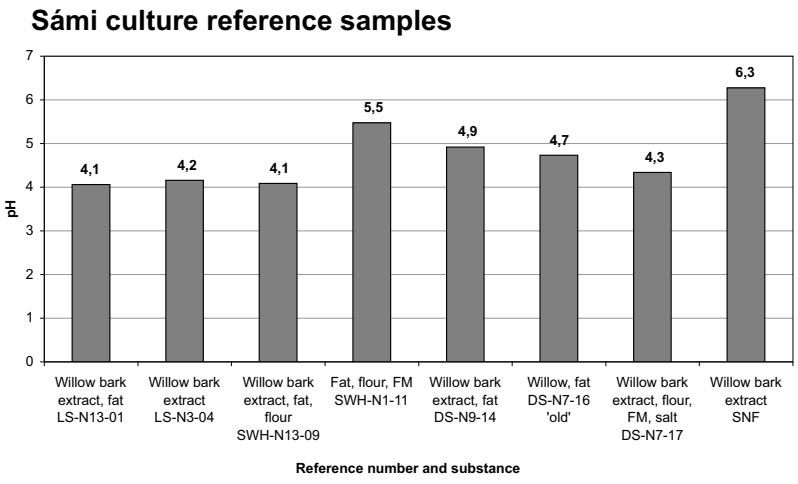


Fig. 6.31. pH measurements of reference skin samples from the Sámi culture.

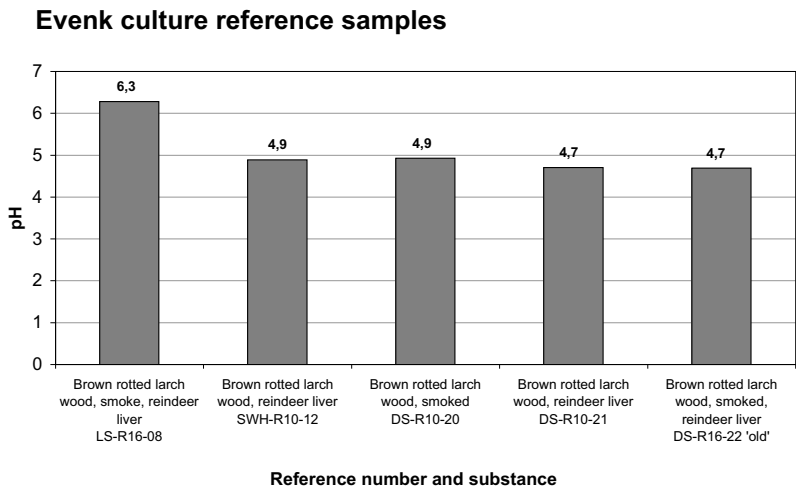


Fig. 6.32. pH measurements of reference skin samples from the Evenk culture.

sixteen samples having a pH difference from 0.7 to 0.9. As these samples are taken from one location on the artefact, these artefacts would benefit from a more thorough analysis. The fact that only the DS samples have pH values lower than pH 4.0, suggest that this skin material is especially prone to accumulating pollution. This is supported by the observation that skin tanned with condensed tannins are more prone to accumulating sulphates than for example skin tanned with hydrolysable tannins, or untanned skin (Larsen, 1994c:169).

The historic samples from the Evenk culture and the historic SWH samples from the Sámi culture exhibit pH values that are within the range which indicate that the materials do not contain strong acids which may cause harm to the artefacts.

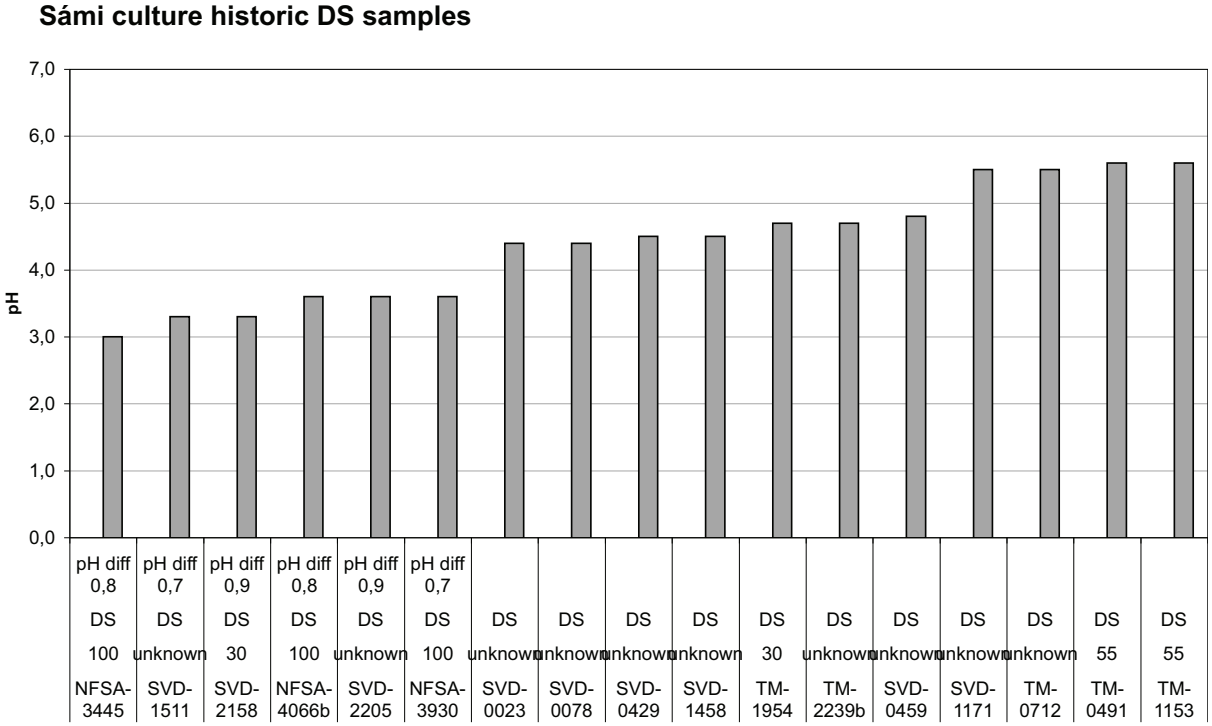


Fig. 6.33. pH measurements of historic DS samples from the Sámi culture. pH difference is included for the samples with pH at 4.0 or below. The age of the samples is listed above the museum number in the graph.

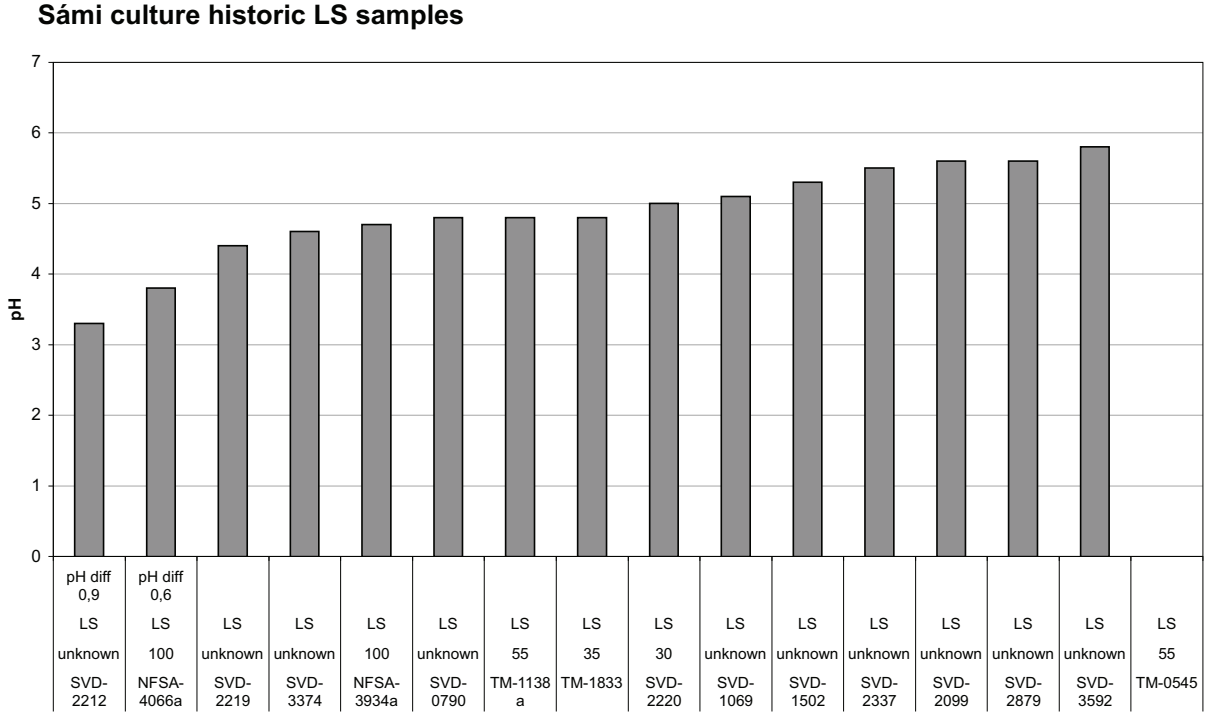


Fig. 6.34. pH measurements of historic LS samples from the Sámi culture. pH difference is included for SVD-2212 at 0.9 and for NFSA-4066a at 0.6. The pH difference of NFSA-4066a is below 0.7, which means that it is does not cause harm to the artefact. The age of the samples is listed above the museum number in the graph.

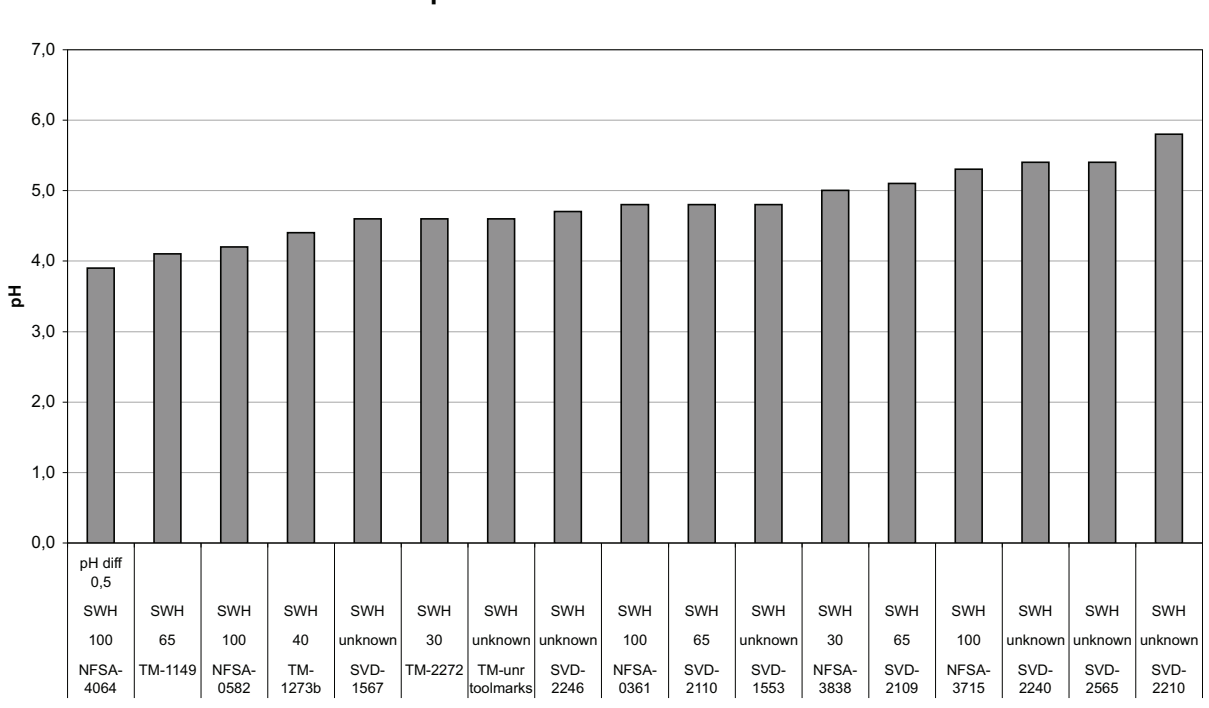


Fig. 6.35. pH measurements of historic SWH samples from the Sámi culture. pH difference is included for NFSA-4064 at 0.5. The pH difference is below 0.7, which means that it is does not cause harm to the artefact. The age of the samples is listed above the museum number in the graph.

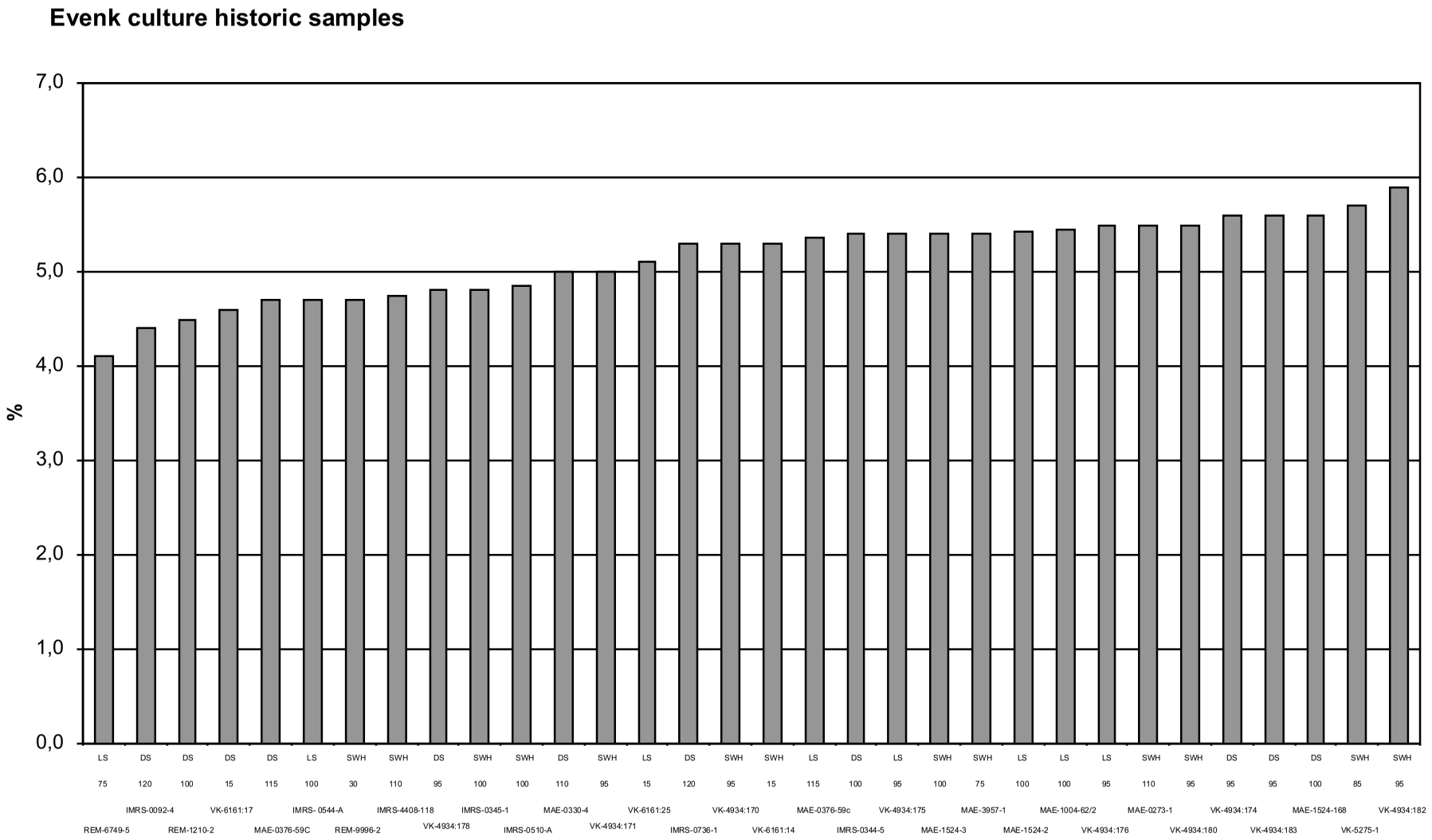


Fig. 6.36. pH measurements of historic samples from the Evenk culture. The age of the samples is listed above the museum number in the graph.

pH – Reference samples and experimental samples

Sample number	Reference samples	Material type	pH
LS-N13-01	Willow bark extract, fat	LS	4.1
LS-N3-04	Willow bark extract	LS	4.2
LS-R16-08	Brown rotted larch wood, smoke, reindeer liver	LS	6.3
SWH-N13-09	Willow bark extract, fat, flour	SWH	4.1
SWH-N1-11	Fat, flour, FM	SWH	5.5
SWH-R10-12	Brown rotted larch wood, reindeer liver	SWH	4.9
DS-N9-14	Willow bark extract, fat	DS	4.9
DS-N7-16	Willow, fat (old)	DS	4.7
DS-N7-17	Willow bark extract, flour, FM, salt	DS	4.3
DS-R10-20	Brown rotted larch wood, smoked	DS	4.9
DS-R10-21	Brown rotted larch wood, reindeer liver	DS	4.7
DS-R16-22	Brown rotted larch wood, smoked, reindeer liver	DS	4.7
Ref-Larix	Brown rotted larch wood	DS	4.6
Ref - Betula	Birch inner bark	DS	6.0
Ref- Alnus	Alder bark	DS	6.0
Untreated	Untreated reindeer skin	SWH	6.3
SNF	Willow bark extract, no fat	DS	6.3
SWF	Willow bark extract, with fat (F5)	DS	5.4
XSM-1	CLO (F4), FM, wheat flour, salt	SWH	4.9
XSM-2	Oil (F3), FM, wheat flour, salt	SWH	5.4
XSM-3	Oil (F2), FM, wheat flour, salt	SWH	4.5
XSM-7	CLO (F4)	SWH	4.9
XSM-9	Willow bark extract, CLO (F4), wheat flour	SWH	5.2
XSM-10	CLO (F4), water, FM, wheat flour	SWH	4.9
XSM-11	Whitish pink oil (emulsion) (F5)	SWH	6.5
XSM-13	Raw reindeer brain	SWH	5.7
Q-1	Quebracho (powder) in water	pure	4.7
Mim-1	Mimosa (powder) in water	pure	4.4
Salix-1	Willow bark (dried) in water	pure	5.5
Alnus-1	Alder bark (dried) in water	pure	5.5
Betula-1	Birch bark inner (dried) in water	pure	4.8
Larix-1	Brown rotted larch wood in water	pure	3.7

Table 6.11. pH measurements of reference samples, experimental samples, and tannin extract samples.

pH - Sámi culture historic samples

Museum number	Material type	pH	pH differenc
NFSA-4066b	DS	3.6	0.8
NFSA-3445	DS	3.0	0.8
NFSA-3930	DS	3.6	0.7
SVD-0023	DS	4.4	
SVD-0078	DS	4.4	
SVD-0429	DS	4.5	
SVD-0459	DS	4.8	
SVD-1171	DS	5.5	
SVD-1458	DS	4.5	
SVD-1511	DS	3.3	0.7
SVD-2158	DS	3.3	0.9
SVD-2205	DS	3.6	0.9
TM-0491	DS	5.6	
TM-0712	DS	5.5	
TM-1954	DS	4.7	
TM-1153	DS	5.6	
TM-2239b	DS	4.7	
NFSA-3934a	LS	4.7	
NFSA-4066a	LS	3.8	0.6
SVD-0790	LS	4.8	
SVD-1069	LS	5.1	
SVD-1502	LS	5.3	
SVD-2099	LS	5.6	
SVD-2212	LS	3.3	0.9
SVD-2219	LS	4.4	
SVD-2220	LS	5.0	
SVD-2337	LS	5.5	
SVD-2879	LS	5.6	
SVD-3374	LS	4.6	
SVD-3592	LS	5.8	
TM-0545	LS	nm	
TM-1138a	LS	4.8	
TM-1833	LS	4.8	
NFSA-3838	SWH	5.0	
NFSA-4064	SWH	3.9	0.5
NFSA- 0361	SWH	4.8	
NFSA-0582	SWH	4.2	
NFSA-3715	SWH	5.3	
SVD-1553	SWH	4.8	
SVD-1567	SWH	4.6	
SVD-2109	SWH	5.1	
SVD-2110	SWH	4.8	
SVD-2210	SWH	5.8	
SVD-2240	SWH	5.4	
SVD-2246	SWH	4.7	
SVD-2565	SWH	5.4	
TM-1149	SWH	4.1	
TM-1273b	SWH	4.4	
TM-2272	SWH	4.6	
TM-unr-toolmarks	SWH	4.6	

Table 6.12. pH measurements of historic samples from the Sámi culture. Nm = not measured.

pH - Evenk culture historic samples

Museum number	Material type	pH
IMRS-0092-4	DS	4.4
IMRS-0344-5	DS	5.4
IMRS-0736-1	DS	5.3
MAE-0330-4	DS	5.0
MAE-0376-59c	DS	4.7
MAE-1524-168	DS	5.6
REM-1210-2	DS	4.5
VK-4934:174	DS	5.6
VK-4934:178	DS	4.8
VK-4934:183	DS	5.6
VK-6161:17	DS	4.6
IMRS- 0544 A	LS	4.7
MAE-0376-59c	LS	5.4
MAE-1004-62/2	LS	5.4
MAE-1524-2	LS	5.4
REM-6749-5	LS	4.1
VK-4934:175	LS	5.4
VK-4934:176	LS	5.5
VK-6161:25	LS	5.1
IMRS-0345-1	SWH	4.8
IMRS-0510A	SWH	4.9
IMRS-4408-118	SWH	4.7
MAE-0273-1	SWH	5.5
MAE-1524-3	SWH	5.4
MAE-3957-1	SWH	5.4
REM-9996-2	SWH	4.7
VK-4934:170	SWH	5.3
VK-4934:171	SWH	5.0
VK-4934:180	SWH	5.5
VK-4934:182	SWH	5.9
VK-5275-1	SWH	5.7
VK-6161:14	SWH	5.3

Table 6.13. pH measurements of historic samples from the Evenk culture.

7 DISCUSSION

The objective of this study is to characterise and identify skin processing technology in Eurasian reindeer cultures and to study the impact these methods and tanning substances have on the preservation potential of the artefacts. This includes the presentation of the continuous changes that take place in material- and tanning substance- use and in physical manipulation of skin materials.

For a comparative technological study, this project focuses on the Sámi culture in northern Norway and on the Evenk culture in Siberia, Russia. Skin processing technology is examined through interviews, observation, learning by doing among Sámi and Evenk women and men, and through literature studies. Subsequently, an analytical design of visual, chemical and physical analysis is carried out to link the practical, investigative knowledge to the theoretical knowledge of skin processing technology. This is accomplished through an assembly of analytical techniques that are applied to artefacts and skin material samples, from the Sámi and Evenk culture, which were examined in museum institutions in Russia, Finland, and Norway.

7.1 Skin processing technology

One purpose of skin processing is to create durable, lightweight, and comfortable garments, which can be used under particularly demanding climatic environments. The animal skin materials that are accessible in a given geographic area would be the obvious choice. The manipulation of these materials, to yield specific properties for specific garments, leads to a variety of skin materials which are available for clothing purposes. From the basic technological principles, one may state that there is a circumpolar methodology, generated through the idea of and the need for functionality, dependent upon the use of local resources as a basis for material and tanning substance. The basic principles of skin processing are associated with: the treatment of the fresh skin; the physical manipulation of skin; the attainment of durability; and the attainment of water repellence properties.

The importance of how fresh skins are treated is emphasized in both cultures. "*If the skin is not properly treated from the beginning, the result will never be good*" (Informants, Russia and Norway). This includes how the skin is removed from the carcass, how the skin is temporarily placed on a 'clean' surface, and how blood spills or other spills are removed prior to drying. Furthermore, it is important that the skin is laid out to dry as soon as possible. Decomposition is rapid, and the preferred drying method is chosen according to location and to the weather. Both cultures also emphasize that whole skins with hairs attached, which are to be used for coats, should not be stretched while drying; they should only be prevented from curling up. Both cultures state that skins should not be dried in the sun or in excessive heat.

Durability is achieved both through physical manipulation and through the addition of tanning substances. The physical manipulation of the skin is also emphasized in both cultures. Malchakitova Ludmila Vasilievna from Chapo Ologo in Transbaikal, Siberia, repeatedly stated: "*You have to stretch the skin*". To work and stretch the skin with your hands and with the various scraping and softening tools are important, not only to soften the skin but also to allow the tanning substances to enter the skin's structure and to evenly distribute the substances in the skin. Tanning substances are chosen for their properties but also because of their availability. The flexible nature of skin processing technology is primarily reflected in the choice of tanning substances. If a substance is no longer is available, another substance yielding similar properties will be used.

Creating water repellence properties is another basic principle in skin processing technology. This is obtained either through preserving the epidermal layer of the skin, and taking advantage of a high fat content inherent in a skin, or by applying fatty substances to a skin with a lower natural fat content. In the Evenk culture, smoking is used in combination with a fatty substance to enhance the water repellent properties.

A major difference between Sámi and Evenk culture skin processing lies in how to remove the hairs from a skin. In the Sámi culture the full grain of the

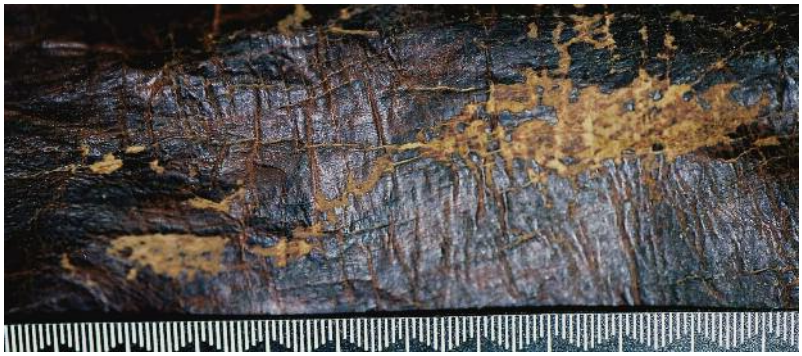


Fig. 7.1. Detail from summer leggings exhibiting cracking and flaking of the grain layer, possibly due to tension between the surface layer and the underlying dermis. The UFA/SFA ratio is 0.5 and the C22/C20 ratio is 0.4, demonstrating a high level of unsaturated fatty acids and possibly the presence of fish oil. Museum number TM-2239. Tromsø Museum, Norway. November 2004.

skin is preserved through the 'sweating' process, while the Evenk culture depilation process relies on mechanically removing the hairs, creating a suede surface. The full grain skin created in the Sámi culture process is more fragile, due to the characteristics of the grain layer. The fibres of the grain layer are finer than the fibres in the dermis and contain more non-fibrous substance, such as hairs or remains of hairs, hair follicles as well as glands and veins, which have not been removed in the depilation process (Ward, 1974:612). The grain layer's structure is therefore looser than the structure of the dermis. Research has also shown that the tear strength of the grain layer is considerably lower than the tear strength of the dermis (O'Leary & Attenburrow, 1996:5677, 5681). The looseness of the grain layer is reduced through the tanning process, for example in the vegetable tanning of depilated Sámi culture skin where, through the hydrophobic interaction and hydrogen bonding, the tannins increase the stability of the collagen fibre structure (Tang *et al.,* 2003:411). If a fatty substance is applied to the skin, the fat will also fill the structure and increase its physical stability.

The presence of a full grain layer therefore affects the preservation of the skin, through the fragility of the surface and through the difference in physical properties of the grain surface and the underlying dermis. This fragility may furthermore be increased as the substances used in manufacturing the skin deteriorate. This can, for example, be observed in depilated full grain artefacts treated with fatty substances and, in particular, surfaces which have been repeatedly waterproofed with a mixture of tar and cod liver oil. The surface of the skin becomes less flexible through, for example, the oxidation of the applied fat and the physical stress between the more flexible and the less flexible part of the skin, resulting in a damaged surface (Fig. 7.1).

This fragility of the surface is not observed in the Evenk culture artefacts. Although there may be parts of the grain layer left on the artefact's surface, the physical removal of hairs and the subsequent scraping do not remove all hairs in the hair follicles, thereby leaving a structurally firmer skin. The suede surfaces are created both on the flesh side and on the grain side of the skin, and the artefact material shows that both sides are used as the exterior of skin garments. The surface damages, which are observed in the Sámi culture DS material, are not observed in the Evenk culture artefact material investigated in this study.

A second major difference in Sámi and Evenk culture skin processing technology is the smoking or not smoking of skin materials. The Sámi culture skin materials are not smoked, and the informants state that they have never smoked skins. This is furthermore confirmed in the available literature (Hatt, 1914:38). In the Evenk culture skin processing, smoking is a regularly applied process, either following the application of fats or carried out prior to fat application. The informants emphasize that the smoke should be as cold as possible and, also for this reason that the process should not take place if the weather is too hot. The materials used to create smoke are mainly white rotted wood, moss, damp wood, or what is described as a low quality wood; it may also be a combination of several of these. Smoking is practised to create water repellence properties in the skin, but also to create a colour. The emergence of rubber boots and waterproof garments has meant that the need to create skin with water repellence properties has decreased. Smoking is, however, still used today but mainly to give colour to the skin.

A third major difference concerns vegetable tanning substances. Willow bark, alder bark and birch inner bark are vegetable tannins especially applied to Sámi culture DS material. Willow bark is today the major vegetable tannin used, although the different properties of the bark extracts are taken advantage of when certain properties are needed or desired in a skin.

This means, for example, exploiting the capacity from birch inner bark to yield structural firmness when dealing with a structurally loose skin or using the excellent colouring properties and stretching properties of the alder bark, when these are desired in a skin material. In the Evenk culture, brown rotted larch wood and alder bark extract are primarily used for colouring purposes. The informants describe the softening effect of the brown rotted larch wood, although a tanning effect is not observed in analysis of hydrothermal stability. Surface tanning, to yield softness and colour to the outermost layer of the flesh side of the skin, is known in both cultures, and it is also used in the processing of leg skin (LS) in the Sámi culture. Leg skins are primarily used for boots and leggings, and the surface tanning results in a raw streak in the skin, which strengthens the skin (Hætta, 1993:36) and acts as a moisture barrier.

The results of the comparative analysis have led to the conclusion that there are primarily two methods of skin processing which are applied in the Sámi and Evenk culture. These are tanning with plant polyphenols and tanning/fat liquoring with a fatty substance. Secondary methods to the primary methods are surface tanning or colouring using plant polyphenols and the combination of fat tanning and smoking. Within these categories there are variations and individual preferences and also examples where other methods and combinations of methods are used. There is, furthermore, a distinction related to material type and to culture. The Sámi culture skin processing technology applies different methods for the three material types DS, SWH and LS, whereas the Evenk culture basically uses one method for all three material types.

7.2 Tanning with plant polyphenols – identification and condition issues – Sámi culture DS

Only the Sámi culture depilated skin (DS) material type can be considered a regular vegetable tanned skin. The artefacts' colour profile primarily belongs to the 7.5YR (light brown/brown/strong brown) or the 5YR (reddish brown/yellowish red/dark reddish brown) colour group in the Munsell® soil colour chart. The samples exhibit high tannin penetration (average 3/4) and exhibit 'coloured' to 'slightly coloured' fibres in the fibre assessment. At the same time most of the samples have substances clinging to the fibres, due to the tanning substance, when observed in water prior to the measurements of hydrothermal stability. Vegetable tannin analysis (HPLC) shows that all samples analysed (eight out of 17 samples) contain a substantial amount of vegetable tannins, from 1124 to 10361 tannin OD/100 mg, and that they belong to the condensed vegetable tannin group (proanthocyanidins) with a 1.1 to 1.5 tannin ratio (tannin-R 240/280 nm) (Table 7.2). All but two samples (NFSA samples) show the presence of the 10.2 minute peak, however, this is not identified as being a component in vegetable tannins (see chapter 5.2.3). One would expect that the DS material, tanned with willow bark extract using principally the same method, would show similar results in the vegetable tannin analysis, regarding the amount of plant polyphenols. This is not the case. The reference samples as well as the historic samples show a considerable variety in tannin content. This is also reflected in the analyses of hydrothermal stability, where reference samples and experimental samples show that the application of a condensed vegetable tannin increases the shrinkage temperature (T_s) of the skin from 5-6 °C to 18-20 °C (Table 7.3). High T_s is observed for a high tannin content, and lower T_s is indicated for a lower tannin content in the reference samples. The harvesting of willow bark for tanning purposes may influence the variability in tannin content, as the content of proanthocyanidins in the raw material, such as willow twigs, varies and is higher in extracts from juvenile twigs than in extracts from mature willow twigs (Tahvanainen *et al*., 1985:321). The tanning degree obtained in the process will also have an effect on the hydrothermal stability (Gustavson, 1956:179). In addition, individual preferences, skill, time available, and the purpose of the skin, are aspects which would influence the content of plant polyphenols in the skin material. This can be observed in the analysis of the skin which was manually tanned with willow bark extract especially for this study. The shrinkage temperature, measured at ten different locations on the skin, shows very varied results throughout the skin, where the lowest T_s is measured to 66.4 °C and the highest T_s is measured to 74.2 °C (Fig. 6.12). This demonstrates that the generally indicated shrinkage temperature of depilated skin tanned with proanthocyanidins of 80-85 °C (Sykes, 1991:10) is not obtained in a manually tanned skin, and that the shrinkage temperature randomly varies from location to location within a skin.

According to the informants from the Sámi culture, some vegetable tanned DS materials are lubri-

Museum number	T_{first} - °C	Ts - °C	ΔT - °C	pH	tannin-R, 240/280	tannin-OD/100 mg	Peak at 10.2 minute, %	tannin-M, %	tannin-GA, %	FA content, %	UFA/SFA ratio	C22/C20 ratio	Fibre cohesion	Absorb water
DS-SVD-1511	42.4	48.4	16.4	3.3	nm	nm	nm	nm	nm	1.0	0.1	0.0	Strong	Not well
SVD-2158	45.0	49.0	13.0	3.3	1.2	4495	3.1	5.0	0.4	1.0	0.1	0.0	Weak	Well
DS-NFSA-4066 b	46.0	49.4	14.9	3.6	1.3	1516	0.0	6.4	0.7	0.4	0.2	0.0	Medium	Medium
DS-SVD-0459	36.6	53.2	15.3	4.8	nm	nm	nm	nm	nm	2.9	0.0	0.0	Medium	Not well
DS-SVD-1458	43.0	56.0	10.9	4.5	nm	nm	nm	nm	nm	1.5	0.1	1.2	Strong	Not well
DS-TM-0491	42.5	56.3	7.7	5.6	nm	nm	nm	nm	nm	1.9	0.0	0.3	Weak	Medium
DS-TM-2239 b	48.8	56.5	8.1	4.7	1.4	1359	2.3	11.1	0.0	0.5	0.5	0.4	Medium	Not well
DS-NFSA-3445	45.5	56.6	12.4	3.0	nm	nm	nm	nm	nm	1.3	0.0	0.0	Weak	Medium
DS-SVD-0078	40.9	57.4	10.3	4.4	nm	nm	nm	nm	nm	2.9	0.1	0.5	Medium	Not well
DS-TM-0712	53.2	57.8	10.2	5.5	1.4	1394	3.2	0.0	0.0	4.3	0.1	0.0	Medium	Medium
DS-SVD-1171	44.2	58.6	9.3	5.5	nm	nm	nm	nm	nm	10.3	0.0	0.0	Medium	Not well
DS-SVD-2205	51.1	63.0	10.9	3.6	1.5	3553	12.9	0.0	0.0	0.4	0.1	0.0	Weak	Medium
DS-TM-1954	57.7	63.2	7.5	4.7	1.1	1124	6.0	13.2	2.2	1.3	0.0	0.0	Weak	Well
DS-SVD-0023	49.1	64.1	17.7	4.4	1.4	3823	2.3	6.8	1.3	3.0	0.0	1.0	Medium	Not well
DS-TM-1153	47.8	65.0	12.5	5.6	nm	nm	nm	nm	nm	8.3	0.2	0.3	Weak	Medium
DS-NFSA-3930	52.8	66.0	8.8	3.6	1.2	10361	0.0	9.6	0.0	0.5	0.2	0.0	Weak	Well
DS-SVD-0429	61.2	69.7	8.9	4.5	nm	nm	nm	nm	nm	3.0	0.3	0.2	Weak	Medium
Reference number														
DS-N7-16 'old'	60.4	63.4	10.3	4.7	0.7	108	64.7	2.3	0.0	0.6	0.3	0.0	Medium	Medium
DS-N7-17	72.9	77.3	11.6	4.3	2.3	1776	6.7	0.0	0.0	5.0	0.9	0.5	Strong	Not well
DS-N9-14	80.5	82.4	8.3	4.9	2.2	10986	32.5	0.1	0.1	0.3	0.8	0.0	Strong	Medium
DS-N5-15	74.2	81.8	12.4											

Table 7.2. Results from chromatographic analyses and the analyses of hydrothermal stability of the DS reference samples and the historic DS samples from the Sámi culture. The samples are sorted by increasing shrinkage temperature, T_s. Nm= not measured.

Experimental sample	T_s -°C	ΔT -°C	T_{first} °C	T_{last} °C	ΔT_{total} °C	FA content, %	UFA/SFA ratio	C22/C20 ratio
Dried reindeer skin, untreated (SWH)	63.9	3.8	61.2	71.8	10.6	0.7	0.8	0.0
SNF, DS with willow bark extract	69.5	8.0	65.6	82.5	16.9	nm	nm	nm
SWF, DS with willow bark extract and fat (F5 – emulsion)	77.0	8.7	72.7	88.3	15.6	nm	nm	nm

Table 7.3. Results from chromatographic analyses and the analyses of hydrothermal stability of the untreated reindeer skin and the experimental samples SNF and SWF. Nm= not measured.

cated. This, in particular, applies to summer leggings, trousers, and boots. Skins for bags and rucksacks are also lubricated but are just as often not lubricated. The results from the lipid analyses show that the primary lipid substance remaining in the sample material consists of saturated fatty acids (SFA). This is not unexpected, as unsaturated fatty acids (UFA), and especially the polyunsaturated fatty acids, decompose rapidly. In the Sámi culture DS material it would be obvious to look for both saturated and unsaturated fatty acids due to the broad range of lipids applied in skin processing. This is observed in the Sámi culture samples, where the presence of, and the relation between the monounsaturated fatty acids docosenoic (22:1 isomer) acid and eicosenoic (20:1 *cis*-11) acid (the C22/C20 ratio) indicates the use of marine oils (Fig. 5.48, 5.54).

The application of a fatty substance does not normally increase the shrinkage temperature of a skin (Kunzel, 1958:426; Young, 1990:627). This is confirmed in the experimental samples, where a variety of fats have been applied to the flesh side of reindeer skin prior to measuring the shrinkage temperature of the collagen fibres (Table 7.7). In these experimental samples it is observed that all the different fatty substances that have been used yield similar results when the shrinkage temperature is measured, from 60.4-63.6 °C. This is discussed further in section 7.4.

7.2.1 Surface tanning/colouring – identification and condition issues – Sámi culture LS

The Sámi culture leg skin (LS) material type is surface tanned, or coloured, and contains a raw streak. A fatty substance is applied, or is not applied, depending on the skin's characteristics and on individual preference. This indicates that this material type should be classified in a category which lies between a vegetable tanned skin and an untanned skin. The artefacts' surface colour profile primarily belongs to the 7.5YR, 10YR or the 5YR colour group in the Munsell® soil colour chart. The surface penetration observed for this material is low (surface to 1/3) (Fig. 4.16), and the fibre colour observed in the fibre assessment is primarily a mix of coloured and uncoloured fibres. A lower number of fibre samples, than for the DS samples, have substance clinging to the surface, and there are fewer samples exhibiting residues on the bottom of the glass slide, than for the DS samples.

The vegetable tannin analysis (six out of 16 samples) shows that the tannin content is very low and that the tannin ratios (tannin-R) extend from 0.4 to 2.8 (Table 7.4). All but two samples (NFSA-samples) have the appearance of the 10.2 peak. The tannin ratios are indicating both hydrolysable and condensed tannins. But, since the tannin-R also decreases as the tannin deteriorates, a low tannin ratio may indicate a deteriorated skin. This is observed in the two samples with low ratios, LS-SVD-2212 and LS-NFSA-3934 a-b. They display a broad elution profile, characteristic of condensed tannins, and low shrinkage temperatures of 48.0 °C and 52.2 °C, indicating that deterioration has occurred. On the other hand, LS-SVD-3374, exhibits a low tannin ratio and a high shrinkage temperature of 64.7 °C. This sample also has a broad elution profile, still indicating that condensed tannins are used in the processing of the skin. The LS material with its diverse fibre nature, caused by the uneven and low tannage degree, is not the best example for the use of the tannin ratio. To be interpreted correctly, the tannin ratio seems to require a vegetable tanned skin. This is also confirmed in the reference samples LS-N13-01 and LS-N3-04, where the tannin ratios for two similarly treated skins, both tanned with willow bark extract,

Museum number	T_{first} - °C	T_s - °C	ΔT - °C	pH	tannin-R, 240/280	tannin, OD/100 mg	Peak at 10.2 minute - %	tannin- M, %	tannin-GA, %	FA content %	UFA/SFA ratio	C22/C20 ratio	Fibre cohesion	Absorb water
LS-SVD-2212	43.7	48.0	11.8	3.3	0.4	174	3.2	6.3	0.0	0.9	0.2	0.4	Weak	Medium
LS-NFSA-3934 a-b	45.4	52.1	7.3	4.7	0.5	237	0.0	0.0	0.0	0.5	0.1	0.0	Medium	Not well
LS-NFSA-4066 a	42.5	52.2	8.1	3.8	2.6	22	0.0	14.2	0.0	0.2	0.1	0.0	Weak	Medium
LS-TM-0545	48.0	52.2	9.5	nm	2.0	985	1.8	0.0	0.0	1.8	0.1	0.3	Weak	Well
LS-SVD-0790	54,5	58.6	6.4	4.8	1.7	752	15.3	0.0	0.0	1.9	0.2	0.5	Strong	Not well
LS-SVD-2220	47.1	59.4	6.1	5.0	2.8	478	9.8	0.0	0.0	1.7	0.6	0.0	Medium	Not well
LS-SVD-2879	47.7	60.1	14.1	5.6	nm	nm	nm	nm	nm	4.2	0.0	1.2	Medium	Medium
LS-SVD-2219	53.9	60.5	7.5	4.4	nm	nm	nm	nm	nm	2.7	0.2	0.8	Medium	Well
LS-TM-1833 a-b	60.2	61.7	6.4	4.8	nm	nm	nm	nm	nm	3.1	0.5	0.6	Weak	Well
LS-SVD-1502	52.4	62.1	6.1	5.3	nm	nm	nm	nm	nm	2.8	0.1	0.9	Strong	Not well
LS-SVD-2337	47.7	62.9	10.5	5.5	nm	nm	nm	nm	nm	2.8	0.2	0.6	Medium	Medium
LS-TM-1138 a	62.7	64.5	3.8	4.8	nm	nm	nm	nm	nm	0.4	0.4	0.0	Medium	Not well
LS-SVD-3374	60.7	64.7	10.2	4.6	0.6	1708	33.7	0.0	0.0	0.6	0.1	0.0	Weak	Not well
LS-SVD-3592	63.7	65.9	8.5	5.8	nm	nm	nm	nm	nm	0.5	0.1	5.8	Weak	Not well
LS-SVD-2099 a-b	55.7	67.4	7.6	5.6	nm	nm	nm	nm	nm	0.4	0.2	0.0	Medium	Not well
LS-SVD-1069	60.2	72.5	8.1	5.1	nm	nm	nm	nm	nm	1.5	0.0	1.0	Medium	Not well
Reference number														
LS-N13-01	53.4	55.8	14.6	4.1	0.9	186	0.0	36.8	36.8	0.4	0.0	0.0	Strong	Well
LS-N3-04	58.5	61.3	24.1	4.2	2.1	14	54.6	0.0	0.0	0.9	0.2	0.0	Strong	Not well
LS-N1-02	62.7	63.9	9.4											
LS-N1-03	68.8	70.2	9.6											
LS-N7-05	64.0	67.7	15.8											

Table 7.4. Results from chromatographic analyses and the analyses of hydrothermal stability of the LS reference samples and the LS historic samples from the Sámi culture. The samples are sorted by increasing shrinkage temperature, T_s. Nm= not measured.

show very variable results of the tannin-R of 0.9 and 2.1 respectively (Table 7.4).

The LS reference samples generally exhibit shrinkage temperatures closer to that of untreated skin, with variation in the T_s from 55.8-70.2 °C. This is not unexpected as the samples contain both tanned and untanned fibres. The shrinkage temperature of the historic LS samples also exhibits a more narrow range, from the lowest to the highest T_s, than the historic DS samples, and does not exceed a shrinkage temperature of 72.5 °C.

Fatty substances are applied if the skin is particularly thick and/or stiff, or if it is part of the manufacturer's preferred method. As for the DS samples, the lipid substances found in the LS samples primarily consist of saturated fatty acids (SFA). There are, however, a few samples with a higher content of unsaturated fatty acids (UFA). This is displayed in the UFA/SFA ratio, which lies within the same range as for the DS samples. High values for the UFA/SFA ratio may indicate the presence of a drying oil, and possibly marine oil. Some of the LS samples exhibit C22/C20 ratios that indicate the use of a marine oil, through the relation between the monounsaturated fatty acids 22:1 (cis-11) and the 20:1 (isomer) acids (Table 7.4, fig. 5.54).

7.3 The application of a fatty substance – identification and condition issues

The Sámi culture SWH material and the Evenk culture DS, LS, and SWH material types are processed primarily using fatty substances. This is reflected in the colour profile in which the skin's flesh side surface has a very light colour, located in the 2.5Y and 10YR group in the Munsell® soil colour chart (pale yellow to very pale brown). The colour profile is close to the natural colour of the flesh side of untanned skin, which means that tannin penetration is not easily observed. The cracking of the epidermis observed on the hair side of the skin, or the root pattern observed on the flesh side of the skin, reflects the quality of the tanning process as well as the general wear and tear of the garment. A less flexible core and thereby a probable raw streak in the skin, indicating a reduced penetration of the fatty substances in the dermis, can cause the cracking of the epidermis and the root pattern to develop as the garment is worn (Fig. 4.17, 4.18, 4.19, and 4.20). Informants, furthermore, imply that skins which have been properly tanned show less root pattern and vertical cracking. The fibre assessment exhibits primarily 'uncoloured' fibres, and residues are observed on the bottom of the glass slide, either as unidentified fragments, fat droplets or as a 'white cloud', although a third of the samples show no significant residues. This also applies to the observation of substance clinging to the fibre's surface.

Plant polyphenols are only to a slight degree detected in the samples. A vegetable tannin extract can be applied superficially prior to the removal of the subcutaneous tissue, and the vegetable tannin would therefore be removed as the subcutaneous tissue is physically removed. Vegetable tannin extracts may also be included as a fluid in the fatty substance and flour mixture which is applied in the tanning process. The plant polyphenols are also used as a colouring substance, with only a slight tanning effect on the skin's surface. This may account for the presence of condensed vegetable tannins (proanthocyanidins) in the chromatograms. The tannin ratio (tannin-R) for the Sámi culture SWH material indicates a condensed vegetable tannin type, although the values for most samples are lower than the suggested values (chapter 5.2.2.3). The tannin-R of the Evenk culture sample material extends from very low to very high, not yielding a defined pattern indicating a tannin type. The tannin ratios observed in these sample groups indicate, as for the Sámi culture leg skin samples, that this value is primarily applicable in the analysis of vegetable tanned skin (Table 7.5).

The analyses of hydrothermal stability reflect the lack of or very low amount of vegetable tannins in the material. The shrinkage temperature of the sample material is also fairly low indicating an ongoing deterioration process in the skin. The reference samples and the experimental samples show a shrinkage temperature within and slightly higher than the general range indicated from 50-63 °C (Sykes, 1991:10) (Table 7.5, 7.6).

Museum number	T_{first} - °C	T_s - °C	ΔT - °C	pH	tannin-R, 240/280	tannin, OD/100 mg	Peak at 10.2 minute - %	tannin-M, %	tannin-GA, %	FA content - %	UFA/SFA ratio	C22/C20 ratio	Fibre cohesion	Absorb water
SWH-NFSA-3715	41.8	50.3	6.9	5.3	0.5	229	0.0	0.0	0.0	0.6	0.1	0.0	Medium	Not well
SWH-SVD-2110	42.6	50.5	11.3	4.8	0.4	3134	0.4	0.0	0.0	0.7	0.0	0.0	Weak	Medium
SWH-TM-1149	39.6	51.0	9.7	4.1	0.2	616	2.4	0.5	0.0	2.0	0.0	0.1	Medium	Medium
SWH-TM-2272	44.9	51.5	9.9	4.6	nm	nm	nm	nm	nm	2.2	0.0	1.8	Medium	Medium
SWH-NFSA-0361	49.0	52.8	3.5	4.8	nm	nm	nm	nm	nm	0.9	0.1	0.3	Weak	Medium
SWH-SVD-1553	49.6	53.7	9.4	4.8	nm	nm	nm	nm	nm	2.2	0.0	0.0	Medium	Medium
SWH-NFSA-0582	46.9	53.8	6.5	4.2	0.4	330	0.0	0.0	0.0	0.4	0.2	0.0	Weak	Medium
SWH-TM-1273 b	41.0	54.1	6.7	4.4	1.2	357	2.4	0.0	0.0	1.4	0.2	0.2	Weak	Medium
SWH-SVD-2246	44.0	54.2	6.8	4.7	nm	nm	nm	nm	nm	3.1	0.0	0.0	Strong	Not well
SWH-SVD-2109	44.6	54.5	8.6	5.1	nm	nm	nm	nm	nm	1.0	0.1	0.0	Medium	Medium
SWH-NFSA-3838	50,1	55.3	8.7	5.0	nm	nm	nm	nm	nm	1.7	0.1	4.6	Weak	Not well
SWH-SVD-2210	49,1	55.5	8.1	5.8	nm	nm	nm	nm	nm	3.7	0.0	0.6	Medium	Not well
SWH-SVD-1567	45,8	55.9	5.9	4.6	nm	nm	nm	nm	nm	1.4	0.0	0.0	Medium	Not well
SWH-NFSA-4064	48.1	56.1	6.0	3.9	1.9	73	0.0	0.0	0.0	0.3	0.1	0.0	Strong	Not well
SWH-SVD-2565	46.8	56.9	6.0	5.4	1.3	360	1.1	0.0	0.0	1.3	0.0	0.0	Weak	Medium
SWH-TM-unr-toolmarks	53.4	58.3	6.0	4.6	nm	nm	nm	nm	nm	1.4	0.7	0.3	Medium	Well
SWH-SVD-2240	55.1	58.7	5.3	5.4	0.5	321	1.6	1.6	1.6	2.4	0.1	0.0	Medium	Not well
Reference sample														
SWH-N13-09	55.3	58.9	11.4	4.1	1.3	26	13.1	24.0	24.0	1.3	0.6	0.0	Strong	Medium
SWH-N1-11	57.9	60.8	4.9	5.5	1.4	105	60.7	0.0	0.0	1.6	0.7	0.0	Medium	Medium
SWH-N3-10	62.5	64.1	6.5	nm										

Table 7.5. Results from chromatographic analyses and the analyses of hydrothermal stability of the SWH reference samples and the SWH historic samples from the Sámi culture. The samples are sorted by increasing shrinkage temperature, T_s. Nm = not measured.

Museum number	T_{first} - °C	T_s - °C	ΔT - °C	pH	tannin-R 240/280	tannin, OD/100 mg	Peak at 10.2 minute - %	tannin-M,%	tannin-GA,%	FA content %	UFA/SFA ratio	C22/C20 ratio	Fibre cohesion	Absorb water
LS-VK-4934-175	34.8	43.3	15.3	5.4	3.8	36	0.0	0.0	0.0	0.6	0.2	0.0	Weak	Well
DS-IMRS-0736-1	35.8	46.6	16.6	5.3	1.1	1855	0.0	7.5	3.8	1.2	0.3	0.0	Weak	Well
DS-IMRS-0092-4	37.9	48.0	12.2	4.4	0.5	214	0.0	0.0	0.0	0.1	0.1	0.0	Weak	Medium
SWH-IMRS-4408-118	40.3	48.9	9.7	4.7	nm	nm	nm	nm	nm	1.5	0.1	0.0	Weak	Medium
SWH-IMRS-0345-1 A	39.7	49.1	8.3	4.8	0.6	232	0.0	4.9	0.0	0.5	0.0	0.0	Weak	Medium
SWH-IMRS-0544 A	35.0	49.1	10.7	4.7	0.3	254	0.0	0.0	0.0	0.5	0.0	0.0	Medium	Medium
SWH-IMRS-0510 A	43.8	50.0	9.7	4.9	1.2	161	0.0	0.0	0.0	14.8	0.0	0.0	Weak	Medium
LS-VK-6161-25	47.6	50.3	5.1	5.1	1.7	112	0.0	27.0	0.0	4.2	0.1	0.0	Strong	Not well
SWH-REM-9996-2	45.1	51.9	8.1	4.7	nm	nm	nm	nm	nm	0.8	0.2	0.0	Weak	Well
SWH-VK-4934-182	47.4	52.8	8.2	5.9	0.6	203	0.0	0.0	0.0	0.3	0.1	0.0	Weak	Medium
DS-VK-4934-183	41.8	53.5	7.1	5.6	nm	nm	nm	nm	nm	1.1	0.0	0.0	Weak	Medium
LS-IMRS-0344-5 A	43.5	53.7	8.8	5.4	nm	nm	nm	nm	nm	0.2	0.1	0.0	Weak	Well
SWH-VK-4934-180	47.8	54.1	8.2	5.5	nm	nm	nm	nm	nm	0.5	0.1	0.0	Medium	Medium
LS-REM-6749-5	46.4	55.3	8.5	4.1	0.4	117	0.0	0.0	0.0	0.7	0.1	0.0	Weak	Well
SWH-VK-5275-1	41.8	56.0	7.2	5.7	0.5	249	0.0	3.6	0.0	0.2	0.0	0.0	Medium	Medium
DS-VK-4934-174	44.7	57.0	9.1	5.6	0.7	319	0.0	14.0	0.0	0.9	0.0	0.0	Medium	Not well
DS-VK-4934-178	45.3	57.4	10.8	4.8	nm	nm	nm	nm	nm	0.6	0.1	0.0	Weak	Well
SWH-VK-4934-171	49.4	57.6	8.5	5.0	nm	nm	nm	nm	nm	1.1	0.1	0.0	Medium	Medium
SWH-VK-4934-170	51.9	58.1	8.0	5.3	1.8	115	0.0	8.4	0.0	0.8	0.1	0.0	Medium	Not well
DS-VK-6161-17	47.9	58.1	8.4	4.6	1.1	462	0.0	5.4	0.0	3.8	0.1	0.3	Medium	Medium
SWH-VK-6161-14	56.9	60.2	3.9	5.3	4.1	29	0.0	10.8	0.0	1.1	0.1	0.0	Medium	Medium
LS-MAE-0376-59 c	45.9	60.3	11.6	5.4	0.6	248	0.0	3.7	0.0	1.0	0.0	0.0	Weak	Well

Museum number	T_{first} - °C	T_s - °C	ΔT - °C	pH	tannin-R 240/280	tannin, OD/100 mg	Peak at 10.2 minute - %	tannin-M,%	tannin-GA,%	FA content %	UFA/SFA ratio	C22/C20 ratio	Fibre cohesion	Absorb water
LS-VK-4934-176	49.3	60.5	6.0	5.5	3.2	26	0.0	0.0	0.0	0.4	0.2	0.0	Medium	Not well
DS-MAE-0330-4 a-b	54.1	64.5	9.2	5.0	nm	nm	nm	nm	nm	0.5	0.1	0.0	Weak	Well
DS-MAE-1524-168	51.9	64.6	9.7	5.6	2.4	40	0.0	15.2	0.0	0.4	0.1	0.0	Weak	Well
LS-MAE-1004-62/2	59.0	64.6	8.9	5.4	1.7	23	0.0	0.0	0.0	0.9	0.1	0.0	Medium	Medium
LS-MAE-1524-2	57.8	65.4	8.0	5.4	1.9	27	0.0	0.0	0.0	0.9	0.2	0.0	Medium	Medium
SWH-MAE-1524-3	54.6	65.6	8.6	5.4	2.3	48	0.0	0.0	0.0	0.9	0.3	0.0	Medium	Medium
SWH-MAE-3957-1	59.3	66.0	7.7	5.4	nm	nm	nm	nm	nm	0.4	0.0	0.8	Medium	Medium
DS-MAE-0376-59 c	43.1	66.3	6.7	4.7	1.1	600	0.0	8.2	0.0	0.3	0.1	0.0	Weak	Well
DS-REM-1210-2	55.8	66.4	7.0	4.5	0.3	309	0.0	4.4	0.0	0.3	0.1	0.0	Weak	Well
SWH-MAE-0273-1	43.4	66.7	5.0	5.5	0.5	171	0.0	3.7	0.0	1.8	0.2	0.0	Weak	Well
Reference samples														
DS-R10-20 (smoke)	60.9	63.7	8.2	4.9	0.5	363	0.0	2.8	0.0	3.7	0.4	0.0	Medium	Medium
DS-R10-21	48.7	54.6	13.8	4.7	1.4	112	0.0	2.9	0.0	2.4	0.4	0.0	Weak	Not well
DS-R16-22 'old' (smoke)	29.3	52.8	12.6	4.7	4.1	11	0.0	0.0	0.0	1.0	1.2	0.0	Strong	Not well
DS-R1-18	63.3	64.0	9.7	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
DS-R7-19 (smoke)	58.9	61.8	8.0	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
LS-R16-08 (smoke)	57.6	61.6	7.1	6.3	2.1	9	0.0	0.0	0.0	0.8	0.8	0.0	Weak	Medium
LS-R7-07 (smoke)	57.5	62.2	7.1	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
SWH-R10-12	52.8	54.9	9.6	4.9	3.4	16	0.0	0.0	0.0	1.8	0.6	0.0	Medium	Medium
SWH-R15-13	54.5	57.6	9.7	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm

Table 7.6. Results from chromatographic analyses and the analyses of hydrothermal stability of the SWH reference samples and the SWH historic samples from the Evenk culture. The samples are sorted by increasing shrinkage temperature, T_s. Nm= not measured.

Nr	Experimental samples - Sámi culture methods	Material type	A_1 - T_{first}	B_1	C - T_s	ΔT	B_2	A_2	T_{last}	ΔT_{total}	FA content - %	UFA/SFA ratio	C22/C20 ratio	Fibre cohesion	Absorb water
XSM-1	CLO (F4), FM, wheat flour, salt	SWH	59.8	60.9	61.3	4.9	66.1	66.7	71.7	11.9	5.2	0.9	0.7	Strong	Not well
XSM-2	Oil (F3), FM, wheat flour, salt	SWH	57.8	59.9	60.6	5.0	65.3	66.1	70.5	12.7	nm	nm	nm		
XSM-3	Oil (F2), FM, wheat flour, salt	SWH	59.2	60.1	60.4	5.1	65.5	66.0	67.2	8.0	nm	nm	nm		
XSM-7	CLO (F4)	SWH	61.7	62.8	63.5	5.1	68.6	69.4	71.9	10.3	nm	nm	nm		
XSM-9	Willow, CLO (F4), wheat flour	SWH	61.0	62.9	63.6	5.5	69.1	69.6	71.9	10.9	nm	nm	nm		
XSM-10	CLO (F4), water, FM, wheat flour	SWH	59.0	61.3	62.2	5.8	68.0	68.5	69.6	10.6	nm	nm	nm		
XSM-11	Emulsion (F5)	SWH	60.8	61.5	61.8	3.8	65.5	65.8	71.8	11.0	nm	nm	nm		
XSM-13	Raw reindeer brain	SWH	60.8	61.5	62.0	5.0	66.9	67.4	68.1	7.4	1.8	0.4	0.0	Strong	Well

Table 7.7. Results from chromatographic analyses and the analyses of hydrothermal stability of the experimental (XSM) samples. Nm= not measured.

7.3.1 The UFA/SFA ratio and the C22/C20 ratio

According to the literature studies (Georgi, 1775:261; Hatt, 1914:27), marine oils have been used in both the Sámi and Evenk culture skin processing technology. This is partly reflected in the results from the chromatographic analyses, and show that only the Sámi culture samples possibly contain residues of marine oils.

The UFA/SFA ratio typically reflects the relation between the sum of all unsaturated fatty acids (UFA) and the sum of all saturated fatty acids (SFA) present in the skin at a specific time. This means that a skin with a high UFA/SFA ratio may or may not contain only UFAs which are characteristic for marine oils, these ay also come from other oils containing unsaturated fatty acid. The UFA/SFA ratio is based on a mixture of all mono- and poly-unsaturated fatty acids found in the skin samples, without specification. Investigating the use of the C22/C20 ratio, which is the relation between two unsaturated fatty acids characteristic for cod liver oil (CLO), as described by DeWitt (1963:95), is an attempt to narrow down the range of oils which have been used in the skin material. It is furthermore observed that a high value of the UFA/SFA ratio does not necessarily mean that the value for C22/C20 ratio is corresponding. This observation supports the impression that the C22/C20 ratio is more important than the UFA/SFA ratio in the determination of the presence or absence of marine oil. A context based interpretation signifies that the marine oils are more commonly found in the analysis of the Sámi culture material than in the Evenk culture material and, therefore, would be expected more frequently in the Sámi culture samples. This is also the case. The argument behind this proposition is the characteristics of the experimental samples XSM-1, which contains cod liver oil, and XSM-13, which does not contain cod liver oil. XMS-1 and XSM-13 both have high levels of SFAs and UFAs, which yield a UFA/SFA ratio of 0.9 and 0.7 respectively. For XSM-13 the UFA/SFA ratio cannot be used as an indicator of cod liver oil, as it is obvious that this sample does not contain any residues of any marine oil. This is confirmed in the C22/C20 ratio, which demonstrates that XSM-13, with a C22/C20 ratio of 0.0, does not contain the required levels of docosenoic (22:1 isomer) and eicosenoic (20:1 *cis*-11) acid. XSM-1, on the other hand, indicates a significant level of cod liver oil through its C22/C20 ratio of 0.7 (Table 7.8).

Museum number	Age	Material type	FA content %	UFA/SFA ratio	SFA SUM	UFA SUM	C22/C20 ratio
TM-unr-toolmarks	Unknown	SWH	1.4	0.7	60	40	0.3
TM-2239 b	Unknown	DS	0.5	0.5	68	32	0.4
TM-1833a-b	35	LS	3.1	0.5	68	32	0.6
SVD-2219	Unknown	LS	2.7	0.2	84	16	0.8
SVD-2337	Unknown	LS	2.8	0.2	85	15	0.6
SVD-2212	Unknown	LS	0.9	0.2	87	13	0.4
NFSA-0361	100	SWH	0.9	0.1	90	10	0.3
TM-0545	55	LS	1.8	0.1	91	9	0.3
SVD-0078	Unknown	DS	2.9	0.1	94	6	0.5
SVD-1502	Unknown	LS	2.8	0.0	95	5	0.9
TM-0491	55	DS	1.9	0.0	97	3	0.3
SVD-2210	Unknown	SWH	3.7	0.0	98	2	0.6
Experimental samples							
XSM-1	**CLO (F4), FM, wheat flour, salt**	**SWH**	**5.2**	**0.9**	**51**	**49**	**0.7**
XSM-13	**Raw reindeer brain**	**SWH**	**1.8**	**0.7**	**60**	**40**	**0.0**

Table 7.8. Comparison of the ratio values of the UFA/SFA ratio and the C22/C20 ratio in historic sample material and in the experimental samples XSM-1 and XSM-13. The table shows that even though a sample contains very little UFAs, and has a low or nonexistent UFA/SFA ratio, the sample may still contain the required levels of docosenoic (22:1 isomer) and eicosenoic (20:1 *cis*-11) acid using the C22/C20 ratio as an indicator of marine oils.

7.3.2 The application of fat and smoke

Two tanning effects occur in a full oil tannage process. These are caused by the autoxidation of the unsaturated fatty acids, through the exposure to oxygen, and by the formation of aldehydes through the subsequent heating process (Kuntzel, 1958:426). Based on the description of an oil tannage, it may be discussed if a full oil tannage of reindeer skin is obtained during skin processing in the Sámi and Evenk culture. The production of an oil tanned skin is dependent on the use of a type of oil which contains highly unsaturated fatty acids, such as for example cod liver oil. For a full oil tannage to occur, heat must be applied during the oxidation of the applied oil. The self-heating which follows when skin treated with cod liver oil is mechanically manipulated does not seem to be enough for a full tanning effect (Gustavson, 1956:295). Brain substance, bone marrow or reindeer liver, which are used prior to a smoking process in the Evenk culture, do not contain sufficient amounts of highly unsaturated fatty acids to be able to create an oil tannage effect in the skin. A slight tanning effect may, however, still be obtained in the Evenk culture processing technology through the smoking process, which contributes to the formation of aldehydes. This tanning effect is also described for the Japanese inden leather (Kuntzel, 1958:434) (See section 3.1.1.2). It would, furthermore, be difficult through analyses of a historic skin garment to determine if smoking has been intentionally used as a skin processing method. The unintentional smoking of a skin, which occurs when a skin garment is worn and kept in a smoke filled environment, would disturb the results. The detection, through analysis, of a smoked or a not smoked skin would only be possible through the production of smoked experimental skin samples.

In the Sámi culture material, where the fat is applied without a subsequent heating and without a sub-

sequent smoking procedure, it is presumed that a full oil tannage is not achieved. The shrinking temperature of oil tanned skin, such as for example wash leather (chamois leather), does not raise much above that of fresh skin (Kuntzel, 1958:426). Elevated shrinkage temperatures of smoked skin have, as well, not been reported, apart from the slightly elevated shrinkage temperatures of the smoked Evenk culture reference samples of this study. However, these variations may be a sign of general variations in the skin material (Table 7.6, reference samples) It is therefore assumed that a full oil tannage, as described in the tanning literature, is not attained in the Sámi culture or in the Evenk culture skin processing technology (Gustavson, 1956:295; Kuntzel, 1958:430-431; Sharphouse, 1995:214).

7.4 Hydrothermal stability

The analysis of the hydrothermal stability of the skin collagen fibres has demonstrated some interesting and indicative features for the artefact sample material in this study. The results show that shrinkage temperature (T_s) for newly manufactured Sámi culture DS material varies considerably due to differences in tanning degree (Fig. 6.12). The results furthermore illustrate the dissimilarity in skin processing methods for the three different material types in the Sámi culture and the similarity in skin processing methods employed in the Evenk culture (Fig. 6.26, 6.27). This results in a division of methods into two main groups - vegetable tanning (CT) and fat tanning - with the sub groups observed in the surface tannage of Sámi culture LS material and the possible smoking effect in the Evenk culture material. The tanning effect of the brown rotted larch wood applied in the reference sample from the Evenk culture may or may not have a slight tanning effect, although it is not specifically observed in the results from the analysis of hydrothermal stability.

For preservation and conservation purposes, the initial shrinkage of individual fibres (T_{first}) is equally important or perhaps more important than the shrinkage temperature, T_s, of the collagen fibres. The length of the A_1 and B_1 intervals is a measure of the uniformity of the fibres' deterioration, as well as a measurement of the tanning degree of the skin material. The length of the A_1 and B_1 interval yields values which can be represented as a 'T_{first}/T_s ratio'. A value indicating a short A_1 and B_1 interval will be close to 1.0, thereby indicating a good condition and an even tanning degree. The lower the ratio, the longer the A_1 and B_1 intervals, indicating the artefact samples are more deteriorated. A ratio from 0.60-0.70 indicates an A_1 and B_1 interval range from 17-23 °C, and a ratio from 0.70-0.80 gives values from 11-16 °C. The ratio from 0.80-0.90 indicates an A_1 and B_1 interval range from 6-10 °C, and the ratio from 0.90-1.0 indicates a range from 0-5 °C.

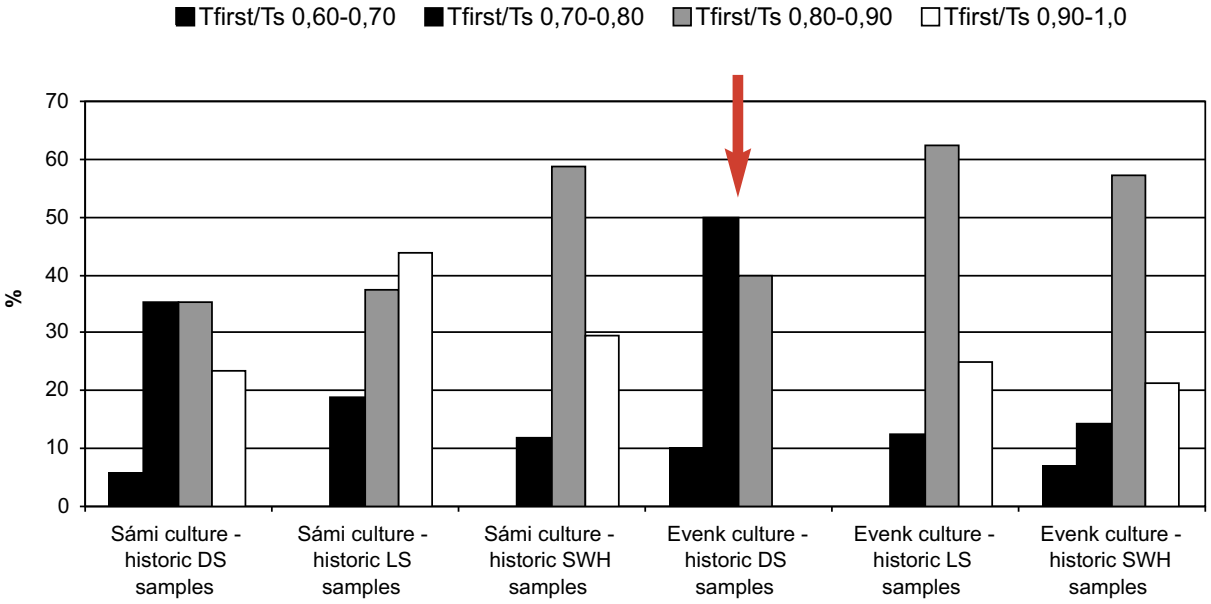


Fig. 7.2. T_{first}/T_s values illustrating the percentage of artefacts within each group. The Evenk culture historic DS samples (red arrow) show a high number of samples with long initial shrinkage intervals (A_1 and B_1).

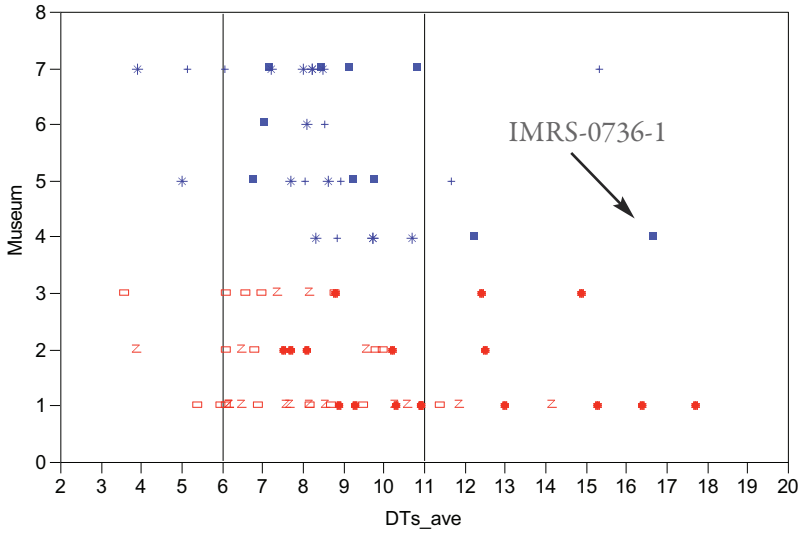


Fig. 7.3. Illustration of ΔT versus museum collection association, illustrating the ΔT range for the various collections. Each museum is represented by an individual number on the Y graph line (7 museum institutions). Red markers show collections with Sámi culture artefacts, and blue markers show collections with Evenk culture artefacts.

This ratio may be used in this study, as the deterioration level of the sample material generally is slight to medium. However, as the deterioration of the artefact develops, the shrinkage temperature (T_s) decreases and the fibres become more evenly deteriorated, and the A_1 and B_1 intervals become shorter. The distance between A_1, B_1 and T_s is reduced, which means that the T_{first}/T_s ratio will yield values closer to 1.0 (Larsen, *et al.,* 1993:155; Larsen, *et al.,* 1994b:152-154).

Figure 7.2 illustrates the distribution of the T_{first}/T_s ratio according to material types; itshows again that the Sámi culture LS material type exhibits a larger percentage of artefacts with a value close to 1.0, which in general signifies an artefact in a good condition. The distributions furthermore demonstrates that the Evenk culture DS material exhibits the largest percentage of samples with low ratios, followed by the DS samples from the Sámi culture, indicating that the samples in general have a non-uniform tanning degree and perhaps more importantly, that the sample material is deteriorated.

The length of the B_2 and the A_2 intervals observed through this study seems to be more related to the uniformity of the tanning of the skin material, although it may also illustrate the deterioration of a fibre, especially when these intervals are very short or non-existing.

It has furthermore been observed that artefacts treated with a fatty substance are located within a distinct range in relation to ΔT (within 5 °C). This is especially found in the Evenk culture artefact collections (Fig. 7.3). The average age of the artefacts in these collections is quite high, indicating that, over time, the deterioration of the skin materials that have been treated mainly with a fatty substance develop a similarity in their deterioration pattern. This must, however, be stated with care, as the sample population from each museum is small.

7.5 The link between visual, chemical and physical analysis

The analysis of the artefact material is divided into features that describe the skin processing technology and features for characterising the condition of the artefact. At times these features overlap. The general condition is a summary of the visual analysis, and it encompasses features such as wear and tear, the amount of soiling and the physical damages to the artefacts. It also includes observed cracking of the epidermis and the extent of the root pattern visible on the flesh side of the artefact. The cracking feature and the root pattern are characteristics also in the identification of skin processing technology. The condition of the artefacts, based on the visual evaluation, concluded that 52 % of the Sámi culture artefacts and 74 % of the Evenk culture artefacts lie within the categories 'good' to 'very good'. In the categories 'fair' to 'poor' the values are 46 % and 24 % respectively (chapter 4.2). This indicates that the Evenk culture artefacts, in a general sense, are in a better condition than the Sámi culture artefacts. The reasons for this are many, but one significant explanation is the varying condition of the artefacts at the time of acquisition, as are also the environmental conditions, storage facilities and exhibition rate that the artefacts have been subjected to.

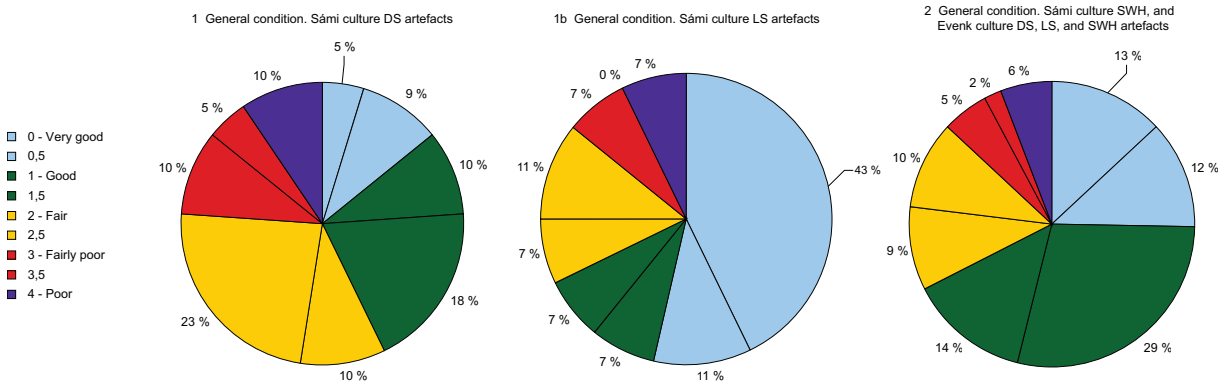


Fig.7.4 General condition distribution of all 187 artefacts which have been visually examined through this study (see fig. 4.40, 4.41, and 4.42 for comparison). The Sámi culture vegetable tanned DS material (1) shows the highest number of artefacts in the 'fair' to 'poor' category, while the Sámi culture LS material, which is surface tanned (2) shows the highest number of artefacts in the 'very good' general condition category. The third group (3) contains all artefacts which are mainly treated with a fatty substance and shows a fairly even distribution, although with a considerable percentage in the 'very good' to 'good' condition category.

The general condition in relation to the proposed tanning methods is illustrated in figure 7.4.

The Sámi culture vegetable tanned DS material (1) exhibits the highest variation in condition and the highest number of artefacts in the 'fair' to 'poor' category. The Sámi culture surface vegetable tanned LS material (1b), considered a sub-group of the vegetable tanned group, exhibits the highest number of artefacts in the 'very good' general condition category. The material types from both the Sámi and the Evenk culture (2), which are mainly tanned with a fatty substance, show a fairly even distribution between the different evaluation categories, and a considerable percentage of the artefacts are located in the 'very good' to 'good' condition category.

The results of the analyses of hydrothermal stability, however, indicate that the Evenk culture DS material separates from the LS and SWH material in this group by exhibiting a deterioration pattern where a considerable amount of the artefacts have low T_{first}/T_s ratios (Fig. 7.2).

The high number of artefacts in the 'fairly poor' to 'poor' category indicates that the DS material from the Sámi culture is more disposed to deterioration and to physical damage. This is not unexpected, due to the nature of the grain layer of the depilated Sámi culture skin material. It is furthermore not unexpected to find the highest number of artefacts with a low pH and a high pH difference in this category. These artefacts have been tanned with vegetable tannins of the condensed type (proanthocyanidins), which are found to be more susceptible to deterioration than hydrolysable tannins or untanned skin (Larsen, 1994c:169; Larsen, 1995:119). 'Red rot' as a phenomenon, with its characteristic red/brown colour and its more or less powdered surface, is observed on very few artefacts in this study, and only on vegetable tanned DS material from the Sámi culture.

Nine samples have been obtained, which upon analysis, exhibit pH values below 4.0. Five out of these nine samples are obtained from artefacts which have been stored and exhibited for approximately the last 100 years in Oslo, the capital of Norway; here the artefacts may have been subjected to high air pollution levels, caused by the use of fossil fuel in transport and in heating. The four other artefacts, SVD-2205, SVD-2212, SVD-1511, and SVD-2158 have been stored and exhibited in Karasjok in the north of Norway. In this area, oxidation through light and heat may be a more obvious cause for deterioration than air pollution. Figure 7.5 illustrates the relation between T_{first} and pH of 81 of the 82 samples in the study. It is here seen that most of the samples with the lowest pH values also have a fairly low T_{first} value and that they are all from the Sámi culture. This same illustration (Fig 7.5) also shows that the majority of the LS samples (red z marker) exhibit initial shrinkage activity above 50 °C.

The LS samples NFSA4066-a and SVD-2212 (red z in fig. 7.5) with a pH value below 4.0 have a pH difference of 0.6 and 0.9 respectively, where 0.6 is not considered high enough to be harmful to the skin (Larsen *et al.*, 1996c:201). These samples are also the

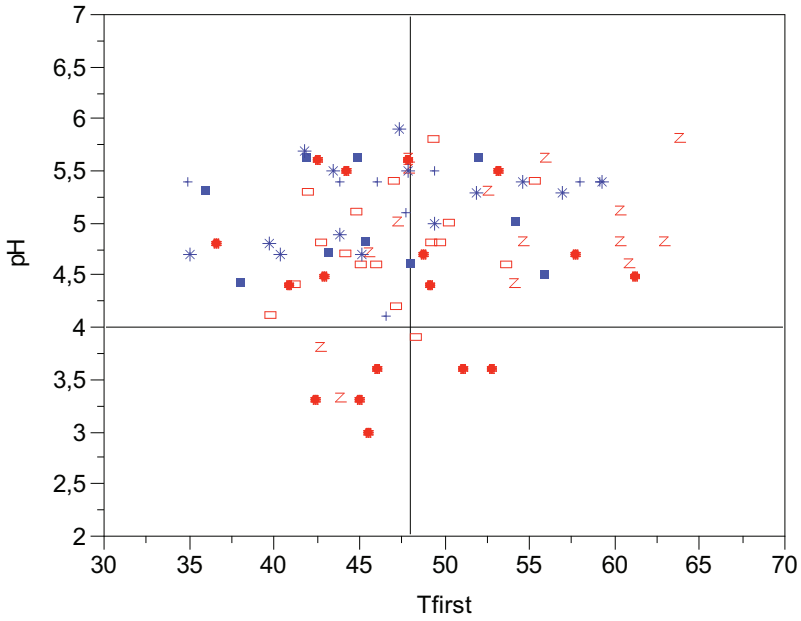


Fig. 7.5. pH versus T_{first} for 81 of the 82 samples from the Sámi culture (red markers) and Evenk culture (blue markers). Filled dots/squares mark DS material, z/+ mark LS material and */□ mark SWH material artefacts.

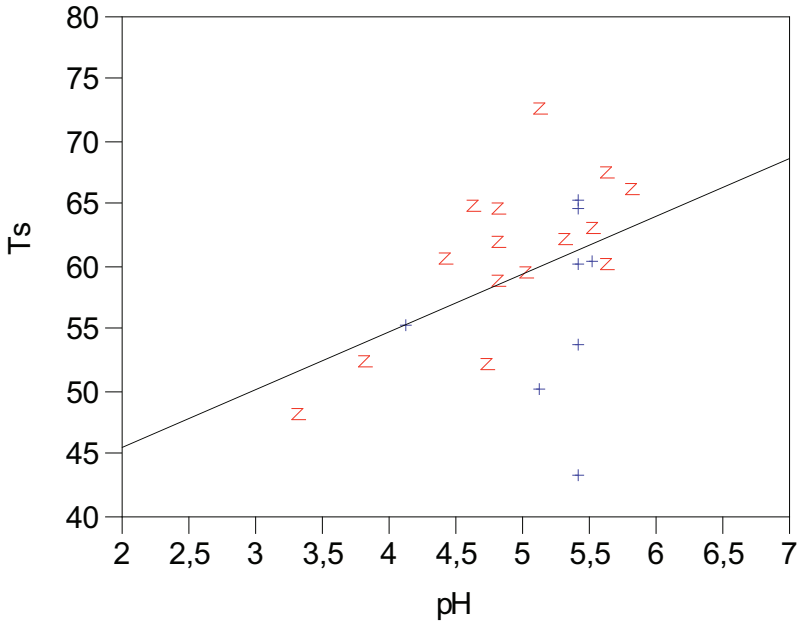


Fig. 7.6. Linear regression model of Ts and pH exhibiting a fairly strong relation between the two variables. Sámi culture (red markers) and Evenk culture (blue markers).

only two LS samples where tannin monomers have been detected in the course of the chromatographic analysis (Table. 5.6).

The shrinkage temperature, through linear regression analysis, shows a fairly strong relation with the measured pH. Linear regression not only explores the relation between the variables, but also quantifies the association between the variables. This is observed in the relation between the leg skin samples where the shrinkage temperature is seen, to a certain extent, to depend on the acidity of the skin samples. The correlation coefficient (R) is 0.7114 and the variation extent of the pH on the T_s is 50.51 % (R^2 = 0.5051), which supports this observation. This is, in particular, observed for the Sámi culture LS sample material (Fig. 7.6) and the shrinkage temperature increases with increasing pH. The same strength is not observed in the SWH or the DS material sample types.

The high percentage of artefacts made from leg skin, which fall into the category 'very good' in the general condition assessment, may also be caused by the fact that LS material is more robust as a skin material than both depilated skin (DS) and whole skin with hairs attached (SWH). This is probably also why it is used for the manufacture of hard-wearing garments, such as boots, leggings and the legs of trousers. This is supported by the results of the visual analysis, where LS materials show no cracking of the epidermis or root pattern formation, apart from in the upper part of the leg skin, which is close to belly skin. The dermis of the LS material typically has a higher average thickness, than the SWH and DS samples, and the fibres generally do not absorb water well, which is a feature assumed to be connected to a fibre's condition.

In the chromatographic analysis of vegetable tannins, tannin monomers are present primarily in the vegetable tanned DS material and the two LS samples (NFSA-4066a and SVD-2212) from the Sámi culture. The SWH samples from the Sámi culture exhibit a low

percentage of tannin monomers; this low percentage is only observed in two of the eight samples which have been analysed (Table 5.6). Tannin monomers, mainly protocatechuic acid (PCA), are present in 13 out of 23 samples from the Evenk culture. This means that vegetable tannins probably have been applied to the skin material in the Evenk culture skin processing technology; even though they do not have an observed negative effect on the pH value, the formation of phlobaphenes or has had an observed effect on the shrinkage temperature measurements.

There is one artefact which bears the characteristics of a vegetable tanned skin and which, at the same time, is an example of the link between visual and chemical analysis. This is IMRS-0736-1 (Fig. 7.7), an open coat, approximately 120 years old, catalogued as an Evenk culture artefact. The coat is composed predominantly of textile material but has depilated skin utilised for sleeves, as reinforcement and as support for decoration. The general condition is set to 4 (''poor') on the evaluation scale, and the coat has been repaired while in use. The coat also bears distinct evidence of wear and tear, and of insect infestation, although primarily on the decorative strips of skin which edge the coat's opening. The skin sample is obtained from the left sleeve, where the cuff is missing (Fig. 7.7). The skin is very thin, lightweight, and very flexible. It is slightly coloured when observed prior to the analysis of hydrothermal stability, has weak fibre coherence, and absorbs water well. The initial shrinkage activity, T_{first}, is 35.8 °C, and T_s is 46.6 °C yielding a T_{first}/T_s ratio of 0.77. ΔT is 16.6 °C, and the ΔT_{total} is 44.2 °C, confirming a deteriorated skin material. The pH of the skin sample is 5.3, which initially indicates that strong acids are not present in the skin. However, strong acids, such as sulphuric acid, could have been present at one point in time and been converted to non-acid compounds, as observed in the analysis of vegetable tanned book binding leather (Wouters & Clayes, 1996:90).

Fig. 7.7. Evenk culture open coat, mainly composed of textile material, elaborately decorated with skin strips and hairs. The arrow indicates where the sample is obtained. IMRS-0736-1. Irkutsk Museum of Regional Studies, Irkutsk, Russia, 2005.

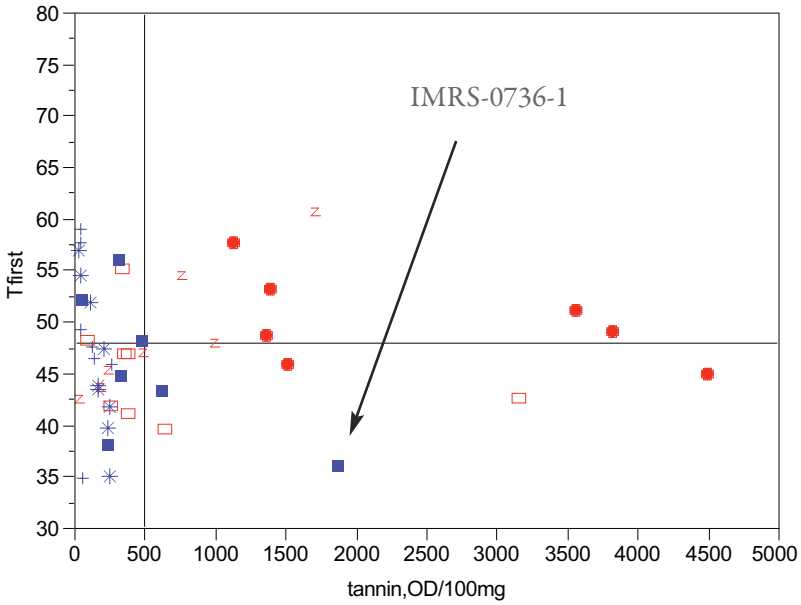


Fig. 7.8. The tannin content of IMRS-0736-1 is very high compared to the other Evenk culture samples, indicating that this particular skin is tanned with vegetable tannins (CT). Sámi culture (red markers) and Evenk culture (blue markers), filled dots/squares mark DS material, z/+ mark LS material and */⊠ mark SWH material artefacts.

The tannin content of this artefact is significant (Fig. 7.8), and the presence of the monomers PCA[1] and PCA[2] are in sum 7.5 % of the total tannin content

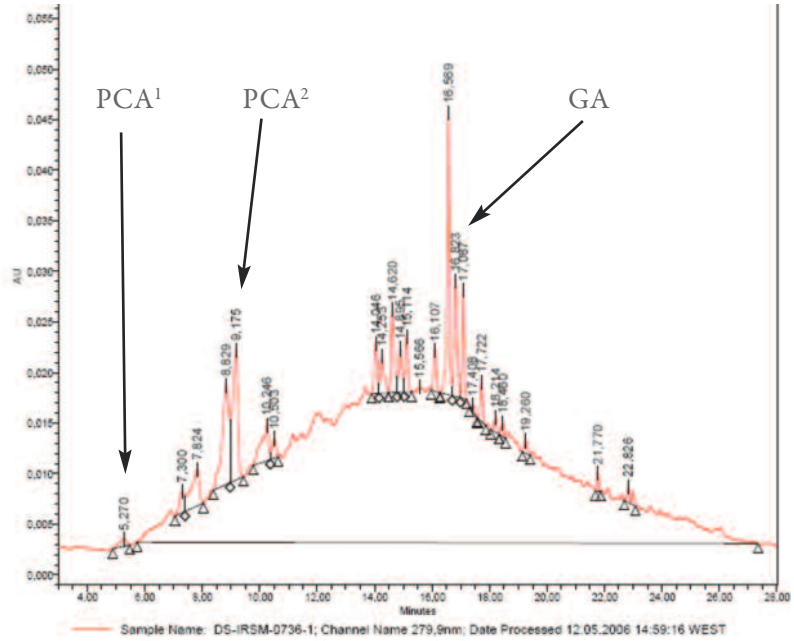


Fig. 7.9. Chromatogram of IMRS-0736-1 at integration 280 nm, illustrating the vegetable tannin content and the location of the tannin monomers, PCA[1] and PCA[2], as well as gallic acid (GA).

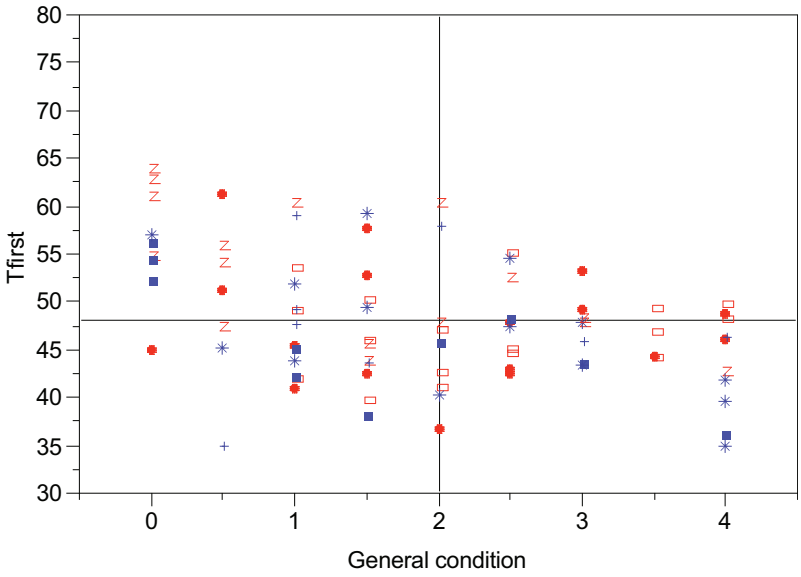


Fig. 7.10. Graph of general condition versus T_{first} demonstrating a link between the visual and the analytical methods. The majority of the artefacts where the condition is suggested to be 'very good' to 'good', have high T_{first} temperatures, and some of the artefacts with low T_{first} temperatures are located in condition categories between 'fair' to 'poor'. A reference line, added at 48 °C for T_{first} on the y-axis, represents the average T_{first} of all samples. On the x-axis the condition categories are: 0 - very good, 1 - good, 2 – fair, 3 – fairly poor and 4 – poor.

(Fig. 7.9). PCA[2] is a peak resembling protocatechuic acid, but it is located at a different retention time. The gallic acid content is 3.8 % of the total tannin content. The tannin-R is 1.1, indicating a condensed vegetable tanned skin. The fat content is 1.2 % of total sample size, the UFA/SFA ratio is 0.3, and the C22/C20 ratio is 0.0, indicating that there are no marine oils used in the skin processing.

IMRS-0736-1 is one example where the majority of the characteristics related to the artefact's identification and condition correlates to the general condition of the artefact. This is, however, one of few artefacts where a correlation is found along a broad range of condition features. The link between the visual characteristics and the chemical analysis of the total artefact sample material is not obvious, and a more comprehensive analysis is required to detect possible structures in the datasets.

Yet, comparing the general condition distribution and the T_{first} values, a pattern appears (Fig. 7.10). This graph demonstrates that a fair number of artefacts exhibiting high values for the initial shrinkage activity, T_{first}, have general condition values indicating a 'very good' to 'good' condition of the artefact. Furthermore, low T_{first} temperatures have general condition values indicating artefacts in a 'fair' to 'poor' condition. There is, however, a large group of artefacts which are not encompassed in this pattern, and these are the artefacts where the condition lies between 'good' to 'fair'. These results therefore indicate that there is a link between the visual condition characteristics and the analysis of thermal stability, but it is observed primarily in the

outermost condition categories. This pattern is present, but is less apparent in the graph where the shrinkage temperature, T_s is plotted against the general condition categories (Fig. 7.11).

For the few samples that do contain gallic acid, it is observed, that the initial shrinkage temperature, T_{first}, increases with increasing gallic acid content (GA %) of the skin sample and, furthermore, that the gallic acid content is related to the condition of the artefact. The graph indicates that the gallic acid content is higher in artefact samples where the condition of the artefact is good (Fig. 7.12). The reason for this is not clear, as gallic acid is a monomer formed in the deterioration of the vegetable tannin.

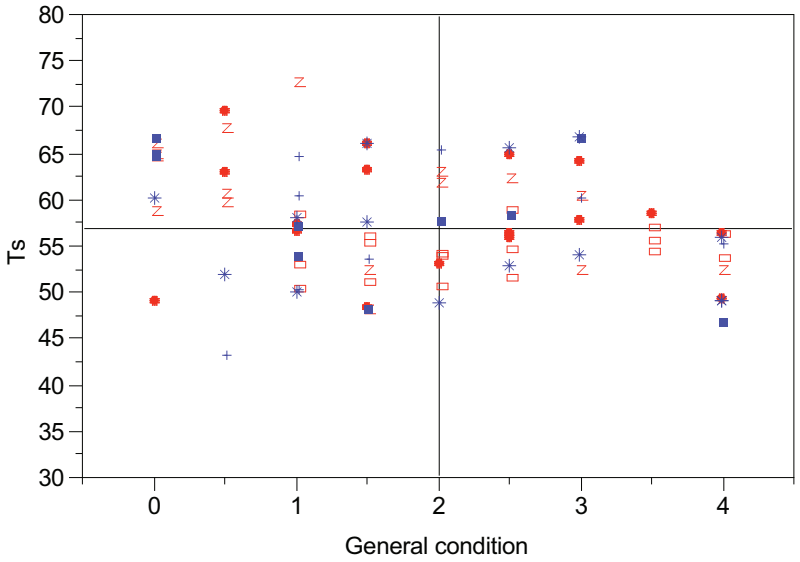
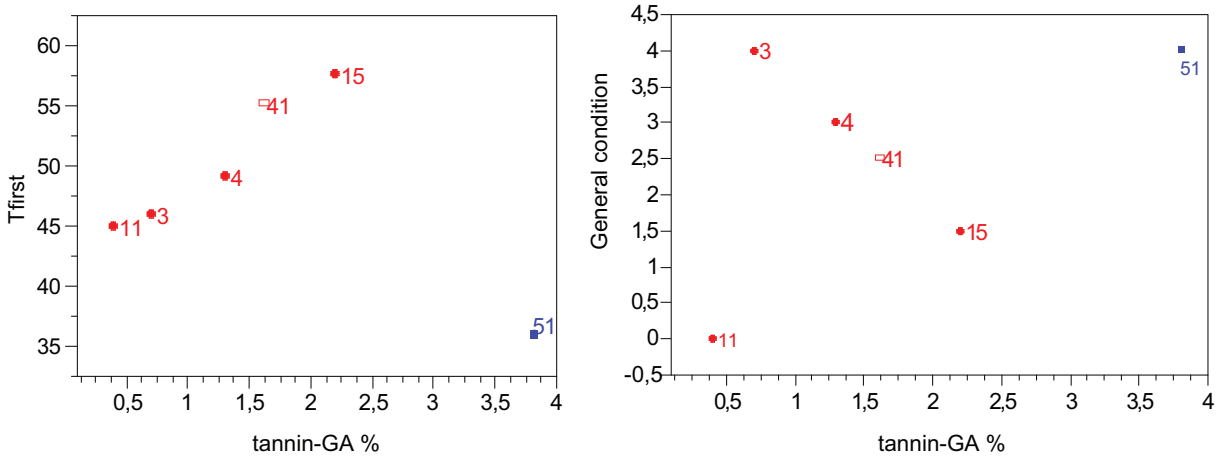


Fig. 7.11. Graph of general condition versus T_s, which demonstrates a much weaker link between the visual and the analytical methods. There is, however, a link in the outermost extremes of the condition categories. A reference line, added at 57 °C for T_s on the y-axis, represents the average T_s of all samples. On the x-axis the condition categories are: 0 - very good, 1 - good, 2 – fair, 3 – fairly poor and 4 – poor.

7.5.1 Principal component analysis, PCA.

The analytical scheme of visual, chemical and thermal analyses has resulted in a dataset with 42 variables for the 82 historic artefacts where samples have been obtained (Appendix 2). From these 42 variables, a selection has been made of the 15 variables assumed to be most significant (Table 7.9). The significance of each variable is assessed on the basis of the results from the individual analytical results and on the completeness of the dataset. Because of a high number of missing values, the dataset from the vegetable tannin analysis has been omitted from the statistical analysis. The relation between the results has been examined, using princi-

Fig. 7.12. Graph (left) demonstrating that, for the five samples from the Sámi culture material that contain the monomer gallic acid, T_{first} increases with increasing gallic acid content (%) and, furthermore, (right graph) that the condition decreases with decreasing gallic acid content.



NAME	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
Age	**0,6783**	-0,1231	-0,0185	-0,3435	-0,2504
Scraping quality	-0,0616	0,2837	0,2810	**0,5414**	0,0914
Tanning quality	-0,3972	**0,6045**	-0,2390	0,1318	-0,1499
Fibre cohesion-wet	**0,7622**	0,0575	-0,0507	0,0796	0,1624
Fibre thickness	-0,3293	-0,1397	-0,0644	-0,0029	**-0,5533**
Fibre colour	-0,1020	**-0,7166**	-0,1218	-0,1451	-0,0514
Residues bottom glass slide	0,0097	0,1215	**0,6605**	0,0588	0,1977
Tanning substance clinging to fibre	0,0182	-0,0885	0,1013	0,0549	**0,7305**
Absorbing water	**-0,8237**	-0,0706	0,0393	-0,1466	-0,2200
Ts	0,0312	-0,2142	0,1592	**0,6279**	-0,3449
ΔT	0,1245	**0,7116**	0,1615	-0,3539	0,0580
ΔT_{total}	0,4410	0,3609	***0,5116***	-0,2830	-0,1667
pH	-0,0170	-0,4853	**0,6381**	0,0871	-0,3140
FA content %	-0,3122	0,0744	***0,5077***	-0,0271	0,3565
UFA/SFA Ratio	0,0490	-0,0243	-0,2235	**0,6969**	0,1646

Table 7.9. The 15 variables selected for the principal component analysis (PCA) and their scores, presenting the hierarchy in the PCs. The variables which are relevant in each PC are marked in bold. The PCA analysis is performed by statistician Judith L. Jacobsen MSc, PhD, external lecturer at The School of Conservation, Copenhagen, Denmark.

pal component analysis, to detect structures in the data material. Principal component analysis is used as a statistical tool, to reduce the number of variables by expressing two or more correlated variables by a single factor. This is done by compressing the data material, creating a new set of variables called principal components (PCs) which represent the main part of the variability in the data. The PCs calculated scores, which yield 'new values' now make up new variables, called factor 1 to factor 5. Factor 1 expresses the majority of variability in the data, and the next, and the subsequent PCs each explain the maximum of the remaining variability in the data. 'Culture' and 'material type' are used as defining and separating elements in the analysis.

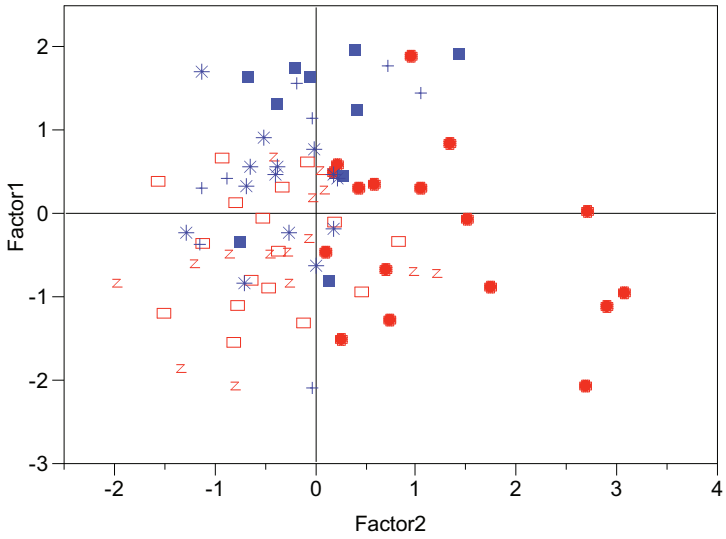


Fig. 7.13. Scatter plot of factor 1 versus factor 2. Filled dots/squares mark DS material, z/+ mark LS material and □/* mark SWH material artefacts. Red colour is used on Sámi culture markers, and blue colour is used on Evenk culture markers.

Factor 1 gives the main direction in the analysis, indicating that fibre cohesion, the ability to absorb water and age are the most important variables in factor 1. The representation (Fig. 7.13) of factor 1 (age, fibre cohesion, and absorption ability) versus factor 2 (tanning quality, fibre colour, and ΔT) indicates a structure where the Sámi DS material and the Sámi SWH and LS material separate. The Evenk culture material type categories gather in more defined groups in the scatter plot. This is primarily observed in the SWH and LS material type categories. This illustrates again that the DS material is more varied with regard to characteristics and to deterioration, within the Evenk and within the Sámi culture material type categories, as the spread of the markers is larger for the DS material type group.

The analysis confirms the correlation between fibre cohesion and the ability of the fibre to absorb water, where weak fibre cohesion follows a good ability to absorb water. The 'uncoloured' fibres are primarily seen in the category which have weak fibre cohesion and a good ability to absorb water, and the 'coloured' fibres are primarily seen in the Sámi culture DS samples, where the condition is more varied.

These results, furthermore, strengthen the division of tanning methods (vegetable tanning and fat tanning), demonstrating that these processing methods yield groups of material types which behave in a similar pattern. These groups have, however, been modified by the condition features, which is assumed to cause a greater spread of the fibre samples. The age of the samples, as well as the tanning quality and ΔT, do not seem to have a significant influence on the classification which is observed.

The basis for further statistical analysis is present in the data sets. It will, however, require a re-evaluation of the variables chosen for analysis, and a re-evaluation of the defining variables. This is a task which can not be completed within this project.

7.6 Condition issues

It is demonstrated through this study that although an artefact seemingly is in a good condition, it may be found to have significant weaknesses when results from chemical and physical analyses are interpreted. And, vice versa, an artefact may give the impression of being in a fairly poor condition although the materials of which the artefacts are composed may be fairly sound. It is therefore important to be able to assess the materials of the artefact by visual analysis, as well as by chemical and physical analysis, and to periodically re-evaluate the artefact's condition. A thorough understanding of the material's composition requires the knowledge of the tanning methods that have been applied in the production of the skin material, as well as the awareness of the possible variations in substance and material use. The results from the visual analysis relate to the analysis of hydrothermal stability (Fig. 7.10) and indicate that it is possible to identify the artefacts in 'very good' condition or the artefacts in a 'poor' condition. The categories between 'very good' and 'poor' require a combined analytical assay to establish the condition of the artefact. In this analytical assay, visual analysis followed by the analysis of hydrothermal stability and the measurement of pH is recommended. Furthermore, a more specific knowledge of the tanning substances is required. This includes the identification of the vegetable tannin type, which again will suggest whether the material is susceptible to acid hydrolysis, as in hydrolysable tannins, or whether the material is more susceptible to acid condensation and oxidation, and thereby the development of 'red rot' as in condensed tannins.

Collagen fibre materials primarily follow two deterioration patterns, one being hydrolysis, through the exposure to pollutants, and the other being oxidation, through exposure to heat, light, ozone and oxygen. These patterns do not, however, proceed separately. There are reciprocal interactions between the factors, which contribute to the artefact's condition. These interactions are furthermore a result of individual variability in the skin material, from the nature of the animal's skin, the processing methods and tanning substances, the use and the maintenance of the artefact, and the treatment and environmental conditions the artefacts have been subjected to in their 'lifetime'. Deterioration of the collagen fibre often occurs through the oxidation of the vegetable tannins and/or the lipids which have been applied to the skin (Larsen & Rahme, 1999:55, 72).

During hydrolysis, sulphur dioxide is adsorbed in the skin, where it oxidises to sulphur trioxide ($SO_2 \xrightarrow{ox} SO_3$). Sulphur trioxide, which is highly reactive, associates with water and forms sulphuric acid ($SO_3 + H_2O \Longrightarrow H_2SO_4$), which may result in low pH values measured in the skin. This reaction has the capacity to split the peptide chains of the collagen molecule by hydrolysing the peptide bonds (Fig. 7.14). The acid will also influence the vegetable tannins in the skin. In condensed tannins the acid influence will lead to a condensation reaction, resulting in a precipitation of the phlobaphenes and the possible development of red rot (Larsen & Rahme, 1999:71).

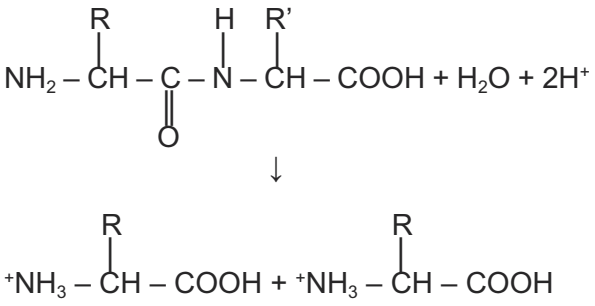


Fig. 7.14. The splitting of a peptide bond through acid hydrolysis.

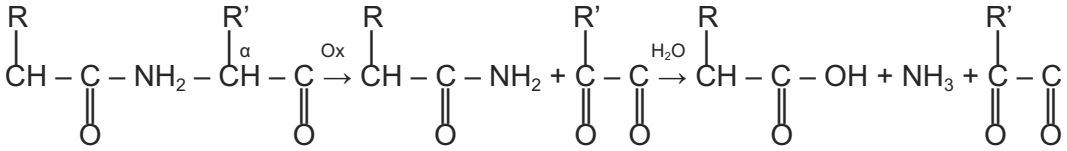


Fig. 7.15. Splitting of the peptide chain by oxidation. The chain is split at the α-carbon atom, leading to the formation of keton, aldehyde and ammonium components.

In less acidic environments the primary deterioration mechanism is oxidation, causing a splitting of the polypeptide chains, at the α-carbon atom, and also a splitting of the amino acid side chains (R). This autoxidation, which is a chain reaction, leads to the formation of radicals which react further, keeping the reaction process going. The oxidation of the vegetable tannin molecule (condensed tannins) may lead to smaller molecules, such as the tannin monomers protocatechuic acid (PCA) and other unidentified monomers given a code 'T'. Gallic acid (GA) and ellagic acid (EA) are also seen as tannin monomers and are observed in the deterioration of condensed vegetable tanned skin, although they are more often observed in the analysis of skin tanned with hydrolysable vegetable tannins (Wouters, *et al.*, 1996:104; Wouters & Claeys, 1996:89; Larsen & Rahme, 1999:71-72). The oxidative cleavage of the amino acid side chains leads to the formation of ammonia, often bound as ammonium sulphate, $(NH_4)_2SO_4$ in the skin (Fig. 7.15), causing increased acidity in the skin.

Amino acid analysis performed on the artefact material samples of this study would yield valuable information on the primary deterioration mechanism. Amino acid analysis is used in determining the oxidative breakdown pattern of the collagen protein, by studying the amino acid distribution, the formation of deterioration products, and the formation of new amino acids in the skin. The relation between the basic and acidic amino acids is calculated as the B/A value = (Arg+Hyl+Lys)/(Asp+Glu), and a lowered B/A value indicates that oxidation has taken place in the sample material (Larsen *et al.,* 1994a:47; Larsen *et al.,* 1996a:39).

Studying the deterioration of an artefact may also require the understanding of the fatty substances which have been applied to the material. Again, the knowledge of the substances that may have been used both in the skin processing and for preservation purposes is very useful, as is also the understanding of the effect these substances may have on the artefact material. Oxidation occurs in the lipid molecules, and particularly in the polyunsaturated fatty acids. This decomposition generally yields smaller molecules, but may also lead to a polymerisation of lipid molecules as observed in the drying of oil films. The autoxidation mechanism, initiated by the abstraction of a hydrogen atom to yield a free radical, follows several steps, forming intermediate compounds such as peroxides and hydroxyperoxides. The secondary products of hydroperoxides are aldehyde and alkoxy radicals. The aldehyde may oxidise further to carboxylic acid (White, 1999:39). It has also been suggested that oxidation, through collagen's absorption in the ultraviolet region, may cause intramolecular or intermolecular cross-linking between peptide chains (Sundholm *et al.*, 1978:757), and may, through condensation, form large and complex molecules, which also increases the cross-linking of the collagen fibres (Larsen & Rahme, 1999:72).

Lipids applied to the skin, either as a tanning agent or as a lubricant, can also have favourable effects on collagen fibre material, acting as an inhibitor in the adsorption of pollutants, by blocking the penetration of pollutants, and especially that of sulphur dioxide (Wouters, *et al.,* 1996:105). The lipids used for preservation purposes should not contain highly unsaturated fatty acids because of their susceptibility towards oxidation, which results in colour changes, and a decrease in the flexibility of the skin. Fats which have been sulphated (treated with sulphuric acid, H_2SO_4) or sulphited (treated with a solution of sodium bisulphite ($NaHSO_3$) (Sharphouse, 1995:327-330) may, furthermore, have a negative effect on hydrothermal stability of the skin. For untanned and tanned skin the shrinkage temperature of the collagen fibre was observed to fall considerably (Kronick, 1996:249; Manich, 2005:208), and these types of oils should therefore be avoided both in skin processing and for preservation purposes (Larsen *et al.,* 1996c:198).

7.7 The changes in skin processing methods and the utilisation of 'new' substances

Continuous changes are occurring in skin processing, and these encompass physical methods of manipulation and the substances used in the processing, include the use of salt (NaCl) or a mixture of salt and alum ($AlK(SO_4)_2{\cdot}12H_2O$) in the initial preservation and in the tanning process. They include the use of washing machines in the vegetable tanning and lubrication of skins, the purchase of vegetable tannin powders such as quebracho and mimosa, and the exploration of fats and lubricants from a variety of sources. These are all changes which are assumed to be non-required, and they are a part of the diversity and the flexible nature of skin processing technology, allowing the manufacturer to investigate new methods and tanning substances, without losing the significance of representing a traditional practice. The alterations also encompass features which are based on changes in the availability of resources, such as problems with obtaining skins which have been appropriately cut from the carcass of the reindeer, reflecting changes in subsistence activity and a change in lifestyle. Whereas the first set of changes may have an effect on the physical and chemical properties of the skin material itself, the second set of changes has a more pronounced effect on the form, or the design of the garments which are manufactured.

Obtaining a raw streak in a skin material, both in leg skin and also in depilated skin, is important in order to obtain waterproofing qualities and to add strength to the skin materials. However, as these qualities are required to a lesser degree today, the washing machine becomes a useful tool, especially in the vegetable tanning and lubrication of especially depilated skin. A washing machine is also used in the processing of leg skins, although it is more difficult to control the penetration of vegetable tannins in the skin through the washing machine process. This would have a negative effect on the required raw streak, which is important for attaining shape and to obtain a moisture barrier in the leg skin. The raw streak is also compromised if leg skins are salted and treated with alum. The physical manipulation of the skins is made easier and the skins have a thicker feel, through the application of salt/alum, but some informants also state that boots and garments become heavy, do not attain their shape well, and may be perceived as being more damp.

Mimosa and quebracho tannin powders are available in some shops today and are particularly used in the tanning of depilated skin in the Sámi culture. They have not yet been observed in the Evenk culture. Informants from the Sámi culture state that the tannin powders are occasionally used, but that the results are not as good as in skins tanned with traditional bark tannins.

The exploration of fatty substances, both for tanning purposes and for lubrication and waterproofing purposes, is continuous in the skin processing technology of the Sámi and Evenk culture. As long as the fat yields the desired properties in the skin, the type of fat used is not that important. This means that artefacts treated with modified fats from a variety of sources, including sulphated and sulphited oils, may eventually be found in museums collections, and the effect these oils have on the skin materials must be considered.

7.8 Preservation issues

Both hydrolytic and oxidative deterioration patterns may be reflected in the Sámi culture DS material, where the shrinkage temperature and the pH for some samples are low, and where a full grain is present and 'red rot' is developing. It is assumed that the deterioration observed in the artefact material housed in Oslo may have been caused by greater exposure to acid deterioration than the artefacts housed in Tromsø and in Karasjok, in the north of Norway, where pollution levels are considerably lower. In these areas, visible and ultraviolet radiation levels are high through at least parts of the year (midnight sun), and high radiation levels in past and present exhibitions may have had an effect on the artefact materials' deterioration.

A different pattern is observed for the Sámi culture LS material, where 61% of the artefacts have shrinkage temperatures above 60 °C. The vegetable tannin content is lower, which also reduces the extent of deterioration of the collagen fibre through the vegetable tannins. In addition, the hair coat layer, on the exterior of the artefacts, may have a protective effect, reducing the direct ultraviolet and visible radiation of the flesh side surface.

The deterioration pattern of the Sámi culture SWH material is closer to the Evenk culture skin material deterioration pattern. This is in particular observed in the T_{first} distribution (Fig. 7.16).

For the Evenk culture artefact material, oxidation of the lipids, and thereby a deterioration of the collagen fibres, is a more likely deterioration path. Al-

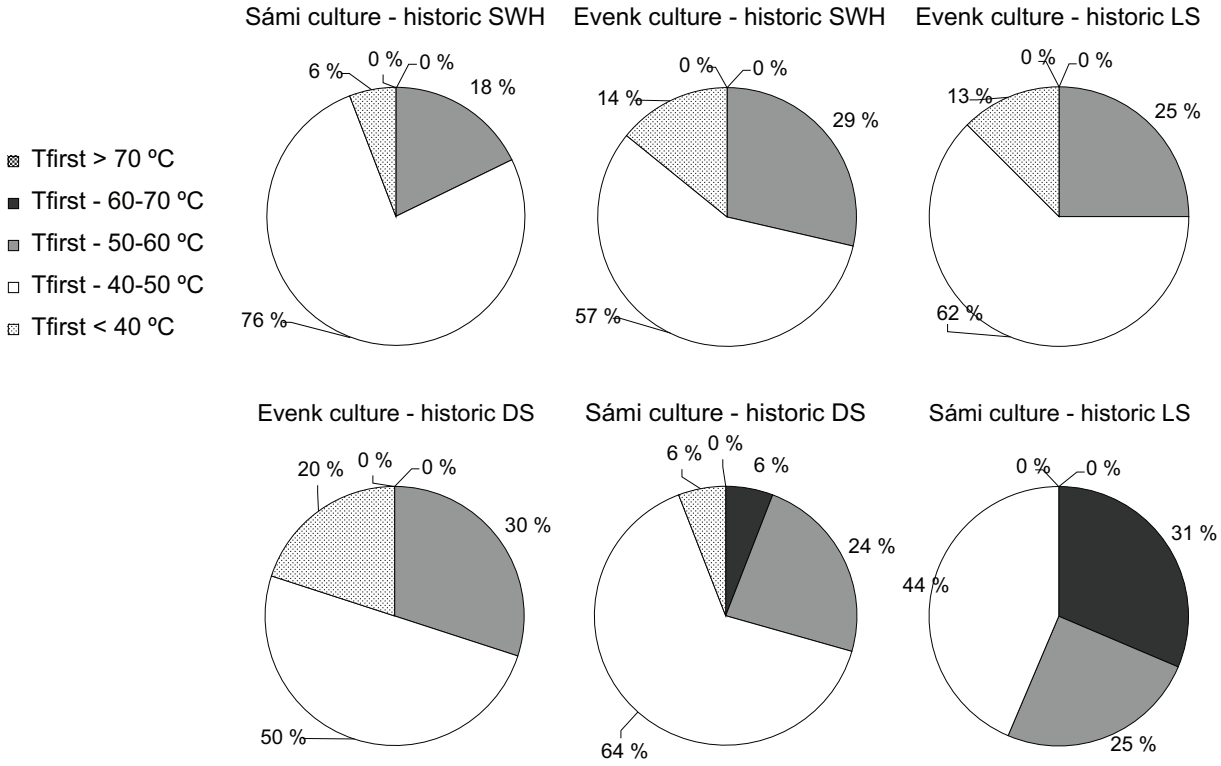


Fig. 7.16. T_{first} distribution of Sámi and Evenk culture historic samples, indicating a similarity in deterioration pattern, observed through analysis of hydrothermal stability. Sámi culture DS and Sámi culture LS material samples show a different pattern.

though it is problematic to compare the original fatty acid composition of a sample with a deteriorated sample, as the relative percentage composition of fatty acids changes as the lipids decompose (Malainey, *et al.,* 1999b:95), the C22/C20 ratio, the information from the informants, and the historic sources indicate that marine oils are the least likely lipids to have been applied to these skin materials. The negative effects of a fat containing polyunsaturated fatty acids, such as yellowing, inflexibility and a sticky surface, are not in particular observed in the Evenk culture artefact material. Whereas darkening of the skins' surface is not observed in the Evenk culture artefacts, fading is observed, which is a characteristic of fat tanned skin material (Fig. 1.23) (Sharphouse, 1995:151).

The Evenk culture artefact material has been subject to a variety of conditions, being located in museums in large cities, where pollution levels may have had an influence, as well as varying climatic conditions in storage and exhibition areas. The age of the Evenk culture sample material is higher than for most of the Sámi culture artefact samples, and the wear and tear of the artefacts, prior to acquisition, is visually observed to be higher. This has also had an effect on the present condition of the artefact material.

How well the collagen fibres absorb water is related to the fibre cohesion. It is observed that a fibre that absorbs water well often exhibits weak fibre cohesion (Table 6.3). This is in particular related to the sample materials which have been treated with a fatty substance, and less obvious in sample materials which are vegetable tanned. This is, furthermore, indicated in the principal component analysis (Fig. 7.13). Fibre absorption and fibre cohesion are sometimes related to the shrinkage temperature, but not always. They are, however, related to the tanning method, and the relation is more pronounced in the Evenk culture samples, where the tanning method primarily is the application of a fatty substance. The ability to absorb water well is shown in the experimental sample XSM-13, which is treated with raw reindeer brain (Table 7.7). The vegetable tanned and untanned samples generally exhibit stronger fibre cohesion and a medium to low ability to absorb water, while the samples treated with a fatty sub-

stance generally have medium to weak fibre cohesion and medium to well water absorption abilities (Tables 6.3-6.5). If the collagen fibre is found to absorb water well, it will influence the skin artefact's reaction towards changes in relative humidity (RH). An unstable RH will lead to fluctuations in the skin's moisture content, causing physical tension in the fibre material. It is therefore important to keep the relative humidity stable, particularly avoiding rapid fluctuation.

The oxidative effect of light, heat and other oxidative contaminants influences not only the lipids or the vegetable tannin, and in particular the condensed tannins, but also the amino acid composition, lowering the B/A value, weakening the collagen fibre and thereby the artefact as a whole. Avoiding ultraviolet radiation and keeping visible light levels and temperature conditions low are therefore important. This is also important for the preservation of skin material primarily tanned with fatty substances, and in particular substances containing polyunsaturated fatty acids, due to the oxidation mechanism taking place in the lipid molecule, and in the collagen molecule.

The results from the general condition evaluation of the artefacts, as indicated in the visual assessment in chapter 4, are modified in the subsequent analyses. The deterioration pattern is, first of all, modified through the division into tanning types, and it shows that vegetable tanned depilated skin materials are more susceptible to deterioration through hydrolysis and oxidation followed by the physical damage of a full grain surface. Suede surfaces seem more robust in regarding to physical damage, but the oxidative deterioration of skin materials treated with a fatty substance is an ongoing process.

Equal weight has to be put on the visual evaluation and the chemical analysis in the assessment of the condition of an artefact. Physical damage is a sign of fragility in the skin material, a fragility which may evolve from chemical deterioration. The monitoring of artefacts, through assessing the condition using a multiple assay of methods is recommended.

To inhibit further deterioration and to reduce the effect of deterioration on the artefact, a number of precautions may be taken. These involve:

Reducing visible radiation and minimising ultraviolet radiation in storage and in exhibition.

Keeping a stable relative humidity (RH) in storage and exhibition, particularly avoiding rapid fluctuations and avoiding condensation on the artefact's surface.

Avoiding rapid temperature changes and keeping a low temperature if possible.

Reducing the pollution levels through the filtration of incoming air, for example by activated carbon filters, as well as reducing the indoor pollution by using localised filtration and/or scavengers.

Reducing the physical damage of artefacts by making sure the artefact is handled, supported and stored according to its requirements.

Implementing an integrated pest management (IPM) system, in the institution. Insects may never be totally eradicated in a museum institution but insect infestations can be kept under control.

Collagen fibres have been seen to shrink irreversibly at room temperature, when immersed in water (Larsen *et al.,* 1994b:152). In this project, initial fibre shrinkage has been observed, for a few artefacts, as low as 35-39 °C. This means that if an aqueous treatment of skin artefacts, is regarded as necessary, it must only be performed after a thorough examination of the artefact including the analysis of hydrothermal stability. Even though the result primarily will reflect the location where the sample is obtained, the conservator can, from an evaluation of the overall results, be able to make a qualified decision whether to use an aqueous treatment or not.

Artefact material which is not in regular or active use should only be treated in cases where physical damage is threatening to develop and further damage the artefact. A minimal intervention strategy is recommended, avoiding the addition of substances which are not part of the artefact's composition.

7.9 Conclusion

The research performed in this study is an initial approach to the understanding of the complex nature of manually tanned skin materials manufactured by individual tradition bearers from indigenous cultures in the circumpolar area; it instigates a series of research topics which can be further addressed, in regards to technological, visual, chemical, and physical analysis. Contextual interpretation comprises traditional knowledge and practices as well as the empirical information obtained through investigative and analytical methods. This requires collaboration between several areas of knowledge, and has led to a considerable amount of information regarding the artefact materials examined through this study. The investigation and the analyses have furthermore established that there is still a lot of information left in the material, from all areas of knowledge, which is waiting to be explored, analysed and presented.

The results from this study have shown that the materials and substances used in skin processing technology are founded on local resources and the availability of resources, rather than on culturally determined traits, and that the processing technology is continuously being renewed and updated. The knowledge of skin processing technology today is primarily upheld by the elders in a community, and alternative ways of passing this knowledge on are being established through the education systems and, for example, through workshops. The individual varietyin skin processing technology may be affected by these changes, as materials and substances available for skin processing is reduced. The consequence of these changes is not yet fully observed.

In the analysis of skin artefacts, primary features to be aware of are the characteristics from the various processing stages of skin materials, such as indicators of pre-processing, skin processing methods, and of maintenance and use. These features yield information which can be applied in the study of all types of skin material artefacts from the circumpolar area.

The division into two main tanning categories, vegetable tanning and fat tanning, affects the way the artefacts are interpreted. This division is observed in the chromatographic analysis of vegetable tannins and in the analysis of the hydrothermal stability. Apart from the Sámi culture DS material, which is considered a vegetable tanned skin, and to a certain extent the Sámi culture LS material type, vegetable tannins are only slightly present in the Sámi culture SWH and the Evenk culture DS, LS, and SWH material types, which do not significantly affect the properties and the condition of the skin. For these material types, the application of fatty substances has a greater impact on the properties and the condition of the artefact. Fats, as opposed to vegetable tannins, do not raise the shrinkage temperature of a skin, and this must be encompassed in the interpretation of the artefact's condition. This study furthermore indicates the possible use of marine oils, an approach that requires further research, but is seen as an important feature in assessing the artefact's condition and preservation prospects.

The management and handling of artefacts which originate from indigenous cultures is important, not only for preservation purposes, but also with regards to the artefact's role as sources of traditional knowledge. In Clavir (2002) the concept of preservation in a museum setting is widened to encompass, not only the physical preservation of the material artefact, but also indigenous cultures' rights to partake in decisions relating to how artefacts should be handled and maintained. The analyses of skin material artefacts from Eurasian indigenous cultures, covers a rich and varied set of materials, substances, and methods, signifying that preventive and interventive preservation methods chosen for these artefact types must ensure that the artefact's inherent information is preserved.

SAMMENDRAG

Skinnberedning i Eurasiske reinsdyrkulturer – en komparativ studie av samiske og evenkiske metoder.

Konserveringsvitenskapelige perspektiver på nedbrytning og bevaring av museumssamlinger av skinn.

Innledning
Publiserte beretninger om skinnberedningsmetoder hos reinsdyrkulturer i nordeurasiske områder er få og generaliserende. Gudmund Hatt (Hatt, 1914) er et unntak og har gitt et viktig bidrag til forståelsen av de prosesser som gjennomføres i beredningen av ulike skinn- og pelsmaterialer i eurasiske kulturer. Tross dette er beskrivelsene begrenset og redegjør ikke for den tidsmessige og geografiske dynamikk som kan iakttas innenfor teknologi og materialbruk, spesielt i perioden fra 1914 fram til i dag. Beretninger om skinn- og pelsberedningsmetoder blant urfolk i Sibir er like generaliserende og mangelfullt beskrevet. Under intervjuene med samiske og evenkiske kvinner kom det fram en variasjon og fleksibilitet i skinnberedningsmetode og materialbruk som tilsier at metodene ikke er avhengig av en bestemt substans og en bestemt prosess – men av valg innenfor mer eller mindre tradisjonsbestemte grupper av substanser og metoder. Metodene er dynamiske, de varierer med tid og sted og er blant annet avhengig av tilgjengelige naturressurser, tillært metode og lokal tradisjon.

Bevaring av kunnskap
Det skjer i dag en sentralisering av tradisjonell kunnskap til et færre antall personer. Kunnskapen ligger nå i stor grad hos den eldre generasjon og det er ikke lenger en selvfølge at denne overføres til den yngre generasjon. Dette har konsekvenser for utviklingen av beredningsteknologien og ikke minst for diversiteten i beredningsteknologien.

En av de endringer som har skjedd i de siste generasjoner er at drakten og/eller draktelementene benyttes i større grad som identitetsfremmende elementer enn som hverdagstøy. Nasjonaldager, festivaler og høytider er blant andre typiske dager/perioder hvor draktene brukes. Likevel er det innenfor det arktiske og subarktiske område naturgitte forhold, hvor man kan tenke seg at teknologien likevel ikke vil forsvinne helt. Når temperaturen synker er det fortsatt reinsdyrets pels som kan gi den beste beskyttelse mot kulden.

Intervju med tradisjonsbærere i Norge og Russland
Prosjektet tar utgangspunkt i nordsamisk område i Norge med komparative studier i russisk område, blant Evenkene i midt og nordøst Sibir. I Finnmark har Samiid Vuorká-Dávvirat/De Samiske Samlinger (SVD/DSS) formidlet kontakt til informanter og i Sibir benyttes etablerte kontakter ved universitetene i Chita og Irkutsk og ved vitenskapsakademiet i Yakutsk. Feltstudiene baserer seg på intervjuer, lydbåndopptak, fotografisk dokumentasjon og gjennom deltagele og observasjon, i perioden 1998 til 2004.

Tradisjonsbærere som ble intervjuet i Finnmark er: Inga Guttorm, Karen Marie Somby, Maret M. Somby Anti og Petter N. Anti, Marit Berit Bær, Nils Nilsen Eira og Anne Kirsten Kemi Eira, Lilly Guttorm, Ellen Marie Gaup Hætta, Karen Marie Eira Buljo, Marit Ragnhild Mikkelsdtr Buljo, Risten Marja M. Buljo, Ellen Sara M. Sara, og Ellen Kristine Buljo Sara. To tradisjonsbærere valgte å være anonyme.

I det nordlige Sakha (Yakutia) ble intervjuene gjennomført i 2001 og i 2004. Til sammen 12 kvinner ble intervjuet: Afanasievna Kristina Benchik, Kristoforova Fedosia Prokofjevna, Matvejevna Kristina Kirillovna, Konstantinova Rosalia Prokopievna, Stepanova Valentina Vasilievna, Egerova Maria Ivanovna, Tomskaya Rosalia Ivanovna, Semekova Varvara Kristoforovna, og Kombagir Ludmila Afanasievna, som alle bor i Kharyyalach i det nordlige Sakha. Intervjuer ble også gjennomført med Ambrosieva Vera Aleksandrovna som bor i Olenek og Afanasieva Tatyana Kambagir og Nikolaeve Maria Vladimirovna som bor på boplasser nord for Kharyyalach.

I Transbaikal fant intervjuene sted i 1998, 1999 og i 2000 og 8 personer er intervjuet: Malchakitova Ludmila Vasilievna, Aleksandra Ivanovna, Gabisheva Anna

Mikhailovna og Praskovia Innokentievna, alle fra Chapo Ologo i det nordlige Transbaikal. I Sredniy Kalar ble Kirillova Janna Iosifovna, Kirillova Ekaterina Innokentievna og Romanova Vera Dmitrievna intervjuet. Kuzmina Julia Anatolievna ble intervjuet og bodde på det tidspunkt (i 2000) på en boplass ved Nichatkasjøen, hun bor nå i Chapo Ologo.

Under noen av intervjuene ble det samlet inn referanseprøver på de tre materialtypene, avhåret skinn (DS), helt skinn hvor hårene er bevart (SWH) og leggskinn (skankeskinn) (LS). Det ble også samlet inn prøver på ulike garvestoffer.

Det ble videre gjennomført studier av tilsammen 187 gjentander fra 9 ulike museer i Finland, Russland og Norge. Det ble gitt tillatelse til å ta ut 82 prøver fra historiske gjenstander for videre studier og for de ulike analyser. Prøvene er tatt ut i samråd med museets ansatte, eller av de ansatte på museene, og kan kun gi et bilde på gjenstandens tilstand eller egenskaper på et avgrenset område.

Studier av museums samlinger er gjennomfør ved følgende museer:

Sámiid Vuorká-Dávvirat (SVD/DSS), Karasjok, Norge. Forkortelse: SVD.

Tromsø Museum, Universitetet i Tromsø, Norge. Forkortelse: TM.

Norsk Folkemuseum, Oslo, Norge. Forkortelse: NFSA.

Museum of Cultural History, University of Oslo, Norge. Forkortelse: KHM

Museum of Cultures, National Museum of Finland, Helsinki, Finland. Forkortelse: VK.

The Russian State Museum of Ethnography, St. Petersburg, Russia. Forkortelse: REM.

Peter the Great's Museum of Anthropology and Ethnography (Kunstkammer), St. Petersburg, Russland. Forkortelse: MAE.

The Irkutsk Museum of Regional Studies, Irkutsk, Russlannd. Forkortelse: IMRS.

University of Cambridge Museum of Archaeology and Anthropology, Cambridge University, Cambridge, Storbritania. Forkortelse: CUMAA.

Bevaring av av gjenstader

Et vesentlig element i fremtidig bevaring av skinn gjenstander og samlinger er kunnskapen om hvilke materialer og metoder som er anvendt på de aktuelle gjenstander på det aktuelle tidspunkt. Likeledes er det viktig å undersøke hvordan de benyttede beredningsmetoder påvirker gjenstandsmaterialet i bevaringssammenheng. Prosjektet klassifiserer observerbare karakteristika i forhold til metode/prosess gjennom visuelle/mikroskopiske metoder og gjennom ulike analyser. De anvendte analysemetoder er gasskromatografi med massespektrometri (GC-MS) og væskekromatografi (HPLC) samt måling av collagenfiberens hydrotermisk stabilitet (MHT) og pH. Resultatene fra de ulike analysene vurderes i forhold til beredningsmetodene og deres innvirkning på tilstand og nedbrytningsforløpet for gjenstandsmaterialet.

Samisk og evenkisk skinnberedningsteknologi - komparativ studie

Tekst, referanser og illustrasjoner i kapittel 3

Den komparative analysen viser at skinnberedningsteknologien kan inndeles både etter kultur men også etter materialtype, DS, SWH og LS. Forskjellene i samisk og evenkisk skinnberedningsteknologi ligger ikke i selve prinsippene for skinnberedning, men i detaljer innenfor beredningsteknologien. Hovedtrekkene i skinnberedning er, under slakteprosessen, å fjerne skinnet slik at hele skinnet, inkludert leggskinn (skankeskinn) og hodeskinn bevares, å unngå sol på kjøttsiden under slakting samt at skinnene raskest mulig tørkes, for å forhindre forråtnelse. Under de ulike trinn i den videre prosess, etter at tørkingen er gjennomført, er det viktig at skinnet strekkes og bearbeides mekanisk, både for å innarbeide og fordele garvestoffer men også for å mykgjøre skinnene. Fleksibiliteten i skinnberedningsteknologien tillater at nye substanser benyttes om de tidligere foretrukne substanser ikke lenger er tilgjengelige. Det å gi skinnet vannavvisende egenskaper er også et generelt trekk i skinnberedning, selv om denne egenskapen i dag er mindre viktig enn tidligere.

Hovedforskjellen i samiske og evenkisk skinnberedningsteknologi ligger i metoden for avhåring, bruken av garvestoffer/substanser og i bruken av verktøy. Innenfor den samiske kultur fjernes hårene ved kontrollert forråtnelse, det vil si at man starter en forråtnelsesprosess, som gjør at hårene løsner i hårsekken. Denne prosessen avbrytes når hårene er løse og enkelt kan fjernes fra skinnets overflate. Dette gir et skinn hvor narven er intakt. Innenfor den evenkiske kultur, fjernes hårene mekanisk. Ved hjelp av en skarp kniv skjæres hårene av (skjæres med hårene) og de resterende hår og rester av epidermis (overhuden) fjernes ved skraping med en forholdsvis skarp skinnskrape. Dette gir en semsket overflate, uten full narv og med rester av hårsekker og hår i den øverste del av huden (dermis).

En annen viktig forskjell ligger i om skinnet røykes eller ikke. Innenfor den evenkiske kultur røykes de fleste skinn, både skinn hvor hårene er bevart og avhårede skinn. Røykeprosessen gir farge til skinnet, men ennå viktigere, den gir vannavvisende egenskaper til skinnet. I dag røykes skinnene mest for fargen sin del, siden vannavvisende materialer kan erhverves i de lokale butikker. Innenfor den samiske kultur brukes ikke røyking som en del av skinnberedningsprosessen. Vannavvisende egenskaper oppnås her ved å behandle skinnets overflate (avhårede skinn) med fettstoffer og tidligere spesielt ved å påføre en blanding av fiskeleverolje og tretjære.

En annen forskjell mellom samisk og evenkisk skinnberedning ligger i bruken av vegetabilske garvestoffer. Innenfor den samiske kultur er bruken av vegetabilske garvestoffer bred, og både olderbark, innerbark av bjørk og særlig seljebark benyttes. De ulike garvestoffer kan tilføre skinnet ulike egenskaper, alt etter hvilke egenskaper man ønsker å oppnå. Innenfor den evenkiske kultur benyttes tørt brunråte angrepet lerketre og også olderbark i en farging eller overflategarving av skinnet. Den evenkiske beredningsteknologi kan videre karakteriseres ved tilføring av ulike fettstoffer og ved at skinnene røykes.

Resultatene fra analysen viser at skinnberedningsmetodene kan deles i to hovedgrupper, en hvor vegetabilske garvestoffer benyttes og en hvor fettstoffer er hovedsubstansen som tilføres i garveprosessen. Undergrupper kan ses for begge grupper. Innenfor den samiske kulturen behandles de tre materialtyper ulikt: avhåret skinn (DS) garves som oftest med vegetabilske garvestoffer. Leggskinn (LS) behandles også med vegetabilske garvestoffer, men kun på overflaten. Dette fører til at det dannes en rårand i skinnet, som fungerer som en fuktsperre i skinnet, men som også gjør at skinnet blir sterkere. Helt skinn hvor hårene er bevart (SWH) behandles hovedsaklig med fettstoffer.

Innenfor den evenkiske kultur benyttes så og si den samme metode for all tre materialtyper. Skinnet kan overflatebehandles med vegetabilske garvestoffer, men den virksomme substansen som benyttes er hovedsaklig ulike fettstoffer. I tillegg røykes skinnet.

Visuell karakterisering og identifikasjon av metode og tilstand
Tekst, referanser og illustrasjoner kapittel 4
Den visuelle analysen av skinnberedningsmetode og gjenstandens tilstand bygger på beskrivelser av karakteristiske og identifiserbare trekk som kan observeres på gjenstand og på skinnets overflate. Dette inkluderer karakteristika for reinsdyrets pels, så som sesongforandringer i farge, tetthet og tykkelse i hår, indikasjoner på alder og på tilstedeværelse av merker i skinnet (for eksempel arrvev fra bremselarvens pustehull). Videre bygger den visuelle analysen på indikatorer på før-garvings prosesser, så som skader fra slakteprosess og på karakteristika som illustrerer garveprosessene og verktøy som er benyttet, fra tørking, avhåring og bruk av garvestoffer. Dette beskrives blant annet ved hjelp av illustrasjoner på verktøyspor, farge, oppsprekking i epidermis og jevnhet i farge. Beskrivelene av gjenstandens tilstand kan illustreres ved observasjoner av fysiske skader, så som for eksempel mugg og insektangrep, rifter og hull, og spor etter slitasje og munner ut i en generell vurdering av tilstanden for de 187 gjenstander som er vurdert. Vuderingen antyder at det evenkiske gjenstandsmaterialet generelt sett er i bedre stand enn det samiske gjenstandsmateiralet. Denne vurdering forventes modifisert når resultatet fra de kjemiske og termiske analyser foreligger.

Karakterisering av vegetabilske garvestoffer og fettstoffer.
Tekst, referanser og illustrasjoner kapittel 5.
De vegetabilske garvestoffene som er benyttet i den samiske og evenkiske skinnberedningsteknologi består av såkalte kondenserbare garvestoffer. Disse karakteriseres ved deres evne til å produsere fargede løsninger og/eller felle ut som phlobaphener eller 'tannin reds', et reaksjonsprodukt av en kondensasjon med mineralske syrer og ofte i sammenheng med en oksidasjon. Dette gir seg utslag som en rødbrun farge i skinnmaterialer og er karakteristisk for nedbrytningsfenomenet man kaller 'red rot'. Skinn garvet med kondenserbare garvestoffer har også en tendens til å bli mørkere over tid, spesielt ved lyseksponering. Garvestoffer i prøvematerialet er karakterisert ved hjelp av væskekromatografi (HPLC) ved CRCDG i Paris og viser at avhåret skinn (DS) fra den samiske kultur er det eneste skinnmaterialet man kan kalle et vegetabilsk garvet skinn. Leggskinn er overflategarvet og kan defineres som et skinn som både består av garvede og ugarvede kollagenfibere.

Garvestoffer nedbrytes over tid, og kan observeres gjennom dannelsen av garvestoffmonomere, som kan ses i spektrogrammene fra garvestoffanalysen. Tilstedeværelsen av garvestoffmonomere viser at også de evenkiske prøvene inneholder garvestoffer, men i svært små mengder. Dette bekrefter at vegetabilske garvestoffer ikke er hovedsubstansen i den evenkiske skinnberedningsteknologien.

Et utall av fettstoffer benyttes i beredning av skinn. I den samiske beredningsteknologien benyttes fett både fra landdyr og fra marine dyr. Fiskeleverolje ble brukt helt fram til idag, men siden 1950-tallet er den ofte brukt sammen med surmelk eller den er utelatt. I de senere år er tilgangen på kommersielle produkter tilgjengelige også for beredning av skinn. Dette er blandinger av fett, eller emulsjoner som ofte selges fra garverier til lokale forhandlere, og kan være blandinger av både naturlige og syntetiske fett.

I den evenkiske beredningsteknologien benyttes hovedsaklig fett fra landdyr, selv om historisk kilder også nevner fett fra marine dyr. Fett deles ofte i to kategorier, fett som inneholder større eller mindre mengder enumettede (MUFA) og flerumettede (PUFA) fettsyrer og fett som hovedsaklig består av mettede (SFA) fettsyrer. Flerumettede fettsyrer nedbrytes raskere gjennom oksidasjon enn enumettede fettsyrer, mens mettede fettsyrer er noe mer stabile. Gjennom en aldringsprosess vil relasjonen mellom umettede (UFA) og mettede fettsyrer endres (UFA/SFA forhold). Dette gjør at analyser av fettsyresammensetning i prøver som er naturlig aldret, vanskelig kan relateres til den fettsubstans som er benyttet i utgangspunktet. I et forsøk på å karakterisere fettstoffene som i dag er tilstede i prøvematerialet ble fettsyresammensetningen analysert. Dette ble gjennomført ved hjelp av gasskromatografi med massespektrometri ved Nasjonalmuseet i København. Resultatene viser, ikke overaskende, at fettsyresammensetningen hovedsaklig i dag består av mettede fettsyrer, men analysene viser også at enumettede fettsyrer og noen flerumettede fettsyrer er til stede. Ved å se på forholdet mellom igjenværende rester av fettsyrer som er karakteristiske for torskeleverolje, så som docosensyre (C22 isomere) og eicosensyre (C20:1), og på forholdet mellom disse, C22/C20 forholdet, kan det antydes at fett fra fiskeolje har vært benyttet i deler av det samiske prøvematerialet. Dette kan ikke observeres i det evenkiske prøvematerialet. I det evenkiske prøvematerialet antydes det derfor at lipider brukt i skinnberedning hovedsaklig består av fett fra landdyr.

Visuell fibervurdering og analyse av kollagenfiberens hydrotermiske stabilitet
Tekst, referanser og illustrasjoner kapittel 6

En vurdering av kollagenfiberens utseende og egenskaper kan gi informasjon både om hvilke garvestoffer som har vært benyttet men ikke minst kan den gi informasjon om fiberens og skinnets tilstand. En vurdering av fiberens egenskaper kan utføres umiddelbart forut for en analyse av fiberens stabilitet (måling av krympingstemperaturen, Ts). I fiberanalysen undersøkes fiberens sammenhengskraft, fiberens evne til å absorbere vann, fiberens lengde, farge, tykkelse, fleksibilitet og karakteristika knyttet til garvestoffer, for eksempel, om det kan observeres substanser på eller omkring fiberen, når den i vann og under mikroskop, observeres i en 40 til 100 gangers forstørrelse. Resultatene fra fibervurderingen viser at fiberens sammenhengskraft og evne til å absorbere vann henger sammen og videre at dette også, til en viss grad, kan knyttes til fiberens lengde, tykkelse og fleksibilitet. Resultatene viser også at resultatene kan knyttes til de ulike beredningsmetodene som er skissert og til en viss grad også til målinger av krympingstemperaturen for prøven.

Krympingstemperaturen (Ts) måles umiddelbart etter fibervurderingen og gir en mer detaljert kunnskap om fiberens egenskaper og tilstand, og kan på samme tid gi indikasjoner på garvestoffer som er benyttet i den aktuelle fiberprøve. Hovedkrympingsintervallets start, Ts, regnes som skinnets krympingstemperatur. I Sykes (1991:10) (kap 6.3) gis det en oversikt som indikerer innenfor hvilke temperaturområder man kan forvente at en fiber krymper, ut fra hvilke garvemetode som er benyttet. Disse verdiene gjelder nygarvet skinn. Når et skinnmateriale nedbrytes synker krympingstemperaturen og de ulike krympingsintervaller endres. Dette observeres i en 40 gangers forstørrelse, mens den finfordelte prøven langsomt oppvarmes i vann. Resultater fra måling av krympingstemperaturen viser at manuelt vegetabilsk garvet skinn (med kondenserbare garvestoffer) kan ha ulike krympingstemperaturer innenfor det samme skinn, en variasjon på mellom 3-8 oC. De samme resultater viser også at krympingstemperaturen er lavere enn det temperaturområdet som antydes, selv for et nygarvet skinn. Resultatene viser også at selv om det evenkiske prøvematerialet er overflategarvet med brunråteangrepet lerketre, gir ikke dette seg utslag i målinger av krympingstemperaturen, ihvertfall ikke i vesentlig grad. Dette er vurdert gjennom målinger på refereranseprøver som ikke er nedbrutt. I bevaringsøyemed, er den første krympingsaktiviteten som kan observeres, Tfirst, ofte like interessant som hovedintervallets starttemperatur (Ts). Tfirst vil ha betydning for de behandlingsmetoder som kan anvendes, og på hvordan gjenstandene bør oppbevares. Et langt temperaturspenn mellom Tfirst og Ts, kan bety ujevn nedbrytning av kollagenfibrene. Etterhvert som fiberenes nedbrytningsgrad utjevnes, vil dette spennet reduseres. I det gjenstandsmaterialet som er vurdert, viser det seg at de avhårede skinnmaterialene har flest prøver

innenfor de lange initierende intervaller, og at den første krympingsaktiviteten kan observeres helt ned til 35-39 oC. Det best bevarte gjenstandsmaterialet er leggskinn fra den samiske kultur, som kun er overflate garvet, og hvor man i krympingsforløpet kan observere både garvede og ugarvede fibere. Generelt sett er tilstanden for det totale gjenstandsmaterialet, om man ser på krympingtemperaturen alene, fra lett til middels nedbrutt, men da med enkeltgjenstander som er mer eller som er mindre nedbrutt.

Relasjonen mellom visuelle og kjemiske analyser

Tekst, referanser og illustrasjoner i kapittel 7.

Relasjonen mellom de visuelle og de kjemiske og termiske analyser viser at for de mest nedbrutte og for de best bevarte gjenstandene er det en sammenheng mellom resultatene. I de mellomliggende tilstander, er denne relasjonen mindre synlig. Resultatene viser også at materialtypene som hovedsaklig er garvet med fettstoffer, gir et mer ensartet nedbrytningsmønster, og at de avhårede materialtyper (DS) skiller seg ut. DS viser et større spenn i tilstand, med en større andel gjenstander hvor tilstanden er mindre god. Igjen skiller den samiske materialtype LS seg ut som et mer robust materiale hvor tilstanden er jevnt god.

Disse resultatene kan ha flere årsaker.

At det samiske avhårede skinnmateiralet generelt viser større variasjon kan også ha noe med de vegetabilske garvestoffene å gjøre. Nedbrytningen av kollagenmaterialer skjer også via de vegetabilske garvestoffene, og kondenserbare garvestoffer har en spesiell affinitet for for eksempel adsorpsjon av svoveldioksyd. Dette kan føre til en forsuring av skinnet og en mulig utvikling av 'red rot', ofte i sammenheng med en oksidasjon, og hvor peptidkjedene splittes. Det er også i denne materialgruppen man finner gjenstander med en pH under 4.

Skinnmaterialer som hovedsaklig er garvet med lipider er også utsatt for en nedbrytning via garvestoffet, fett. Lipider med høye andeler av flerumettede fettsyrer vil oksidere raskere enn fett som inneholder mindre mengder flerumettetde fettsyrer. Torskeleverolje, som er benyttet i skinnberedning, ihvertfall i den samiske kultur, inneholder større mengder flerumettede fettsyrer som raskt vil nedbrytes. Dette kan kan føre til gulnede, klebrige overflater, og et stivere skinn. Resultatene av de visuelle observasjonene viser at gjenstandsmaterialer garvet med lipider også kan falme. Dette er beskrevet i litteraturen for indutriell fettgarving. I det samiske materialet er dette ikke observert, mens det i det evenkiske gjenstandsmaterialet er tydelig på en rekke gjenstander.

Bevaring av gjenstander fra den samiske og evenkiske kultur

Ved en vurdering av tilstanden for skinnmaterialer må det legges like stor vekt på resultater fra de visuelle analyser som på resultater fra de kjemiske og termiske analyser. Fysisk skade er et tegn på at materialet er skjørt, en skjørhet som kan ha utviklet seg fra en kjemisk ustabilitet. For eksemel, den oksidative effekten av lys, varme og andre oksidative stoffer influerer både på de vegetabilske garvestoffer og lipidene, men også kollagenet, hvor aminosyresammensetningen endres. Dette kan føre til en lavere B/A verdi, en svekkelse av kollagenfiberen og dermed gjenstandens materiale.

Det er en rekke tiltak som kan iverksettes for å forsinke en videre nedbrytning. Dette kan skje ved å:

Redusere lys- og varmepåvirkning, spesielt i det utraviolette området, men også i det synlige lysområdet.

Holde en stabil relativ luftfuktighet (RH) og unngå raske svingninger i luftfuktigheten.

Unngå raske temperatursvingninger og holde temperaturen lav.

Redusere påvirkningen fra forurensning, ved filtrering av inngående luft, for eksempel ved bruk av aktive kullfilter. Gjennomføre lokal reduksjon av forurensning gjennom bruk av filtere og såkalte 'scavengers' (fjernere).

Redusere fysiske skader ved å sørge for at gjenstanden håndteres, støttes og magasineres etter de behov gjenstanden har.

Innarbeide gode rutiner for kontroll av gjenstandene, både i form av tilsyn og periodiske tilstandsvurderinger, og ikke minst i forbindelse med skadedyr og insekter (IPM-system).

Gjenstander som ikke er i aktiv bruk, bør ikke utsettes for inngrep som påvirker gjenstandens sammensetning. Aktive inngrep bør i først omgang kun tillates i tilfeller hvor fysiske skader truer gjenstandens videre bevaring.

Denne studien utgjør en begynnelse for en forståelse av individuelt tilvirkede skinn og pels gjenstander fra urfolk i det nordeurasiske området, og for forståelsen av de prosesser som påvirker og styrer gjenstandens tilstand. Kombinasjonen av tradisjonell kunnskap, materialkunnskap og naturvitenskapelige analyser, gir oss en enestående mulighet til å håndterer samlinger og gjenstander på en måte som ikke bare kommer gjen-

standene til gode, men også synliggjør den komplekse og omfattende kunnskapen som ligger bak fremstillingen av materialer og gjenstander. I Clavir (2002) utvides bevaringsbegrepet til å omfatte ikke bare det museale konsept å bevare gjenstander for fremtiden – men til også å inkludere urfolks rett til å delta og ha tilgang til museumsmaterialer/gjenstander/prosesser i en videreføring av levende tradisjoner. Dette er en utfording for konservatorer og museumsansatte og krever en fleksibilitet i tilnærmingen og håndteringen av denne gjenstandsgruppen.

DEFINITIONS AND ABBREVIATIONS

Definitions

Alum: potassium aluminium sulphate, $KAl(SO_4)_2 \bullet 12H_2O$ (Wikipedia, 2006).

Burning the skin: This term is used in the Sámi culture and the Evenk culture translation. There does not seem to be a Norwegian or English word which can be used for this phenomenon. It is used in describing damage that occurs if excessive heat is applied to skin material during drying or smoking, for example in strong sun. It also may mean that the skin has been damaged due to blood spill on the skin.

Chamois tannage: see oil tannage

Combination tannage: Tannage with two or more tanning agents of different types usually applied separately in succession (IULTCS Glossary).

Depilated skin: Skin where the hairs have been removed

End scraper: scraping device placed at the end of a handle.

Fat liquoring: Introduce oil into leather, normally by drumming it with an oil-in-water emulsion, to provide lubrication to the leather. (IULTCS Glossary).

Fur: The whole of the hair coat of various animals used for making furs, such as of foxes, beavers, mink, etc.

Full grain: Leather bearing the original grain surface as exposed by removal of the epidermis and with none of the surface removed by buffing, snuffing or splitting (IULTCS Glossary).

Grain: Outer surface pattern of a hide or skin which includes the hair follicles and pores just beneath the thin layer of epidermis. During the unhairing process the epidermis is removed and the underlayer becomes the grain surface (IULTCS Glossary).

Hand stuffing: Application of grease by means of a pad or brush, to the surface of damp leather, spread upon a table. (IULTCS Glossary).

Lime (v); liming: Treatment of hides and skin, originally essentially with a lime solution, but today also with other alkalis, or alkalis together with reducing agents, in order to loosen, or destroy, the hair or wool, remove unwanted proteins, saponify fatty matter, open-up fibre structure, etc (IULTCS Glossary).

Oil tannage: Tannage by means of certain unsaturated fish or marine animal oils which, in contact with the pelt, undergo oxidation and other chemical changes, leading to irreversible fixation of various fatty derivatives. (IULTCS Glossary).

Raw streak: An untanned centre layer of leather, visible in cross section as a light – coloured streak, especially as applied to heavy leather (Thorstensen, 1976:287).

Reindeer calves in the Sámi area are born April or May. According to informants they are regarded as calves until they are one and a half years old.

Relax the skin: Relaxing the skin means letting it soak up humidity from the surroundings.

Semi-tanned leather: Leather which may not be sufficiently tanned to be satisfactory in use, though it may be stuck-through by the tanning agent, East India tanned sheep, goat skins, etc. (IULTCS Glossary).

Skin: Tissue forming the outer covering of the body (human and other animal bodies), tough and flexible (IULTCS Glossary). Used in this thesis as a general description of skin materials, with hair and without hair.

Splitting the skin: The operation of cutting a hide or skin horizontally into two or more layers. A grain and a flesh layer (IULTCS Glossary).

Suede: Generic term for leathers whose wearing surface, either grain or flesh side, has been finished to have a more or less fine, velvet-like nap, produced by abrasive action (IULTCS Glossary).

Sweat (v); sweating: Process for loosening the attachment of the hair or wool of hides or skins by maintaining them under such conditions of warmth and moisture that bacteria develop and attack the hair roots and lower epidermal layer action (IULTCS Glossary).

Tan (v); tanning: Treating prepared hides or skins with suitable chemicals to give a fibrous product, imputrescible when wet, more or less soft and flexible when dry and capable of being wetted and dried without loss of these

Two-handed scraper: Scraping device placed at the centre of a handle.

Tannin: General term for the active tanning principles contained in vegetable tanning materials (IULTCS Glossary).

Vegetable tannin: one of many extracts from plant material. Extracted from the bark, heart wood and sap wood of these plants. Tannins may also be extracted from leaves, fruits, galls and roots of plants, and their specific use is based on their properties as tannins

Abbreviations

ng: nanogram = one billionth (10-9) of a gram.
µg: microgram = 1000 nanogram
mg: milligram = 1000 microgram
g: gram = 1000 mg
kg: kilogram = 1000 g
µl: microliter
ml: milliliter

B/A: The relation between the basic and acidic amino acids is calculated as the B/A value = (Arg+Hyl+Lys)/(Asp+Glu)

BAM: Baikal Amur railroad
CLO: Cod liver oil
CRCDG: Centre de Recherches sur la Conservation des Documents Graphiques
CT: Condensed vegetable tannins
CUMAA: University of Cambridge Museum of Archaeology and Anthropology, Cambridge University, Cambridge, United Kingdom.
DS: Depilated skin
FA: Fatty acid
FM: Fermented milk
GC-MS: Gas Chromatography Mass Spectrometry
HCl: Hydrochloric acid
HPLC: High Performance Liquid Chromatography
HT: Hydrolysable vegetable tannins
IMRS: The Irkutsk Museum of Regional Studies, Irkutsk, Russia.
IPM: Integrated pest management
IPR: Intellectual property rights
KHM: Museum of Cultural History, University of Oslo, Norway.
LS: Leg skin
MAE: Peter the Great's Museum of Anthropology and Ethnography (Kunstkammer), St. Petersburg, Russia.
NaCl: Sodium chloride
NFSA: The Norwegian Museum of Cultural History, Oslo, Norway.
PCA: Protocatechuic acid
PAC: Proanthocyanidins
Psi: Pound force per square inch
RDL: Reindeer liver
Ref: Reference
REM: The Russian State Museum of Ethnography, St. Petersburg, Russia.
SVD: Sámiid Vuorká-Dávvirat (SVD/DSS), Karasjok, Norway.
SWH: Whole skin with hairs attached
TM: Tromsø Museum, University of Tromsø, Norway.
VK: Museum of Cultures, National Museum of Finland, Helsinki, Finland.

BIBLIOGRAPHY

Ackman, R. G., 1967. "Characteristics of fatty acid composition and biochemistry of some fresh-water fish oils and lipids in comparison with marine oils and lipids". *Comparative biochemistry and physiology*. Vol. 22, pp. 907-922.

Ackman, R. G. & Hooper, S. N., 1968. "Examination of isoprenoid fatty acids as distinguishing characteristics of specific marine oils with particular reference to whale oils". *Comparative biochemistry and physiology*. Vol. 24, pp. 549-565.

Aidos, I., Jacobsen, C., Jensen, B., Luten, J. B., Padt, van der, A., & Boom, R. M., 2002. "Volatile oxidation products formed in crude herring oil under accelerated oxidative conditions". *European journal of lipid science and technology*. Vol 104, pp. 808-818.

Antropova, V. V., 1964. "The Koryaks". In: *The peoples of Siberia*. Eds. M. G. Levin & L. P. Potapov. The University of Chicago Press, Chicago and London, pp. 851-876.

Antropova, V. V. & Kuznetsova, V. G., 1964. „The Chukchi". In: *The peoples of Siberia.* Eds. M. G. Levin & L. P. Potapov. The University of Chicago Press, Chicago and London, pp. 799-836.

Banfield, A. W. F., 1974. *The mammals of Canada*. University of Toronto Press, Toronto, 438 p.

Behrens, A., Maie, N., Knicker, H. & Kögel-Knabner, I., 2003. "MALDI-TOF mass spectrometry and PSD fragmentation as means for the analysis of condensed tannins in plant leaves and needles". *Phytochemistry.* Vol. 62, pp1159-1170.

Berg, J. M., Tymoczko, J. L., Stryer, L. & Clarke, N. D., 2002. *Biochemistry.* W. H. Freeman and Company. New York. Online: http://bcs.whfreeman.com/biochem5/. Reading date: 19.4.2007.

Berge, S., 1949. "Hår og hårlag hos rein". *Naturen.* Vol. 73, pp. 289-302.

Bogoras, W., 1909. *The Chukchee*. The Jesup North Pacific Expedition. Memoir of the American Museum of Natural History. Vol. 7. Ed. F. Boaz. G. E. Stechert & Co. New York, pp. 1-276.

Bohl, B. K. & Nikolajewsky, L.D. 1931. "Der Bau der Hautdecke des Rentieres und ihre jahreszeitlichen Veränderungen". *Zeitschrift für Mikroskopish-Anatomishe Forschung*. Vol. 25, pp. 1-29.

Borgos, J, 1993. "Tradisjonall Samisk kunnskap og forskning". In: Traditionell samisk kunskap och forskning. Ed. N. L. Lasko. *Diedut*. No. 5, pp. 7-21.

Bos, M. van, Wouters, J., Oostvogels, A., 1996. "Quantitative and Qualitative Determination of Extractable Fat from Vegetable Tanned Leather by GC-MS." In: *Environment leather project. Deterioration and conservation of vegetable tanned leather.* Protection and Conservation of the European Cultural Heritage, Ed. R. Larsen, EV5V-CT94-0514. Research Report no 6. Copenhagen, pp. 95-101.

Budge, S. M., Iverson, S. J., Bowen, W. D. & Ackman, R. G., 2002. "Among- and within-species variability in fatty acid signatures of marine fish and invertebrates on the Scotian Shelf, Georges Bank, and Southern Gulf of St. Lawrence". *Canadian journal of fisheries and aquatic sciences*. Vol. 59, pp. 886-898.

Buijs, C, 1997. "Ecology and the principles of polar clothing". In: *Braving the cold. Continuity and change in Arctic clothing*. Eds. C. Buijs & J. Oosten. Research School CNWS. Leiden, pp. 11-33.

Buren, J. P. van. & Robinson, W. B., 1969. "Formation of complexes between protein and tannic acid". *Journal of agricultural and food chemistry*. Vol 17, pp. 772-777.

Bush, R. J., [1871] 1970. "Reindeer, dogs and snow-shoes: A journal of Siberian travel and explorations made in the years 1865, 1866, and 1867". In: *Reindeer, dogs and snow-shoes*. Eds. H. Tupper & H. W. Nerhood. Arno Press & The New York Times. New York. 529 p.

Castrén, M. A., 1852. *Reseminnen. Från åren 1838-1844*. Helsingfors. 320 p.

Chambard, P., 1958. "Miscellaneous mineral tannages". In: *The chemistry and technology of leather.* Eds. F. O'Flaherty, W. T. Roddy & R. M. Lollar. Reinhold Publishing Corporation. New York. Vol 2, pp. 349-387.

Christie, W. W., 2006. "Gas chromatography and lipids". Chapter 2 – A: Definitions. *Lipid Library* © W.W. Christie and The Oily Press Ltd. Online: http://www.lipidlibrary.co.uk/gc_lip.html.

Clavir, M., 2002. *Preserving what is valued. Museums, conservation and first nations*.

UBC Museum of anthropology research publication. UBCPress. Vancouver. 295 p.

Cochran, P., 1997. *Traditional knowledge systems in the Arctic.* Bering Sea ecosystem, workshop report, Anchorage, Alaska, pp. 93-98.Online: http://www.nativescience.org/html/traditional_knowledge.html "What is traditional knowledge? When an elder dies, a library burns". Reading date: 27.5.2005.

Collinder, B., 1953. *Lapparna. En bok om samefolkets forntid och nutid.* Forum AB. Stockholm. 252 p.

Covington, A. D., Lampard, G. S. Hancock, R. A. & Ioannidis, I. A., 1998. "Studies on the origin of hydrothermal stability: A new theory of tanning". *Journal of the American leather chemists association*. Vol. 93, pp. 107-120.

Covington, A.D., 2006. "The chemistry of tanning materials". In: *Conservation of leather and related materials*. Eds. M. Kite & R. Thomson. Butterworth-Heinemann Series in Conservation and Museology. Amsterdam, pp. 22-35.

Debray, R. 1997. "*Transmitting culture*" Columbia University Press. New York. 157 p.

Delaporte, Y., 2004. *Le vêtement lapon. Formes, functions, evolution*. The Institute of Comparative Research in Human Culture. Oslo. Vol. 113. Peeters. Paris. 536 p.

Demant-Hatt, E., 1913. *Med lapperne i højfjeldet. Lapparne och deras land*. Skildringar och studier. II. A.-B. Nordiska Bokhandeln. Stockholm. 203 p.

DeMouthe, J. F., 2006. *Natural materials. Sources, properties, and uses*. Elsevier. Amsterdam. 204 p.

DeWitt, K. W., 1963. "Seasonal variations in cod liver oil". *Journal of the science of food and agriculture*. Vol. 14, pp. 92-98.

Dobell, P., [1830] 1970. "Travels in Kamtchatka and Siberia". Vol. 1 & 2. In: *Travels in Kamtchatka and Siberia*. Eds. H. Tupper, H. W. Nerhood. Arno Press & The New York Times. New York. 341 p.

Drake, S., 1918. *Västerbottenslapparna under förra hälften av 1800-talet*. Etnografiska Studier. Lapparne och deras land. Skildringar och studier. 7. Stockholm. Wahlström & Widstrand. 367 p.

Dunfjeld, M., 2003. "Samekofte som verdi". In: *Árvvut Árvo Vierhtie. Samiske verdier*. Ed. E. Hætta Eriksen, Verdikommisjonen. Davvi Girji OS. Karasjok, pp. 163-168.

Düben von, G., 1873. *Om Lappland och Lapparne, företrädesvis de svenske*. Ethnografiska Studier. P.A. Norstedt och Söners Förlag. 528 p.

Eira Buljo, K. M., 1997. Gáma-goarrun. Sámi oahpahusráđđi. Goaráhat. 80 p.

Erman, A., 1833. *Reise um die Erde durch Nord-Asien und die beiden Oceane in den Jahren 1828, 1829 und 1830 ausgeführt*. Historischer Bericht. 1833-1848. Bind 1. G. Reimer. Berlin. 747 p.

Erman, A., 1838. *Reise um die Erde durch Nord-Asien und die beiden Oceane in den Jahren 1828, 1829 und 1830 ausgeführt*. Historischer Bericht. 1833-1848. Bind 2. G. Reimer. Berlin.

Evershed, R. P., 1993. "Biomolecular Archaeology and Lipids". *World Archaeology*, Vol. 25, pp. 74-93.

Feller, R. L., 1994. *Accelerated aging. Photochemical and thermal aspects*. The Getty Conservation Institute. Ann Arbor. 275 p.

Fessas, D, Schiraldi, A. Tenni, R. Vitellaro Zuccarello, L. Bairati, A. & Facchini, A., 2000. "Calorimetric, biochemical and morphological investigations to validate a restoration method of fire injured ancient parchment". *Thermochimica acta*. Vol. 348, pp. 129 -137.

Fjellström, P., 1985. *Samernas samhälle i tradisjon och nutid*. P.A. Norstedt & Söners Förlag. Stockholm. 640 p.

Folstad, I., 1986. "Hudbrems hos rein". *Ottar*. Tidsskrift for nordnorsk natur og kultur. Vol. 161, No. 4, pp. 38-44.

Forbes, R. J., 1966. *Studies in ancient technology*. Vol 5. E. J. Brill. Leiden, pp. 1-79.

Fors, G. & Enoksen, R., 1991. *Vår folkedrakt. Sjøsamiske klestradisjoner*. Sámi Instituhtta, Davvi Girji o. s. 126 p.

Fors, G., 2004. *Selskinn som en mulig ressurs. Bruk av sel i Finnmark, Grønland og Island*. Master thesis. Finnmark University College, Alta, Norway. Unpublished. 108 p.

Frankel, E. N. 2005. *Lipid Oxidation*. The Oily Press, Bridgwater. 486 p.

Freudenberg, K. & Weinges, K., 1960. "Systematik und Nomenklatur der Flavanoide". *Tetrahedron*, Vol. 8. Pergamon Press Ltd, pp. 336-349.

Gansser, A., 1950. "The early history of tanning». *Ciba Review*. Vol. 81, pp. 2938-2962.

Georgi, J. G., 1775. *Bemerkungen einer Reise im Russischen Reich 1772 – 1774*. Vol. 1. Gedruckt bey der Kayserl. Academie der Wissenschaften. St. Petersburg. 506 p.

Giddens, A., 1994. "Living in a post-traditional society". In: *Reflexive modernization. Politics, tradition and aesthetics in the modern social order*. Eds. U. Beck, A. Giddens, & S. Lash. Polity Press. Oxford, pp. 56-109.

Giddens, A., 1999. "Runaway World: The Reith Lectures revisited". The Director's Lectures LSE. Lecture 3: 24 November 1999. London. Online: http://www.globalpolicy.org/globaliz/define/1999/1110giddens.pdf Reading date: 28.10.2005.

Gjessing, G. & Gjessing, G., 1940. *Lappedrakten. En skisse av dens opphav*. Institutt for Sammenlignende Kulturforskning. C IV – 2. H. Aschehoug & Co. Oslo. 86 p.

Glastrup, J., 1998. "Diazomethane preparation for gas chromatographic analysis". *Journal of chromatography A*. 827, pp. 133-136.

Grahl-Nielsen, O., Andersen, M., Derocher, A. E., Lydersen, C., Wiig, Ø. & Kovacs, K-M., 2003. "Fatty acid composition of the adipose tissue of polar bears and of their prey: ringed seals, bearded seals and harp seals". *Marine ecology progress series*. Vol. 265, pp. 275-282.

Grøn, O, & Kuznetsov, O, 2003."Ethno-archaeology among Evenkian forest hunters. Preliminary results and different approach to reality!" In: *Mesolithic on the move*. Eds. L. Larsson, H. Kindgren, K. Knutsson, D. Loeffler, A. Åkerlund. Papers presented at the Sixth International Conference on Mesolithic in Europe. Stockholm, pp. 216-221.

Guldbeck, P. E., 1969. "Leather: its understanding and care". *Technical leaflet 1. History News,* Vol, 24, American Association for State and Local history, 12 p.

Gunstone, F. D., Harwood, J. L., & Padley, F. B., Eds. 1994. *The lipid handbook*. Chapman & Hall, London. 722 p.

Gunstone, F. D., 2004. *The chemistry of oils and fats. Sources, composition, properties and uses.* Blackwell Publishing Ltd. Oxford. 288 p.

Gustavson, K. H., 1956. *The chemistry of tanning processes*. Academic Press. New York. 403 p.

Gaare, E., 1997. "Naturlige betingelser for reindrift". In: *Flora i reinbeiteland*. Eds. B. Ekendahl & K. Bye. Landbruksforlaget, pp. 7-18.

Hagerman, A. E. & Butler, L. G., 1978. "Protein precipitation method for the quantitative determination of tannins." *Journal of agricultural and food chemistry*. Vol. 26, pp. 809-812.

Haines, B., 1991. " Mineral, alum, aldehyde and oil tannage". In: *Leather. Its composition and changes with time*. Eds. C. Calnan, & B. Haines, The Leather Centre. Northampton. 90 p.

Hames, D. & Hooper, N., 2005. *Biochemistry*. Taylor & Francis. New York, 438 p.

Harborne, J. B., 1989. "Flavanoids". In: *Natural products of woody plants I. Chemical extraneous to the lignocellulosic cell wall.* Ed: J. W. Rowe. Springer Verlag. Berlin, pp. 533-570.

Haslam, E., 1966. *Chemistry of vegetable tannins*. Academic Press. London. 179 p.

Haslam, E., 1989. "Gallic acid derivatives and hydrolysable tannins". In: *Natural products of woody plants I. Chemical extraneous to the lignocellulosic cell wall.* Ed: J. W. Rowe. Springer Verlag. Berlin, pp. 399-438.

Haslam, E., & Cai, Y., 1994. "Plant polyphenols (vegetable tannins): Gallic acid metabolism". *Natural products report*. Vol. 1, pp. 41-66.

Hatt, G., 1914. *Arktiske skinddragter i Eurasien og Amerika*. J. H. Schultz Forlagsboghandel. København. 255 p.

Helander, E., 1996. "Sustainability in the Sámi era: the x-file factor". In: Awakened Voice. The return of Sámi Knowledge. Ed. E. Helander. *Dieđut*. No 4, pp. 1-6.

Hemingway, R.W., 1989. "Structural variation in proanthocyanidins and their derivatives". In: *Chemistry and significance of condensed tannins*. Eds. R. W. Hemingway & J. J. Karchesy. Plenum Press. New York, pp. 83-107.

Hernes, P. J. & Hedges, J. I., 2004. "Tannin signatures of barks, needles, leaves, cones and wood at the molecular level." *Geochimica et cosmochimica acta*, Vol. 68, pp. 1293-1307.

Hilditch, T. P., & Williams, P. N., 1964. *The chemical constitution of natural fats.* Chapman & Hall. London. 745 p.

Hobson, G, 1992. "Traditional Knowledge is Science". *Northern Perspectives*. Vol. 20. Online: http://www.carc.org/pubs/v20no1/science.htm Reading date: 28.12.2005.

Hobsbawm, E., 1983. "Introduction: Inventing traditions". In: *The invention of tradition*. Eds. E. Hobsbawm & T. Ranger. Cambridge University Press. Cambridge. pp. 1-15.

Holmes, T, Ed. 2003. "Trends, Friends and Enemies...– An Overview of the Boreal Forest". *Taiga rescue network*. Online:: www.taigarescue.org.

Howes, F. N., 1953. *Vegetable tanning materials.* Butterworths Scientific Publications. London. 325 p.

Hua, L. & Haslam, E., 1992. "Vegetable tannins and durability of leathers.". In: *Conservation of leathercraft and related objects interim symposium*. Eds. P. Hallebeek, M, Kite, & C. Calnan. Victoria and Albert Museum. London, pp. 24-27.

Humphreys, A and Mits, K, Eds., 1993. *The red book of the peoples of the Russian empire*. Online: http://www.eki.ee/books/redbook/. Reading date: 12.7.2005.

Hætta, I. H., 1993. *Sisti.* Master thesis. Statens Lærerhøgskole i forming, Oslo. Unpublished. 229 p.

Hætta, O. M. 2002. *Samene. Nordkalottens urfolk.* Norwegian Academic Press. Oslo. 260 p.

Høiris, O., 1988. "Kulturbegrepet i antropologien". In: *Kulturbegrepets kulturhistorie*. Eds. H. Hauge & H. Horstbøll. Aarhus Universitetsforlag. Aarhus, pp. 95-120.

Innis, S. M. & Kuhnlein, H. V., 1987. "The fatty acid composition of Northern-Canadian marine and terrestrial mammals". *Acta medica scandinavica*. Vol. 222, pp. 105-109.

Issenman, B. K., 1997. "*Sinews of survival. The living legacy of Inuit clothing*". UBCPress and Études/Inuit/Studies. Vancouver. 274 p.

Josefsen, T. D., Åsbakk, K & Oksanen, A., 2006. "Parasitter og sjukdom hos rein". *Ottar.* Tidsskrift for nordnorsk natur og kultur. Vol. 263, No. 5, pp. 30-38.

Julkunen-Tiitto, R, 1985. "Phenolic constituents in the leaves of northern willows: Method for the analysis of certain phenolics". *Journal of Agricultural and Food Chemistry*. Vol. 33, pp. 213-217.

Kamenskaya, I. J, Karpuchina, M. N., Matvejeva, E. E., Sarvas, N. N. & Smurova, N. V., Eds., 1997. *Atlas ,Geografia Russia.* Roskartografia. Moskva. 164 p.

Kanner, J. & Rosenthal, I., 1992. "An assessment of lipid oxidation in foods". *Technical report. International union of pure and applied chemistry*. IUPAC. Vol. 64, pp. 1959-1964.

Kaplan, H., 1971. *Furskin processing.* Pergamon Press. Oxford. 231 p.

Kawamoto, H & Nakatsubo, F., 1997. "Effects of environmental factors on two-stage tannin-protein co-precipitation." *Phytochemistry.* Vol. 46, pp. 479-483.

Kay, A. N., 1958. "The process of vegetable tannage". In: *The chemistry and technology of leather*. Eds. F. O'Flaherty, W. T. Roddy & R. M. Lollar. Reinhold Publishing Corporation. New York. Vol. 2, pp. 161-200.

Kelsey, R. G., & Harmon, M. E., 1989. "Total extractable phenols and tannins in the tissues of 1 year old conifer logs". *Canadian Journal of Forest Research.* Vol. 19, pp. 1030–1036.

Khanbabaee, K., & Ree, T. van, 2001. "Tannins: Classification and definition." *Natural products report.* Vol. 18, pp. 641-649.

Kirsch, P. E., Iverson, S. J., Bowen, W. D., Kerr, S. R., & Ackman, R. G., 1998. "Dietary effects on the fatty acid signature of whole Atlantic cod (Gadus *morhua*)". *Canadian journal of fisheries and aquatic sciences.* Vol. 55, pp. 1376-1386.

Klokkernes, T., 1994. *Caribou-pels. En undersøkelse av caribou-pels fra Roald Amundsens samling, Gjoaekspedisjonen.* The Royal Danish Academy of Fine Arts, School of Conservation.. Master thesis. Unpublished. 118 p.

Klokkernes, T., & Sharma, N., 2005. "The Roald Amundsen collection. The impact of a

skin preparation method on preservation". In: *Arctic clothing of North America-Alaska,*

Canada, Greenland. Eds: J. C. H. King, B. Pauksztat, & R. Storrie. London: The British Museum Press, pp. 91-94.

Krasheninnikov, S. P., [1735-1741], 1972. *Explorations of Kamchatka*. Translation, introduction and notes by: E. A. P. Crownhart-Vaughan. North Pacific Studies Vol. 1. Oregon Historical Society. Portland. 375 p.

Kronick, P. L., 1996. "Destabilization of collagen hide and leather by anionic surfactants. I. Differential scanning calorimetry of complexes with sulphates". *Journal of the American leather chemists association*. Vol. 91, pp. 246-251.

Kuntzel, A., 1958. "Oil tanning and sulfonylchloride tanning". In: *The chemistry and technology of leather* Eds. F. O'Flaherty, W. T. Roddy & R. M. Lollar. Reinhold Publishing Corporation. New York. Vol 2, pp. 426-454.

Labba, S., 2005. "Renens betydelse för slöjden". Lecture at Jokkmokk Winter market, 3.2.2005. Ájtte. Jokkmokk, Sweden.

Larsen, R., 1992. «The STEP Leather Project Background and First Results.» I: Conservation of Leathercraft and Related Objects Interim Symposium. Eds. Hallebeek, P., Kite, M., Calnan, C. Victoria & Albert Museum. London. 24 & 25 June 1992. ICOM Committee for Conservation.

Larsen, R., Vest, M. & Nielsen, K., 1993. "Determination of hydrothermal stability (shrinkage temperature) of historical leathers by the micro hot table technique". *Journal of the society of leather technologists and chemists.* 77, pp. 151 - 156.

Larsen, R., Vest, M., Poulsen, D. V., Kejser, U. B. & Jensen, A. L., 1994a. "Amino acid analysis". In: STEP Leather Project. Evaluation of the correlation between natural and artificial ageing of vegetable tanned leather and determination of parameters for standardization of an artificial ageing method. Ed. R. Larsen. The Royal Danish Academy of Fine Arts, School of Conservation. Copenhagen, pp. 39-57.

Larsen, R., Vest, M. & Nielsen, K., 1994b. "Determination of hydrothermal stability (shrinkage temperature)". In: STEP Leather Project. Evaluation of the correlation between natural and artificial ageing of vegetable tanned leather and determination of parameters for standardization of an artificial ageing method. Ed. R. Larsen. The Royal Danish Academy of Fine Arts, School of Conservation. Copenhagen, pp. 151-164.

Larsen, R., 1994c. "Summary discussion and conclusion". In: STEP Leather Project. Evaluation of the correlation between natural and artificial ageing of vegetable tanned leather and determination of parameters for standardization of an artificial ageing method. Ed. R. Larsen. The Royal Danish Academy of Fine Arts, School of Conservation. Copenhagen, pp. 165-180.

Larsen, R., 1995. "Summary discussion and conclusion". Appendix III. STEP Leather Project. Research report N° 1. December 1994. In: *Fundamental aspects of the deterioration of vegetable tanned leathers.* The Royal Danish Academy of Fine Arts, School of Conservation. Copenhagen, pp. 105-124.

Larsen, R., Vest, M., Poulsen, D. V., Kejser, U. B. & Jensen, A. L., 1996a. "Amino acid analysis". In: *Environment leather project. Deterioration and conservation of vegetable tanned leather.* Protection and Conservation of the European Cultural Heritage, Ed. R. Larsen, EV5V-CT94-0514. Research Report no 6. Copenhagen, pp. 39-68.

Larsen, R., Vest, M., Poulsen, D. V., & Kejser, U. B., 1996b. "Fibre assessment". In: *Environment leather project. Deterioration and conservation of vegetable tanned leather.* Protection and Conservation of the European Cultural Heritage, Ed. R. Larsen, EV5V-CT94-0514. Research Report no 6. Copenhagen, pp. 113-120.

Larsen, R.; Wouters, J., Chahine, C., Brimblecombe, P. & Calnan, C., 1996c. "Recommendations on the production, artificial ageing, assessment, storage and conservation of vegetable tanned leathers". In: *Environment leather project. Deterioration and conservation of vegetable tanned leather.* Protection and Conservation of the European Cultural Heritage, Ed. R. Larsen, EV5V-CT94-0514. Research Report no 6. Copenhagen, pp. 189-202.

Larsen, R. & Rahme, L., 1999. *Læder, pergament og skind. Fremstilling, historie og nedbrytning*. Det Kongelige Danske Kunstakademi, Konservatorskolen. København. 88 p.

Larsen, R., Poulsen, D. V. & Vest, M., 2002a. "The hydrothermal stability (shrinkage activity) of parchment measured by the micro hot table method (MHT)." In: *Micro analysis of parchment.* Ed. R. Larsen. Archetype Publications, London, pp. 55-62.

Larsen, R., Poulsen, D. V., Odlyha, M., Nielsen, K., Wouters, J., Puchinger, L., Brimblecombe, P. & Bowden, D., 2002b. "The use of complementary and

comparative analysis in damage assessment of parchments." In: *Micro analysis of parchment.* Ed. R. Larsen. Archetype Publications, London, pp. 165-180.

Legat, A., 1991. *Report of the Traditional Working Group.* Department of Northwest Territories. Yellowknife. 116 p.

Leem, K., [1767], 1975. *Beskrivelse over Finmarkens lapper.* Rosenkilde og Bagger. International Boghandel og Forlag. København. 544 p.

Levin, M. G. & Potapov, L. P., Eds., 1964. *The peoples of Siberia.* The University of Chicago Press. Chicago and London. 948 p.

Lewis, N.G. & Yamamoto, E., 1989. "Tannins – Their place in plant metabolism". In: *Chemistry and significance of condensed tannins.* Eds: R. W. Hemingway & J. J. Karchesy. Plenum Press. New York and London, pp. 23-46.

Linné, C., [1732], 1975. *Iter Lapponicum*. Dei Gratia Institutum. Wahlström & Widstand. Stockholm. 277 p.

Luck, G.; Liao, H.; Murray, N. J.; Grimmer, H. R.; Warminski, E. E.; Williamson, M. P.;

Lilley, T. H. & Haslam, E., 1994. "Polyphenols, astringency and proline-rich proteins". *Phytochemistry,* Vol. 37, pp. 357-371.

Magga, O. H., 2002. "Samisk forskning i et selvbestemmelsesperspektiv". In: Samisk selvbestemmelse. Ed. N. Oskal. *Diedut*. Vol. 2, pp. 130-138.

Magga, O. H., 2003. "Tangible and Intangible Cultural Heritage. An indigenous perspective". The World Heritage Convention: Future challenges and possible lines of actions. European Conference, Røros, Norway, 3-5. September 2003. Online: http://www.unesco.no/. Reading date: 20.5.2005.

Maie, N., Behrens, A., Knicker, H., & Kögel-Knabner, I., 2003. "Changes in the structure and protein binding ability of condensed tannins during decomposition of fresh needles and leaves". *Soil Biology & Biochemistry*, Vol. 35, pp. 577-589.

Malainey, M. E., Przybylski, R., & Sherriff, B. L., 1999 a. "Fatty acid composition of native food plants and animals of Western Canada". *Journal of archaeological science*. Vol. 26, pp. 83-94.

Malainey, M. E., Przybylski, R., & Sherriff, B. L., 1999 b. "The effects of thermal and oxidative degradation on the fatty acid composition of food plants and animals of Western Canada: Implications for the identification of archaeological vessel residues". *Journal of archaeological science.* Vol. 26, pp. 95-103.

Manich, A. M., Cuadros, S., Cot, J.,Carilla, J. & Marsal, A., 2005. "Determination of oxidation parameters of fatliquored leather by DSC". *Thermichimica acta.* Vol. 429, pp. 205-211.

Markley, K. S., 1947. *Fatty acid. Their chemistry and physical properties*, Interscience, New York. 668 p.

Mason, O. T., 1891. *Aboriginal skin-dressing – a study based on material in the U.S. National Museum*. Report U. S. National Museum 1889. Washington, pp. 553-589 + plates LXI-XCIII

Mason, O. T., 1895. *Woman's share in primitive culture.* Macmillian & Co. London and New York. 295 p.

MacDonald, D., Ed. 2004. *The encyclopaedia of mammals.* Oxford University Press, Oxford. 930 p.

McGill, A. S. & Moffat, C. F., 1992. "A study of the composition of fish liver and body oil triglycerides". *Lipids.* Vol. 27, pp. 360-370.

McKean, T, 2003. "Tradition as communication". *Oral Tradition*. Vol.18, pp. 49-50.

McManus, J. P., Davis, K. G., Lilley, T. & Haslam, E., 1981. "The Association of proteins with polyphenols". *Journal of the chemical society, chemical communications.* Vol. 7, pp. 309-311.

Middendorff, A. Th. von, 1953. *Auf Schlitten, Boot und Renntierrücken*. Veb F. A. Brockhaus Verlag. Leipzig. 582 p.

Mills, J. S., 1966. "The gas chromatographic examination of paint media, Part 1: Fatty

acid composition and identification of dried oil films". *Studies in conservation*. Vol. 11, pp. 92-107.

Mills, J. S. & White, R., 1999. *The organic chemistry of museum objects.* Butterworth-Heinemann. Oxford. 206 p.

Morice, I. M. & Shorland, F. B., 1955. "The isolation of n-Pentadecanoic and n-Heptadecanoic acids from shark (Galeorhinus *australis* Macleay) liver oil". *Biochemical journal*. 61(3), pp. 453-456.

Mourier, H. & Winding, O., 1999. *Vilde dyr i hus og hjem*. Gads Forlag. 222 p.

Munsell® soil colour charts, 2000. 9 chart version. Munsell® Color. Gretag-Macbeth, New Windsor.

Müller-Wille, L., 2001. "Cultural identity among Sámi and Inuit: Issues of ethnic groups and boundaries." *Études/inuit/studies*. Vol. 25, pp. 285-294.

Nelson , E. W., 1899. "The Eskimo about Bering Strait". In: *Eighteenth annual report of the Bureau of American Ethnology*. Ed. J. W. Powell. Smithsonian Institution, Washington, pp. 3-518.

Nesheim, A., 1964. "The Lapp fur and skin terminology". Reprint from *Studia ethnographica Upsaliensia*. Vol. 21, pp. 199-218.

Niemi, S., 1998. "An automly Sami capital – Lovozero". *Samefolket*. October 1998.

Oakes, J. E., 1991. *Copper and Caribou Inuit skin clothing production.* Canadian Ethnology Service. Mercury Series Paper, Vol. 118. Canadian Museum of Civilization. 277 p.

Oakes, J. E., Riewe, R., Riewe, R. R., 1996. *Our boots: An Inuit women's art.* Thames & Hudson. 224 p.

Oakes, J & R. Riewe, 1997. "Factors influencing decisions made by Inuit seamstresses in the circumpolar region". In: *Braving the cold. Continuity and change in Arctic clothing*. Eds. C. Buijs & J. Oosten. Research School CNWS. Leiden, The Netherlands, pp. 89-104.

Oakes, J. E., Riewe, R., Riewe, R. R., 1998. *Spirit of Siberia: traditional native life, clothing, and footwear.* Bata Shoe Museum Foundation. Smithsonian Books. 215 p.

O'Hearn, T., 2002. *Inuit Women's Traditional Knowledge Workshop on the Amauti and Intellectual Property Rights*. Final Report, Rankin Inlet, Nunavut, May 24-27, 2001, March 2002 © Pauktuutit Inuit Women's Association. Online: http://www.wipo.int/tk/en/igc/ngo/amauti_report.pdf. Reading date: 5.9.2005

O'Leary, D. N. & Attenburrow, G. E., 1996. "Differences in strength between the grain and corium layers of leather." *Journal of material science*. Vol. 31, pp. 5677-5682.

Ophardt, C., 2003. http://www.elmhurst.edu/~chm/vchembook/550lipids.html. Reading date: 17. 9. 2006.

Otak, L. A., 2005. "Iniqsimajuq: Caribou-skin preparation in Igloolik, Nunavut". In: *Arctic clothing of North America-Alaska, Canada, Greenland*. Eds: J.C.H. King, B. Pauksztat, and R. Storrie. London: The British Museum Press, pp.

Padley, F. B., Gunstone, F. D. & Harwood, J. L., 1994. "Occurrence and characteristics of oils and fats". In: *The lipid handbook*. Eds. F. D. Gunstone, J. L. Harwood, & F. B. Padley, Chapman & Hall, London, pp. 47-223.

Pallas, P. S., [1768-1774], 1973. "Reisen durch verschiedene Provinsen des russisches Reiches in den Jahren 1768-1774". In: *Jenseits des Steinernen Tores. Reisen Deutscher Forscher des 18. und 19. Jahrhunderts durch Sibirien.* Ed. H. von Scurla, Verlag der Nation, Berlin, pp. 177-251.

Parry, D. A. D., 2005. "Structure and functional implications of sequence repeats in fibrous proteins". *Advances in protein chemistry*. Vol. 70, pp. 11-35.

Piez, K. A., 1968. "Cross-linking of collagen and elastin". *Annual reviews biochemistry*. Vol 37, pp. 547-570.

Porsbo, S. J., & Nordenhem, E., 1988. *Samisk dräktskick i Gällivare, Jukkasjärvi och Karesuando socknar*. Skrifter från Ájtte 1. Ájtte Förlag. Jokkmokk. 87 p.

Popov, A. A., 1964. "The Nganasans". In: *The peoples of Siberia.* Eds. M. G. Levin & L. P. Potapov, The University of Chicago Press, Chicago and London, pp. 571-582.

Popov, A. A., 1966. *The Nganasans. The material culture of the Tavgi Samoyeds*. Vol. 56. Uralic and Altaic Series. Indiana University, Bloomington. 168 p.

Porter, L. J., 1984. "Haemanalysis: the relative astringency of proanthocyanidin polymers". *Phytochemistry*, Vol. 23, No.6, pp. 1255-1256.

Porter, L. J., 1989. "Condensed tannins". In: *Natural products of woody plants I. Chemical extraneous to the lignocellulosic cell wall.* Ed: J. W. Rowe. Springer Verlag. Berlin, pp. 651-690.

Poulsen, D. V., 2000. *A study of the role of tannins in the deterioration of vegetable tanned leather*. Master Thesis. School of Conservation. The Royal Danish Academy of Fine Arts. Copenhagen. Unpublished. 80 p.

Prokofyeva, E. D., 1964. "The Sel'kups". In: *The peoples of Siberia*. Eds. M. G. Levin & L. P. Potapov. The University of Chicago Press, Chicago and London, pp. 587-607.

Prokofyeva, E. D., Chernetsov, V. N., & Prytkova, N. F., 1964. "The Kants and Mansi". In: *The peoples of Siberia*. Eds. M. G. Levin & L. P. Potapov. The University of Chicago Press, Chicago and London, pp. 511-547.

Reed, R., 1972. *Ancient skins parchments and leathers.* Seminar Press. London, New York. 331 p.

Ross M. H. , Romrell L. J. & Kaye, G. I. 1995. *Histology: A text and atlas.* 3rd ed. Williams and Wilkins, Baltimore.

Rottsieper, E. H. W., 1946. *Vegetable tannins*. W. Cartmel & Sons, Printers, St. Albans. 100 p.

Rouiller, Ch. & Jézéquel, A.M., 1963. "Electron microscopy of the liver". In: *The Liver. Morphology, Biochemistry, Physiology.* Ed. C. Rouiller, Vol 1. New York. Academic Press. 683 p.

Rudmin, F. W., 2003. Catalogue of acculturation constructs: Descriptions of 126 taxonomies, 1918-2003. In: *Online Readings in Psychology and Culture* (Unit 8, Chapter 8), Eds.W. J. Lonner, D. L. Dinnel, S. A. Hayes, & D. N. Sattler http://www.wwu.edu/~culture. Center for Cross-Cultural Research, Western Washington University, Bellingham, Washington USA. Reading date 1.8.2006.

Sakai, K., 2001. "Chemistry of bark". In: *Wood and cellulose chemistry*. Eds: D. N.-S. Hon & N. Shiraishi. Marcel Dekker Inc. New York, pp. 243-274.

Santappa, M. & Rao, V. S. S., 1982. "Vegetable tannins - a review"

Journal of scientific and industrial research. Vol. 41, pp. 705-718.

Sara, M. N., 2001. *Reinen – et gode fra vinden*. Davvi Girji. Karasjok. 142 p.

Schefferus, J., [1673], 1956. *Lappland.* Translation: H. Sundin. Nordiska Museet: Acta Lapponica. 8. Gebers. 470 p.

Schmidt, A.L., 1991. *Eskimoiske skinds bevaringstilstand belyst ved hjælp af kemiske og fysiske analyser.* School of Conservation. The Royal Danish Academy of Fine Arts. Master thesis. Unpublished. Copenhagen.

Schmidt, A. L.; Feldthus, A. & Carlsen, L., 1993. "On the changes of skin characteristics through an Inuit tanning procedure. International Council of Museums, Committee for Conservation. Ed. J. Bridgland. Preprints for the 10th Triennial Meeting, Washington, D.C. Vol 1, pp. 182-186.

Schofield, J. A., Hagerman, A. E., & Harold, A, 1998. "Loss of tannins and other phenolics from willow leaf litter". *Journal of chemical ecology.* Vol. 24, pp. 1409 – 1421.

Schofield, P., Mbugua, D. M. & Pell, A. N., 2001. "Analysis of condensed tannins: a review". *Animal feed science and technology*. Vol. 91, pp. 21-40.

Sharphouse, J. H., 1995. *Leather technician's handbook.* Leather Producers' Association. Northampton. 580 p.

Shils, E., 1981. "*Tradition*". The University of Chicago Press. Chicago. 334 p.

Shirokogoroff, S. M., 1935. "*Psychomental complex of the Tungus*". Kegan Paul, Trench, Trubner & Co. London. 469 p.

Sirelius, U. T., 1983. *Reise zu den Ostjaken.* Übersetzt. I. Schellbach. Travaux ethnographiques de la société Finno-ougrienne. Helsinki. 350 p.

Sirelius, U. T., 1904. *Die Handarbeiten der Ostjaken und Wogulen*. Journal de la Société Finno-Ougrienne. 22. Helsinki. 75 p.

Spencer, C. M., Cai, Y.; Martin, R., Gaffney, H., Goulding, P. N., Magnolato, D., Lilley, T. H. & Haslam, E. D, 1988. " Polyphenol Complexation – some thoughts and observations". *Phytochemistry.* Vol. 27. Pergamon Press, pp. 2397-2409.

Steller, G. W. [1753], 1973. "Bescreibung von dem Lande Kamschatka". In: *Jenseits des Steinernen Tores. Reisen Deutscher Forscher des 18. und 19. Jahrhunderts durch Sibirien.* Ed. H. von Scurla, Verlag der Nation, Berlin, pp. 123-174.

Stenton, D. R., 1991. «The adaptive significance of caribou winter clothing for arctic hunter-gatherers.» *Etudes/Inuit/ Studies.* Vol. 15, pp. 3-28.

Stenzel, K. H., Miyata, T & Rubin, A. L., 1974. "Collagen as a biomaterial".

Annual Review of Biophysics and Bioengineering. Vol. 3, pp. 231-253.

Steward, J. H. 1955. "*Theory of Cultural Change*". University of Illinois Press Urbana. 244 p.

Strack, D., 1997. "Phenolic Metabolism". In: *Plant Biochemistry.* Eds. P. M. Dey & J. B. Harborne. Academic Press. London, pp. 387-416.

Stær, Aa., 1952. "Gær". In: *Karl Meyer Vareleksikon*. Ed. H. Egede Glahn, Aschehoug Dansk Forlag. København, pp. 453-455.

Sundholm, F., Visapää, A. & Björksten, J., 1978. "Cross-linking of collagen in the presences of oxidizing lipid". *Lipids*. Vol.13. No. 11, pp. 755-757.

Svensson, T., 1992. "Clothing in the arctic: A means of protection, a statement of identity." *Arctic.* Vol. 45, No 1, March 1992. pp. 62-73

Svensson, T., 2003. "Knowledge and artefacts – people and objects, on cultural traditions and researched based collecting". ICOM-ICME Conference: *Cultural traditions in danger of disappearing in contemporary society – a challenge for museums*. September 26-30 2003. Romania. Web: http://museumsnett.no/icme/icme2003/svensson.html Reading date: 12.5.2005.

Sverdrup, H. U., 1938. *Hos Tundra-folket.* Gyldendal Norsk Forlag. 175 p.

Sykes, R. L., 1991. "The principles of tanning". In: *Leather. Its composition and changes with time.* Eds. C. Calnan & Haines, B. The leather conservation centre. Northampton, pp.10-11.

Tahvanainen J., Helle, E., Julkunen-Tiitto, R. & Lavola A., 1985. "Phenolic compounds of willow bark as deterrents against feeding by mountain hare". *Oecologia*. Vol. 65, pp. 319-323.

Tancous, J. J., 1986. *Skin, Hide and Leather Defects*. Leather Industries of America Laboratory. Lee Corporation. Cincinnati. 363 p.

Tang, H. R., Covington, A. D. & Hancock, R. A., 2003. "Structure-activity relationships in the hydrophobic interactions of polyphenols with cellulose and collagen". *Biopolymers.* Vol. 70, pp. 403-413.

Thorstensen, T. C., 1976. *Practical leather technology.* Robert E. Krieger Publishing Company, New York. 294 p.

Tuck, D. H., 1983. *Oils and lubricants used on leather*. The Leather Conservation Centre. Northampton. 22 p.

Tyler, N. & Røed, K., 1993. "Utbredelse og klassifisering av reinsdyr". *Ottar*. Vol. 195. Nr.2, pp. 3-10.

Umezawa, T., 2001. "Chemistry of Extractives". In: *Wood and cellulose chemistry*. Eds: D. N.-S. Hon & N. Shiraishi. Marcel Dekker Inc. New York, pp. 213-242.

Vasilevich, G. M. & Smolyak, A. V., 1964. "The Evenks". In: *The peoples of Siberia*. Eds. M. G. Levin & L. P. Potapov. The University of Chicago Press, Chicago and London, pp. 620-655.

Vest, M, 1996. *Hvidgarvet læder. Identifikation, teknologi og nedbrydning*. Master thesis. School of Conservation. The Royal Academy of Fine Arts. Copenhagen. Unpublished. 107 p.

Vorren, Ø., 1951. "Reindrift og nomadisme i Varangertraktene". *Tromsø Museums Årshefter*. Vol. 69. Tromsø. 145 p.

Ward, A. G., 1974. "The mechanical properties of leather." *Rheologica acta.* Vol. 13, pp. 103-112.

Wess, T. & Orgel, J. P., 2000. "Changes in collagen structure: drying, dehydrothermal treatment and relation to long term deterioration". *Thermochimica acta*. Vol. 365, pp. 119-128.

Wess, T. J. & Nielsen, K., 2002. "Analysis of collagen structure in parchment by small angle x-ray diffraction". In: *Micro analysis of parchment.* Ed. R. Larsen. EU project: SMT4-CT96-2106. Archetype Publications. London, pp. 149-153.

Wouters, J., 1993. "High-performance liquid chromatography of vegetable tannins extracted from new and old leather". ICOM Committee for Conservation, 10th Triennial Meeting, Washington, DC, USA Paris, pp. 669-673.

Wouters, J., 1994. "Tannin and ion analysis of naturally and artificially aged leathers". In: *STEP Leather Project. Evaluation of the correlation between natural*

and artificial ageing of vegetable tanned leather and determination of parameters for standardization of an artificial ageing method. Ed. R. Larsen. The Royal Danish Academy of Fine Arts, School of Conservation. Copenhagen, pp. 91-105.

Wouters, J., 1994/95 (1998). "Qualitative and quantitative analysis of tannins, extracted from new and aged leathers, by high performance liquid chromatography". *Bulletin*. Institut Royal du Patrimoine Artistique, 26.1994/95(1998), pp. 199-208.

Wouters, J., & Claeys, J., 1996. "Analysis of tannins, sulphate, fat, moisture and ash: Evolution and significance of parameters to be followed for measuring the degradation of vegetable tanned leather". In: *Environment leather project. Deterioration and conservation of vegetable tanned leather.* Protection and Conservation of the European Cultural Heritage, Ed. R. Larsen, EV5V-CT94-0514. Research Report no 6. Copenhagen, pp. 87-94.

Wouters, J., Bos, M. Van, Claeys, J. & Oostvogels, A., 1996. "Analysis of tannins, sulphate, fat, moisture and ash of leather, treated or produced for conservation purposes". In: *Environment leather project. Deterioration and conservation of vegetable tanned leather.* Protection and Conservation of the European Cultural Heritage, Ed. R. Larsen, EV5V-CT94-0514. Research Report no 6. Copenhagen, pp. 103-112.

Young, G. S., 1990. "Microscopical Hydrothermal Stability Measurements of Skin and Semi-Tanned Leather." *ICOM Committee for Conservation*, 9th Triennial Meeting, Dresden.Vol. 2, pp. 626-631.

Young, G. S., 1992. "Loss of infrared linear dichroism in collagen fibers as a measure of deterioration in skin and semi-tanned leather artifacts." In: *Material issues in art and archaeology* III. Eds. P. B. Vandiver, J. Druzik & G. S. Wheeler. Material Research Society. Symposium Procceedings, pp. 856-867.

Yorozu, M., 2005. " Inden". *Kateigaho International Edition*. Sekai Bunka Publishing INC, Tokyo. Web site: http://int.kateigaho.com/. Reading date: 15.3.2007.

Internet resources:

Alaska Native Knowledge Network, 2000. *Guidelines for Respecting Cultural Knowledge.* http://www.ankn.uaf.edu/. Reading date 27.05.2005.

Alaska Native Science Commission:
http://www.ankn.uaf.edu/IKS/ansc.html

Guidelines in respecting cultural knowledge:
http://www.ankn.uaf.edu/publications/knowledge.html. Reading date: 29.10.2005.

Alaska Native Science Commission."What is traditional knowledge"?
http://www.nativescience.org/html/traditional_knowledge.html. Reading date: 27.5.2005.

ANSIPRA, Arctic network for the support of the indigenous peoples of the Russian arctic. http://www.npolar.no/ansipra/english/Index.html. Reading date: 29.9.2005.

Cyberlipid. Resource site for lipid studies. http://www.cyberlipid.org/. First reading date: 2.5.2005.

Den virtuella floran. http://linnaeus.nrm.se/flora/welcome.html. First reading date: 2.5.2005.

DUPDA see: IDAP: http://www.idap-parchment.dk/.

IDAP - Improved Damage Assessment of Parchment, EVK4-CT-2001-00061. http://www.idap-parchment.dk/

Fishbase. A Global Information System on Fishes.
http://www.fishbase.org/home.htm. Reading date: 12.10.2005.

I.U.L.T.C.S. International Union of Leather Technologists and Chemists Societies. Glossary

of Leather terms. Extract for the IULTCS Glossary. A European funded project under the

Leonardo programme «Eureka». Web site:
http://www.iultcs.org/leather_terms/index.asp.

First reading date: 1.7.2004.

Karasjok County web page: http://www.karasjok.kommune.no/. Reading date: 26.5.2005.

Kautokeino County web page: www.kautokeino.kommune.no/. Reading date: 26.5.2005.

Lipid bank. The official database of Japanese Conference on the Biochemistry of Lipids (JCBL). http://www.lipidbank.jp/. First reading date: 5.5.2006.

Lipomics. Fatty acid library. http://www.lipomics.com/fatty_acids. First reading date: 5.5.2006.

Microsoft Encarta Online Encyclopaedia. http://encarta.msn.com/artcenter_/browse.html. First reading date: 5.9.2004.

NESH. Samisk forskning og forskningsetikk. 2002. *Den nasjonale forskningsetiske komité for samfunnsvitenskap og humaniora.*. Publikasjon nr. 2,

www.etikkom.no/Etikkom/HvaGjorVi/Publikasjoner/Samisk. Reading date: 26.5.2005.

Norwegian Meteorological Institute, http://met.no. Reading date: 15.5.2006.

Sámi Council web page. http://www.samediggi.no. Reading date: 29.10.2005.

UNESCO. Convention for the safeguarding of the intangible cultural heritage.

http://www.unesco.org/culture/ich/index.php?lg=EN&pg=home. Reading date: 3.8.2006.

United Nations. The Convention on Biological Diversity.1992. United Nation's Earth Summit in Rio de Janeiro, Brazil. http://www.biodiv.org/convention/default.shtml. Reading date: 3.8.2006.

Wikipedia, the free encyclopedia. http://en.wikipedia.org/wiki/Main_Page. First reading date: 18.2.2005.

Museum web pages:

Museum of Cultural History, University of Oslo, Norway. Online: http://www.khm.uio.no/

Museum of Cultures, National Museum of Finland, Helsinki, Finland. Online: http://www.nba.fi/en/museum_of_cultures

Peter the Great's Museum of Anthropology and Ethnography (Kunstkammer), St. Petersburg, Russia. Online: http://www.kunstkamera.ru/en/

Sámiid Vuorká-Dávvirat (SVD/DSS), Karasjok, Norway. Online: http://www.desamiskesamlinger.no/

Tromsø Museum, University of Tromsø, Norway. Online: http://uit.no/tmu/

The Norwegian Museum of Cultural History, Oslo, Norway. Online: http://www.norskfolke.museum.no/

The Russian State Museum of Ethnography, St. Petersburg, Russia. Online: http://eng.ethnomuseum.ru/

The Irkutsk Museum of Regional Studies, Irkutsk, Russia. Online: http://www.museum.irkutsk.ru/.

University of Cambridge Museum of Archaeology & Anthropology, University of Cambridge, Cambridge, United Kingdom. Online: http://museum.archanth.cam.ac.uk/

Personal communication:

Afanasievna, K. B., 2001. Personal communication.

Anatolievna, J. K., 2000. Personal communication.

Eira Buljo, K. M., 2004. Personal communication.

Eira Nilsen, N, 2005. Personal communication.

Glastrup, J., 2007. Experimental GCMS, e-mail.

Grøn, O., 2005. Information on skin processing in Khatanga region, Irkutsk, Russia.

Guttorm, I., 2004. Personal communication.

Juchauld, F., 2006. Spectrograms of catechin, gallic acid, ellagic acid, and protocatechuic acid.

Juchauld, F., 2007. Experimental HPLC, e- mail. Investigation of vegetable tannins in sample material, e-mail.

Kemi Eira, A. K., 2004, 2006. Personal communication.

Kirillovna, M. K. 2001. Personal communication.

Knifesmith Strømeng, 2004. Knife smiths in Karasjok since the 18th century. E-mail.

Web page: http://www.karport.no/cgi-bin/kp/imaker?id=133

Larsen, R., 2007. E-mail.

Oakes, J., 1993. Instructor and organizer. Skin processing workshop in Churchill, Manitoba, Canada. Organiser: Canadian Conservation institute (CCI), Ottawa. Canada.

Turov, M. 2004. University of Irkutsk. Russia. Personal communication.

Vasilievna, L. M., 1999. Personal communication.

Examples of conservation literature:

Boulton, A., 1986. "The examination, treatment and analysis of a pair of boots from the Aleutian Island including a note about possible pesticide contamination." *Journal of the American institute for conservation*. Vol. 25, pp. 1-13.

Canadian Conservation Institute, 1992. "Care of rawhide and semi-tanned leather". *CCI Notes* 8/4. Ottawa: Canadian Conservation Institute.

Collins, C., 1986. "Conservation techniques for ethnographic leather artifacts: application to the Paul Kane Collection." In: *The care and preservation of ethnological materials.* National Museum of Canada, CCI, pp. 62-67.

Del Re, C., 1986. "Technology and conservation of five northwest coast head-dresses." In: *Proceedings symposium 86. The care and preservation of ethnological materials*. National Museum of Canada, CCI, pp. 53-61.

Dignard, C., 1992. "Tear repair of skins with minimal access to their backs: The treatment of a kayak." *Leather conservation news*. Vol. 7, pp. 1-8.

Florian, M.-L. E., 1976. "Fungicide treatment of Eskimo skin and fur Artifacts." *Journal of the international institute for conservation, Canadian group.* Vol. 2, pp. 10-17.

Horie, C. V. & Murphy, R.G., Eds, 1988. *Conservation of natural history specimens-vertebrates.* Proceedings of the short course at Manchester University. University of Manchester. 77 p.

Howatt-Krahn, A., 1987. "Conservation: Skin an Native-Tanned Leather." *American Indian art magazine*. Vol. 12, pp. 44-52.

Kaminitz, M. & Levinson, J., 1988. "The conservation of ethnographic skin objects at the American Museum of Natural History." *Leather conservation news*, Vol. 5, pp. 1-8.

Komanowsky, M., 1990. " Drying of leather with microwaves." *Journal of the American leather chemists association*. Vol. 85, pp. 131-141.

Lougheed, S., Mason, J. & Vuori, J., 1983/84. "Repair of tears in fur skin garments". *Journal of the Canadian association for conservation.* Vol. 8 & 9.

Myers, M., 1980."Storage of leather objects" In: *Konservering og restaurering af læder, skind og pergament.* Kompendium fra Nordisk Videre-uddannelseskursus 1978. Kulturen, Lund, Sverige. Konservatorskolen. Det Kongelige Danske Kunstakademi. København, pp. 364-379.

Nikitina, K. F., 1978. "Conservation and restoration of fur clothes from the burial place Oglakhty." *ICOM Committee for Conservation*. 5th Triennial Meeting Zagreb.

Raphael, T., 1986. "Ethnographic skin and leather products: a call for conservation treatment." In: *The care and preservation of ethnological materials.* National Museum of Canada, CCI, pp. 68-73.

Raphael, T., 1993. "The care of leather and skin products: A curatorial guide." *Leather conservation news.* Vol. 9, pp. 1-14.

Richardson, H., 2002. "The conservation of Plains Indian shirts at the National Museum of the American Indian, Smithsonian Institution". In: *The conservation of fur, feather and skin*. Ed. M. M. Wright. CEA Series No.3. Archetype Publications, pp. 7-24.

Schaffer, E., 1974. "Properties and preservation of ethnographical semi-tanned leather." *Studies in Conservation*, Vol. 19, pp. 66-75.

Schmitzer, W., 1978. "Conservation of leather objects in ethnographic museums." ICOM Committee for Conservation. 5th Triennial Meeting. Zagreb, pp. 1-7.

Wills, B., Calver, A. & Cruickshank, P., 1987 "Experimental Freeze-drying of Ethnographic Skins and Gut." ICOM Committee for Conservation. 8th Triennial Meeting. Sydney, Australia, pp. 225-230.

List of photographs.

Photo 1.8: www.turgleder.com

Photo 3.17: A. Nilssen

Photo 3.24, 3.37, 3.42, 3.43: O. Grøn

Photo 3.14: E. Wessel

ISBN 978-87-88509-33-5