Capacity building to the
Mongolian vegetable tanned yak leather cluster
on bio-leather and bio-leather products
SWITCH/2021/428-657

Yak Leather; Production, Processing and Utilisation

МОНГОЛ САРЛАГ
ФЕСТИВАЛ

WP7. DISSEMINATION

Activity A.7.2. Development of dissemination and communication tools

May, 2025

Preface

Mongolia is the eighteenth largest country in the world with major resources of livestock; which in 2023 (NSO, 2024) included:

- 29.4 million sheep,
- 24.6 million goats, and
- 5.4 million cattle.

Unlike many other countries, Mongolia also has resources of:

- 4.8 million horses,
- 1.0 million yaks, and
- 0.5 million camels,

More particularly, domestic yaks are limited to Mongolia and about seven other countries; and the animal is very distinctive in a number of ways in addition to its appearance.

In Mongolia, most animals are still raised in the traditional nomadic way (by a quarter of a million herder households) providing meat, milk, fibres, hides, skins and manure. Yaks are particularly valued, because they are better able to survive the harshest weather, even in a country already renowned for its severe winters. Yaks also provide a regular (annual) harvest, of fine underwool - '*yak cashmere*' - which is comparable, in price and performance, with goat and camel cashmere. Though various hides and skins can be used as raw materials to make many different types of leather using a variety of processes, yak hides – vegetable tanned, and more particularly '*full grain*' – provide special attractions.

Although yak hides commonly accumulate a range of lesions throughout the animal's life (and during slaughtering and butchering) many of these do not adversely affect the physical performance of the finished leather. Indeed, some such signs of the animal's '*wear-and-tear*' - when still visible in full grain leathers - add to their aesthetic appeal and contribute to the finished product's desirable patina.

In Mongolia, the number of domestic yaks (*Bos grunniens*) has, like all other livestock – increased in recent years. Utilisation of their hides, which might otherwise be discarded and wasted, can provide the basis for gainful employment by means of added value (leather) products for export. This could help to sustain the herders' traditional way of life, and increase attention to the protection of wild yaks (*B. mutus*, found only in Tibet) which are currently classified as' *vulnerable*' by the International Union for Conservation of Nature (IUCN).

In 2019, within the Government of Mongolia's *Mongol Export Program; 2019-23*, the European Union sponsored the *Trade Related Assistance for Mongolia* (TRAM) project - in collaboration with the Mongolian National Chamber of Commerce and Industry (MNCCI) – which facilitated establishment of the Yak Leather Cluster. This cluster was to manufacture and export yak products; especially those using vegetable tanned leather. This document was started by the author, while designated International Leather Consultant within the TRAM project. It was completed by him (with the addition of sections on quality assurance, marketing, etc.) coincidental to the follow-up to the TRAM project; namely, the International Trade Development in Mongolia (ITDM) project.

Given the limited availability of reliable information on the utilisation of yak hides in general (in English or Mongolian), and the prevalence of misunderstandings with respect to some related topics, the objective of this document was to provide insights on:

- yak hides as raw material,

- hides production and preservation,
- vegetable tanned leather,
- leather products, and
- marketing.

To provide for integration, consolidation and development of these topics by stakeholders within the Vegetable Tanned Yak Leather Cluster, it was also necessary to include attention the concepts of value chains and clusters. Both of these have provided for improvement in tanning and leather products manufacturing in other countries.

In depth attention to, and coverage of, all the above, would justify a number of volumes. Accordingly, this small document is limited to providing some essentials only; based on priorities identified for attention during the course of the Sustainable Yak Leather (SYL) project in Mongolia; with references to other sources of information whenever appropriate.

Though yak hides, and the leathers and leather products made from them, are the main objects of interest in this document, many of the issues described are equally applicable to other hides and skins.

Acknowledgments

The invaluable support of Carl Krug in the initiation and completion of this document, is gratefully acknowledged. While Senior Private Sector Development Expert in the European Union-funded TRAM project, he was responsible for promoting development of a number of clusters in Ulaanbaatar, including the Yak Leather Cluster. Mr Krug also encouraged preparation a reference resource for cluster members, entitled *Yak (Full Grain) Vegetable Leather; Production, Processing and Finishing for Products Manufacturing*. Later, as Team Leader of the ITDM project, Mr Krug, endorsed the SYL project's elaboration of the document into its current form. Also during the ITDM project, Mr Krug hosted a meeting of the Sea Buckthorn Cluster during which Axel Wähling (NIG Nahrungs-Ingenieurtechnik GmbH) introduced the concept of using of tannin (from the leaves of the plant) for the manufacture of vegetable tanned leather.

Publicity Disclaimer

This publication was produced with the financial support of the European Union. Its contents are the sole responsibility of the SYL consortium and do not necessarily reflect the views of the European Union.

Cover Illustration

Logo of the *Mongol Yak Festival*, of 2015. https://mongolia.gogo.mn/r/630my

Abbreviations and Acronyms

BOD	Biological oxygen demand
CIE	Commission Internationale de l'Éclairage (International Commission on Illumination
CIS	Commonwealth of Independent States
COD	Chemical oxygen demand
FAO	Food and Agriculture Organisation
GI	Geographical Indication
INESCOP	Asociación de Investigación para la industria del calzado (Footwear Technology Centre)
ISO	International Standards Organisation
ITDM	International Trade Development in Mongolia
IUCN	International Union for Conservation of Nature
LWG	Leather Working Group
MNCCI	Mongolian National Chamber of Commerce and Industry
MNS	Mongolian National Standard
NSO	National Statistical Office
NWF	National Wildlife Federation
R&D	Research and development
RLRT	Responsible Leather Round Table
SLF	Sustainable Leather Foundation
SYL	Sustainable Yak Leather
TOTF	Tannery of the Future
TQM	Total quality management
TRAM	Trade Related Assistance or Mongolia
UN	United Nations
UNIDO	United Nations Industrial Development Organisation
WWF	World Wildlife Fund
ZDHC	Zero Discharge of Hazardous Chemicals

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1. YAKS; DISTRIBUTION AND CHARACTERISTICS.

Unlike other cattle, the distribution of yaks is very restricted. Small numbers of about 15,000 of the wild yak (*Bos mutus*, or *Poephagus mutus*) survive in parts of China only. Numbers of the domestic yak (*B. grunniens* or *P. grunniens*) were reported to total 13.8 million (at the start of the century; FAO, 2003; see *Appendix 1. References*) with 13.0 million (94.4%) in China, 0.6 million (4.4%) in Mongolia and 0.2 million (1.2%) elsewhere (CIS, Bhutan, Nepal, India, Pakistan and Afghanistan). About 15% of domestic yaks are thought to be hybrids - from cross-breeding with *B. taurus* or *B. indicus* species - and there are even small populations of feral animals. Within China, 12 breeds of the domestic yak are reported to exist (Wiener, et al, 2010). However, the genetic distinction between the breeds is difficult to assess in the absence of pedigree records.

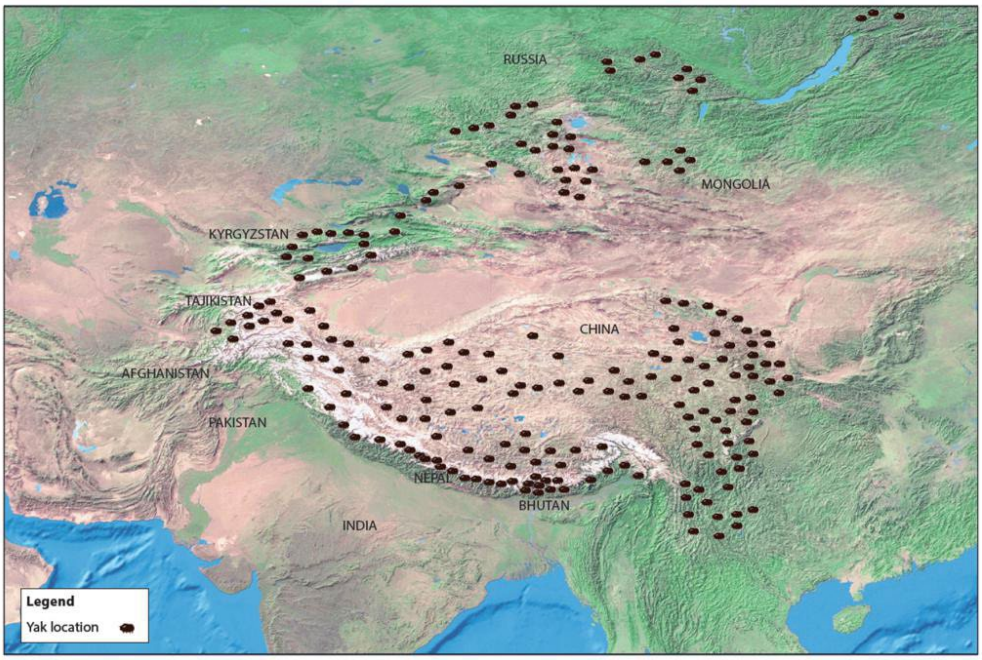


Figure 1. Distribution of yaks. Joshi, et al., 2020.

Figure 2. Wild yak. FAO, 2003.

Yaks are particularly suited to high altitudes (greater than 3,000m above sea level) and cold environments. The wild yak is typically larger than the domesticated species; and the male offspring of cross-breeding with other domesticated cattle are sterile. Cross-breeding of domestic yaks is used to improve their reproduction, parturition, productivity (e.g. milk) and/or range (altitude) and/or that of the cattle they are crossed with.

In Mongolia, there are two types of yak – the Khangai and the Altai - distinguished more by their location rather than any pronounced genetic differences. Most of the yaks in Mongolia are black, and most are the Khangai type.

The short (97 days) frost-free growing season in Mongolia (31 May to 5 September) and the severe winters, mean the yaks (like all other livestock) exhibit a regular seasonal pattern of weight gain in the summer and autumn, followed by weight loss in winter. For new-born yaks, the first winter's weight loss is about 20%; for one-year-olds it is 16%. Up to 30% of weight loss is possible over the course of each winter (Wiener, et al., 2010). Because of their utility in the production of milk and fibres (hair and wool), within subsistence production systems, yaks may be at least five years old when ultimately slaughtered for meat production.

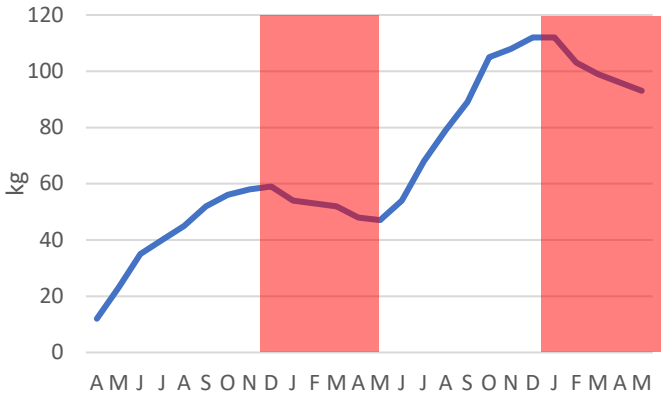


Figure 3. Bodyweight of yaks; birth to two years. Based on Xue, et al., 2005.[1]

After a period of decline in the number of yaks in Mongolia – during the last decades of the twentieth century – they have recently been increasing; to their current level of about one million animals.

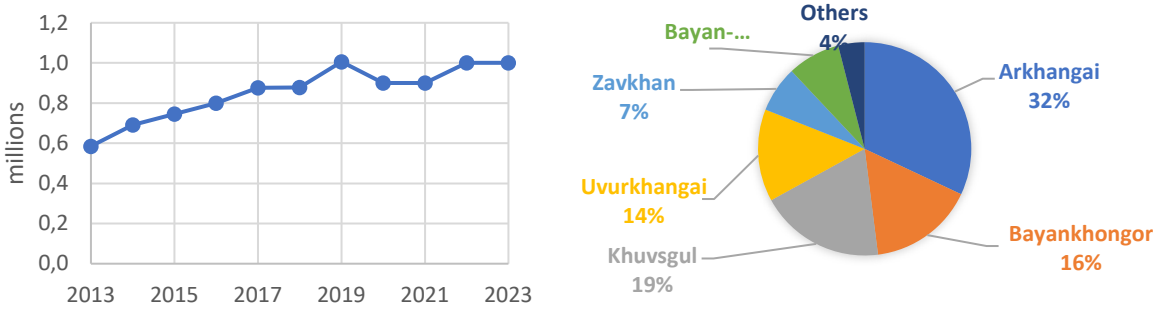


Figure 4. National resources of domestic yaks, and distribution by province; Mongolia. NSO, 2020.

All but 4% are located in six provinces of the country; in the higher altitude and mountainous Altai and Khangai (Western and Mountain) regions. Most, 81%, are to be found in just four provinces; Arkhangai, Bayankhongor, Khuvsgul and Uvurkhangai.

[1] A = April, J = June, etc.

2. YAK HIDES

Given variations in the yaks themselves - related to species, breed, season and age - the hides (sometimes referred to as '*skins*'; see *Appendix 2. Glossary*) they provide are also subject to variation. Among a sample of animals ranging in body weight from 116 to 576kg (FAO, 2003) the weight of the hides (20.1±8.7kg) was equivalent to 6.5% of the carcase; ranging from 5.4 to 8.3%. The area of the hide is said to amount to 0.11m^2/kg for males and 0.20m^2/kg for females (Zhang Rongchang, 1986) and the average thickness; 2.7mm for a three-month animal and 3.9mm for an adult.

The pelage is composed of guard hairs (>50µm dimeter), intermediate fibres (25-50µm) and fine under down ('*wool')* often referred to as '*yak cashmere'* (<25µm). The yak cashmere content - collected by combing in spring - can be more than 3.0kg in an adult male; though only 20% (0.6kg) might be fine under down ('*wool*'). Given the high density of fibres on the hide (3,000/cm^2; Wiener et al., 2003), and extreme length (up to 0.5m) of guard hairs, the pelage can amount to more than the weight of a hide itself.

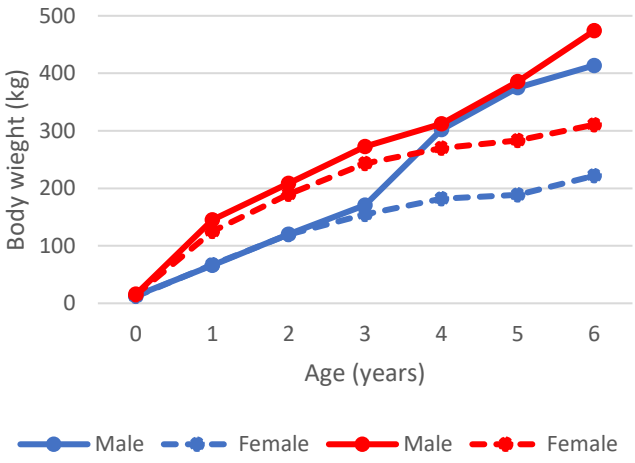
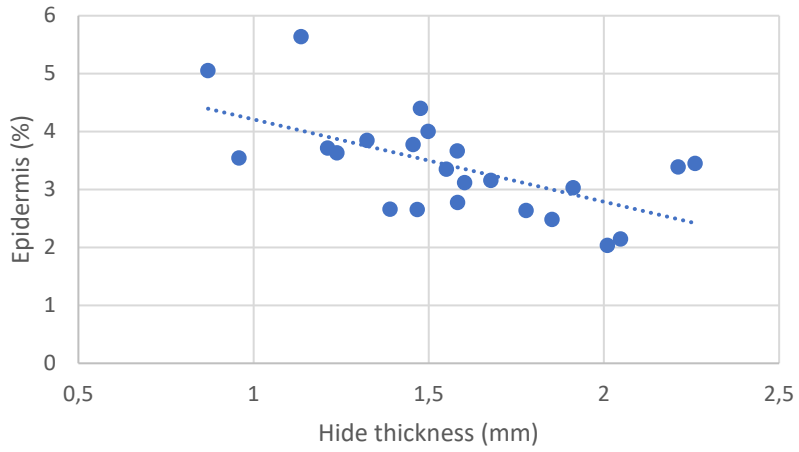


Figure 5. Body weight[2] of yaks; Maiwa and Jiulong Breed. FAO, 2003.



In a study of 20 yaks (Xue Yang et al., 2017) it was determined that the very thin epidermis ranged from 34µm to 78µm; averaging about 3.4% of the total (epidermis and dermis), but was proportionally thinner in thicker hides. In another study (Hossain, et al., 2016) the epidermis averaged 45µm; 1.3% of the total thickness of the hide; 1.4% in those of female yaks and 1.2% in those of males.

Figure 6. Thickness of epidermis vs yak hide. Based on Xue Yang, 2017.

The thickness of the papillary layer was also greater in the hides of females 17.8%, compared to 13.5% in males. But overall, the average thickness of the hides of female yaks (3.18mm) was 77.0% that of males (4.13mm). Despite the usefulness of average figures in general, those for thickness obscure a three-fold range, from a minimum of 2.1mm in the axilla, to maximum of 5.9mm in the back (Xue Yang et al., 2017).

[2] At the start of winter.

Across the surface of most hides and skins, one prominent feature is the direction of hair (or wool) fibres; radiating from a centre in the shoulder area, and running down the back and the legs. This is associated with a similar orientation, in the uppermost collagen fibres in the underlying dermis. Hair fibres will also vary (in different locations across the hide) in terms of diameter, length and density. And yak are exceptional in the presence of a '*skirt*' of exceptionally long hair around the belly.

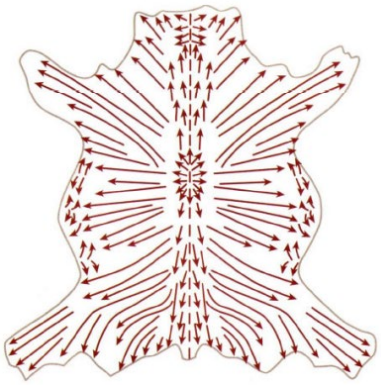


Figure 7. Orientation of hair fibres. Mete, et al., 2014.

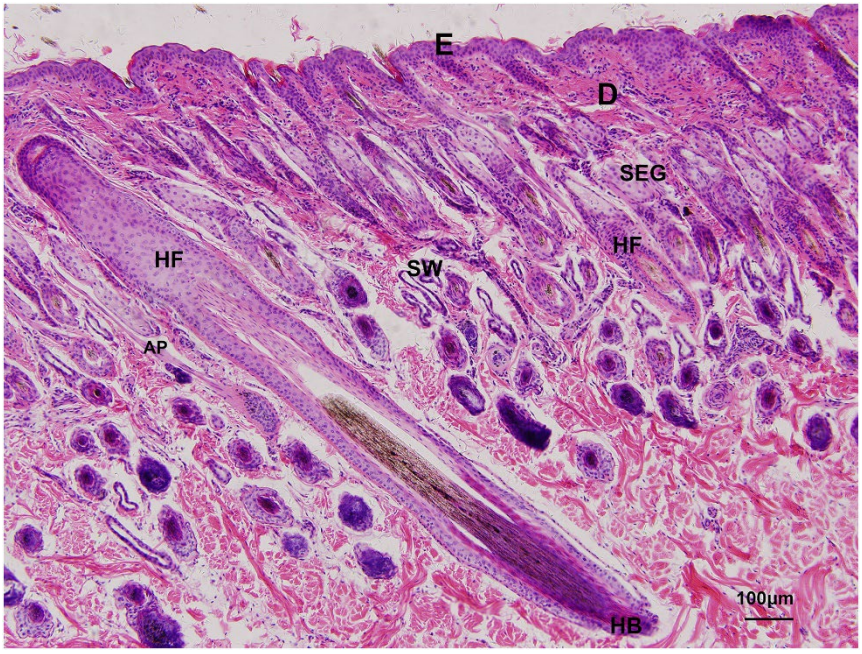


Figure 8. Transverse section of yak hide. Xue, et al., 2017.[3]

Throughout a cut section of a hide, it is possible to see other variations, particularly in the network of collagen fibres of the dermis. The fibres are typically finer, and vertically orientated in the papillary layer; coarser and horizontally oriented in the reticular layer. But again, the detailed pattern may vary in samples from different parts of a hide, those from different breeds, those from older/younger animals and from males and females.

The complex pattern of collagen fibres – associated with the direction of hair fibres and underlying organs - gives rise to lines (*Langer's Lines*) of tension (tightness), and contrasting lines of stretch. These persist after tanning and command attention during physical testing of leathers and when cutting pattern (especially in soft leathers).

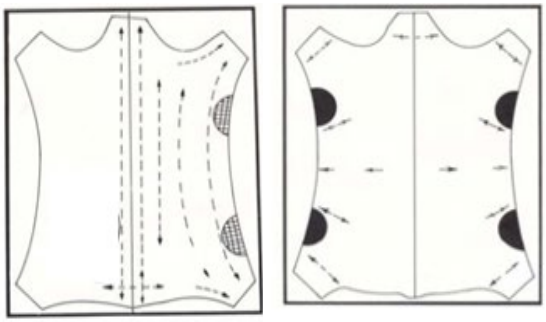


Figure 9. Lines of tightness and lines of stretch. [4]

[3] E = epidermis, D = dermis, and HF = hair follicle.

[4] eGyanKosh- a National Digital Repository

3. HIDES PRODUCTION AND PRESERVATION

Despite the very large number of livestock in the country, there is very little commercial production in Mongolia. Most animals – including yaks – are cared for within extensive, subsistence systems. Slaughtering, and the associated production of hides and skins, is not continuous throughout the year, nor is it wholly formalised.

Apart from minor increases in slaughtering during major holidays - such as the Lunar New Year in late winter, and Nadaam (‘*summer festival’*) in July - most (63%) production occurs in the last three months of the year; during early winter. Moreover, slaughtering is widely dispersed across the country, with more than 85% occurring informally; not within designated slaughterhouses or (better-equipped and staffed) abattoirs. Taking advantage of the low ambient temperatures during winter, chilling and natural freezing are the most common methods of preservation, including for yak hides.

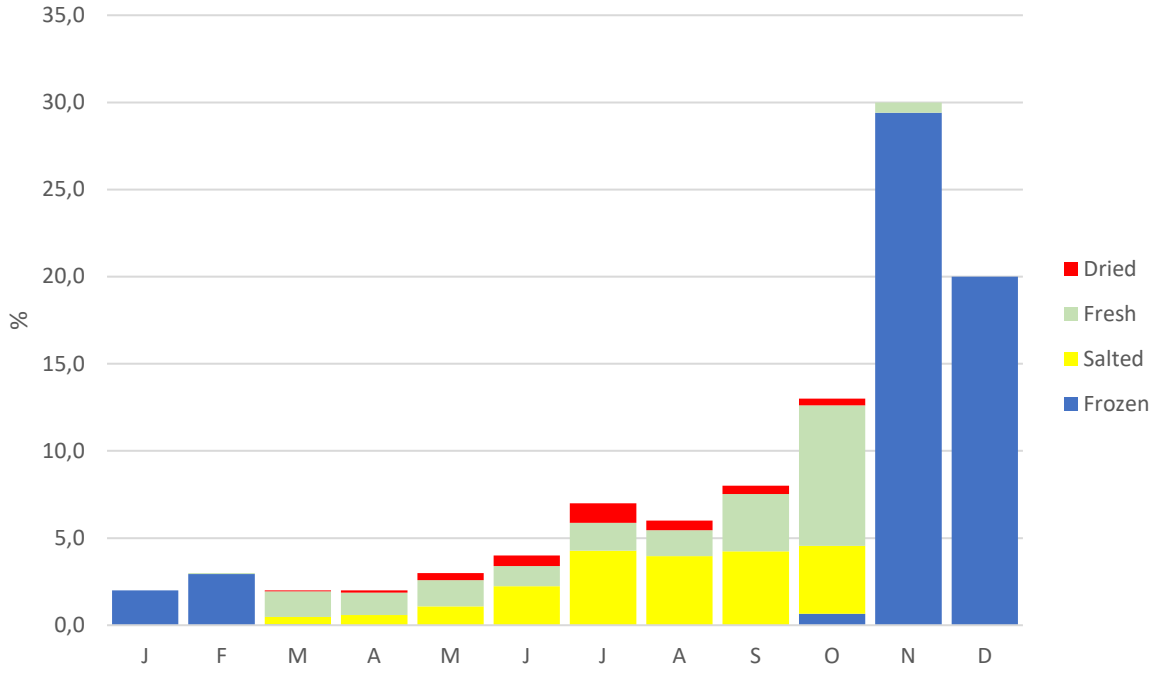


Figure 10. Production of hides and skin; by month and preservation. MALI.

Figure 11. Yak hide with blood stains, cuts and holes.

In practice, very soon after slaughtering and flaying, the yak’s hide is commonly used as a protective mat, on which to butcher the rest of the carcase upon the floor. Inevitably therefore, the hides that reach markets in Ulaanbaatar are heavily contaminated with blood, and exhibit innumerable cuts and holes due to very rough flaying, or chopping damage during butchering. Yak hides very often contain material from around the animal’s head, the lower part of the leg, and even the feet my remain attached.

Ideally, the slaughtering of yaks (like all other livestock processed for human consumption) should be done in appropriate facilities, with skilled staff, and using proper techniques. For example:

- animals should be treated humanely,
- staff should be properly dressed with protective clothing,
- carcases should be suspended to facilitate good hygiene practices,
- flayed hides should be symmetrical, without cuts/holes, and so on

Hides should be trimmed to remove any odd-shaped pieces around the edges (including head skin, legs and feet), and fleshed (to remove residual tissue such as muscle and fat) in order to:

- facilitate preservation (whether by chilling freezing, salting or drying) and
- reduce transportation costs associated with extraneous material.

Full details of recommended production procedures - and the theory and practice of preservation of hides and skins in general, including drying and salting - are provided in *Hides and Skins for the Tanning Industry* (FAO, 1995). Commercially, preservation by chilling and/or freezing is limited to situations where suppliers of hides and skins work very closely with the users (e.g. tanners). For example, large abattoirs may chill (2 to 4°C) hides during storage overnight, pending delivery to the tannery the next day. Chilled hides are very convenient and easy to use – with a shelf life of up to two weeks – and have much less environmental impact than salted ones. Though hides preserved by naturel (ambient temperature) freezing, avoid some of the costs associated with other methods, they present a range of problems to tanners. For example, the inside of frozen pieces may take considerably longer than the outside to defrost, and rough handling of partially frozen (brittle) material (e.g. prizing them open) can cause severe cracks. Ideally, hides for freezing should be folded onto each other; flesh side out to protect the grain from being damaged.

In Mongolia, some preserved yak hides are delivered directly to markets near Ulaanbaatar (e.g. Emeelt) but most are sold to local (or itinerant) traders or merchants, pending storage and transport in bulk. It is important that conditions are appropriate for the method of perseveration. For example, frozen materials should not be allowed to thaw (to reduce the risk of spoilage). And salted hides must similarly be protected from contact with water (e.g. melting snow, or rain).

Though some tanners express preferences for particular methods of preservation for their raw material, all hides and skins (including those of yaks) that have been properly dried, chilled, salted or frozen can all be processed successfully into leather. In Mongolia, for the foreseeable future at least, freezing is likely to remain the most appropriate method of preservation for the bulk of yak hides (those produced in the winter). For the smaller proportion on hides produced throughout the rest of the year, suspension drying or salting is likely to remain popular. However, it is important that tannery processes – especially the initial beamhouse operations – are appropriate for the raw material. For example, dried hides and salted hides require very different soaking procedures.

4. LEATHER MANUFACTURE

4.1. General

Almost all countries have livestock resources for meat and/or milk production, so hides and skins are available everywhere. In some places the hide or skin is left on the carcase and consumed as '*meat*'. Elsewhere even after flaying, the hide or skin may be consumed as food, but is most often destined for use in the leather trade. Other uses for hides and skins – immediately, or as waste materials from tanning – include the following:

- gelatin manufacture (for the food industry, pharmaceutical capsules, and – historically – photographic film),
- cosmetics,
- fertiliser, and
- pet food.

But, the production of leather, and the manufacture of leather products, accounts for the bulk of hides and skins used globally.

At the centre of the leather value chain are the tanneries, of which there are four main sorts based on their types of production:

- pickled pelts,
- wet blues, wet whites, etc.,
- dry (crust) leathers, and
- finished leathers.

The first two sorts of products in particular are responsible for the generation of considerable quantity of effluent and other wastes; but are very easy to sort and grade. They are, accordingly, a popular choice of raw material for tanneries engaged in finishing operations only. Much of Mongolia's resources of hides and skis are processed as pickled pelts and/or wet blues, and exported. Thereafter, tanneries may be differentiated by the type of:

- raw material used (cattle hides, sheep skins, etc.),
- tannin engage in (mineral, vegetable, etc.),
- end product (full grain premium leather, corrected grain utility leather, etc.), or
- application (shoe upper, garment, etc.)

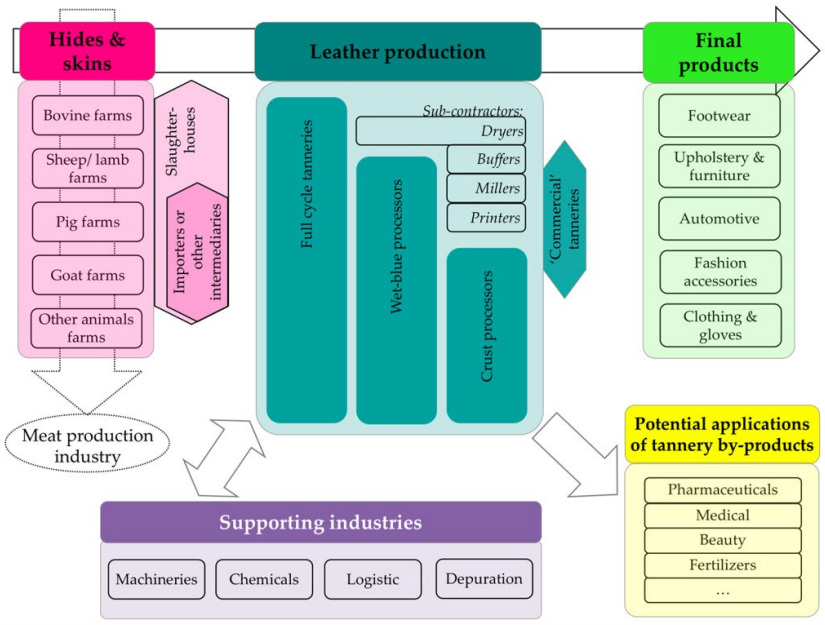


Figure 12. Global leather value chain. De Marchi and Di Maria, 2019.

Some tanneries may not specialize so much, but use a variety of raw materials and produce a range of leather products.

4.2. Beamhouse Operations

Beamhouse operations transform hides and skins, into a material that can be tanned; by removing material that cannot be tanned, and changing what remains. For example, hair (wool or fur), epidermis, flesh and fat cannot be made into leather and must be removed from hides. Moreover, the remaining (leather-making) network of collagen fibres within the dermis must be '*opened up*' to facilitate the entry of relatively large vegetable tannin molecules, and to provide for a softer texture. Conventionally, the main beamhouse operations are:

- **soaking/rehydration**; to restore something like material's original state, and to clean,
- **fleshing**; to remove of residual flesh and superficial fat,
- **liming**; alkaline hydrolysis to detach/destroy epidermis and hair (wool or fur),
- **unhairing**; to remove hair loosened during liming,
- **trimming**; to extraneous material,
- **splitting;** to remove surplus material from flesh surface,
- **deliming**; to restore neutral pH of material,
- **bating**; enzymatic degradation of interfibrillary material of dermis to increase porosity/softness,
- **pickling**; acidification to facilitate tanning (and/or provide for temporary storage)

The details of particular beamhouse operation will vary according to:

- type and size of material,
- method of preservation,
- nature of subsequent tanning and finishing operations, and
- type of leather to be produced.

For example, dried yak hides to make shoe sole leather and salted yak skins for garments manufacture will require very different treatments in the beamhouse.

Inevitably, beamhouse operations produce a lot of physical waste; such as: flesh/fleshings, fat, hair, trimmings and splits. In addition, the operations account for the bulk of many emission (usually in the form of waste water) including more than three-quarters of the chemical oxygen demand (COD) and biological oxygen demand (BOD). Conventional beamhouse operations are so '*dirty*' that many tanneries prefer to avoid them completely, by purchasing relatively cleaner, semi-processed raw materials (pickled hides or skins) from tanneries that engage in beamhouse operations only.

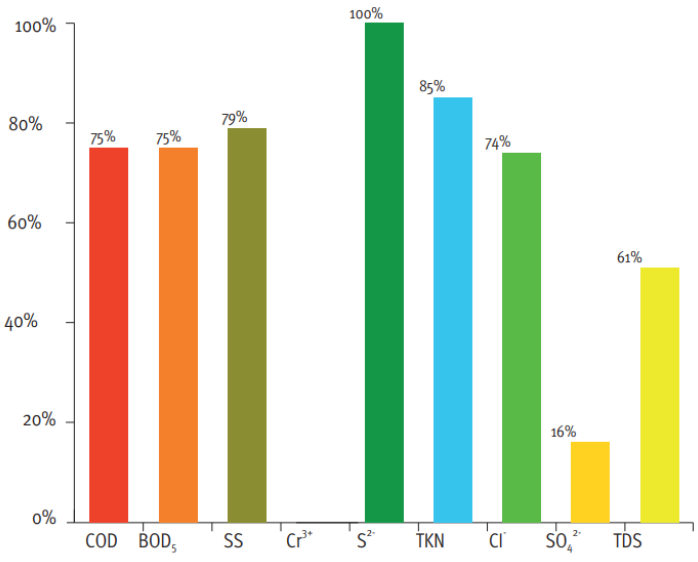


Figure 13. Beamhouse emissions in tanning. UNIDO, 2018.

4.3. Vegetable Tanning

Tanning (transforming hides and skins into durable, rot-resistant material - leather - suitable for various applications) can be accomplished with any one (or a combination) of chemicals. For thousands of years vegetable tannins were used almost exclusively, but were largely replaced during the Industrial Revolution in the nineteenth century, by mineral tannins (based on use of chromium). Chrome tanned leathers are easy and quick to produce, but are not so environmentally-friendly. Recent developments, such as better understanding of the chemistry of vegetable tannins and greater appreciation of their environmental benefits, have led to a resurgence of organic, vegetable tanning. So far, in Mongolia, materials like mimosa and quebracho have been used, but these have to be imported, so more attractive alternatives are currently being sought. One such possibility is sea buckthorn.

There are at least seven species and 11 subspecies of sea buckthorn (also referred to as sandthorn, sallowthorn or seaberry) but the total of breeds and cultivars may exceed 150. The most important species commercially is *Hippophae rhamnoides*. The plant is widespread in Mongolia with 6,686ha being cultivated in 2021 - and plans (in 2022) to increase this to at least 20,00ha – with considerably more growing wild. The berries have long been valued (particularly for their high Vitamin C content) and various parts of the plant have been used for traditional medicine and animal feeds. More recent applications have included the manufacture of cosmetics, and possibly vegetable tanning. Various sources report the leaves contain about 0.1 to 0.8% tannin dry weight basis

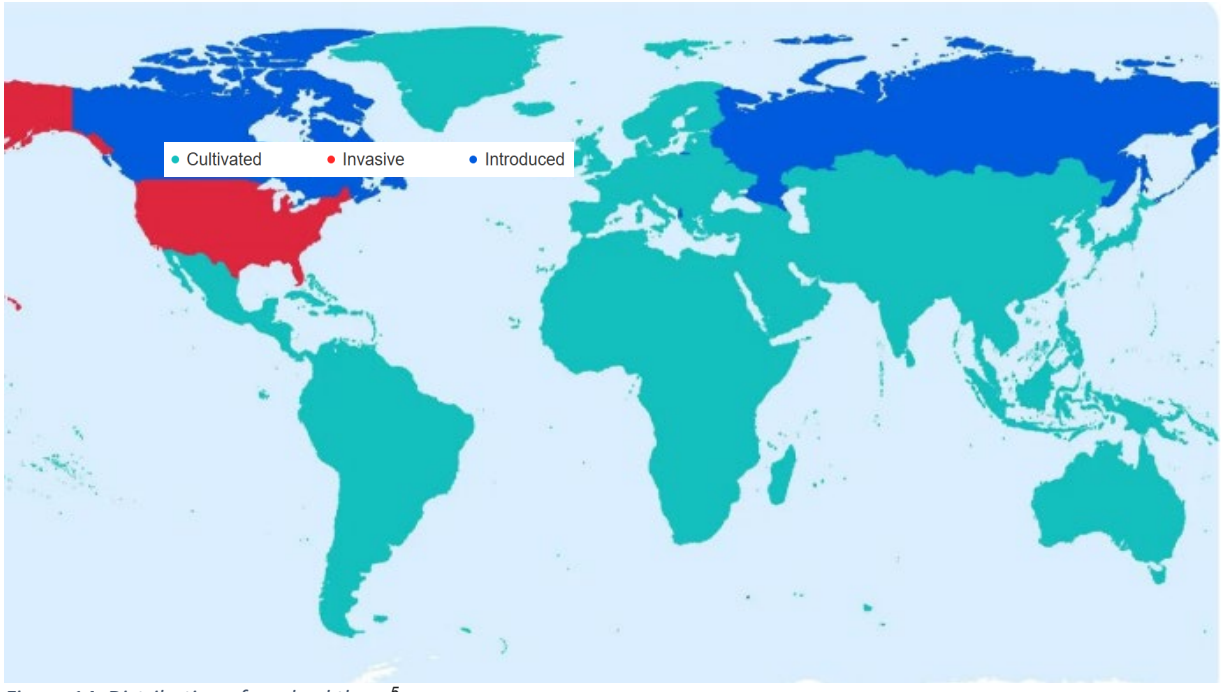


Figure 14. Distribution of sea buckthorn[5].

Though the tannin content of sea buckthorn leaves is lower than some other already-used commercial sources, utilization of the plant is particularly interesting in Mongolia because:

- it is ideally suited to many areas which are too cold or too arid for anything else,
- it offers scope for improvement/modification based on genetic selection,
- it is already being promoted for other purposes (e.g. land reclamation, habitat protection, wildlife conservation, etc.),

[5] https://www.picturethisai.com/wiki/Hippophae_rhamnoides.html

- the locally sourced tannin (for use by the domestic leather industry) would offset the need for imports of traditional tannins, and
- like '*Uvs Chatsargana'* sea buckthorn berries from Uvs province - registered in the EU as the first *Protected Geographical Indication* (GI) from Mongolia in 2022 – other sea buckthorn-related products offer scope for trade protection under GI.[6].

Confirmation of the utility and commercial viability of sea buckthorn tannins, would provide scope for the development of wholly '*made in Mongolia'* leather and leather products.

4.4. Finishing

Yak hides that have been vegetable tanned may be described as '*leathers'* but are not yet suitable for the manufacture of leather products. Fresh, vegetable tanned leathers are likely to be:

- wet,
- variable in thickness,
- of one, predetermined colour, and
- without lubrication (oiling, fat liquoring)

Used without further processing ('*finishing'*), the products made from such vegetable tanned leather would be hard, brittle, uncomfortable and unattractive. Finishing includes a wide range of physical and chemical process, designed to improve one or more characteristic of the leather. Finishing processes are directed at:

- thickness, e.g. splitting and shaving,
- colour, e.g. dyeing and painting/spraying,
- feel, e.g. fat liquoring, oiling, waxing, staking, etc.,
- water tolerance, e.g. water proofing, water resistance, stain resistance, etc.
- abrasion tolerance, and
- texture e.g. buffing, binding, plating, embossing etc.

Many of these processes overlap, such as the softer '*feel'* of thin, well fat-liquored leathers, and the feel of leather after finishing, will be determined to a large extent by variations in the operations before and during tanning. For example, prolonged liming and bating will tend to provide softer leathers. Conversely, some finishing processes are difficult to reconcile with other desirable features of the leather. For example:

- waterproofness, and permeability to water vapor), and
- some particular colours, and light fastness (resistance to fading).

Moreover, some chemicals used in particular finishing processes, may be incompatible with some others used earlier in the leather manufacturing process; leading to stains, bleeding and/or precipitation. While most finishing processes can be completed soon after tanning, by the leather manufacturer, they may also be postponed and/or undertaken by the leather products manufacture; especially in the case vegetable tanned crust leathers. Because of the large range of potential finishing processes, and the diverse requirements of customers, most tanners will hesitate to '*finish'* a particular batch of leather until they have a confirmed customer. And, at any one time, a tannery

[6] https://montsame.mn/en/read/294841

might be producing very different types of *'finished'* vegetable tanned leathers; ranging from thick, hard, dense and waterproof shoe sole leathers, to thin, soft, open and stain resistant material suitable for making garments. In many instances, the performance of a particular type of finish for the leather may be specified by the producer or the consumer. So, for example, the leather to upholster a chair may be required to exhibit a rub resistance is excess of 40,000 cycles[7].

4.5. International Standards

Most aspects of finishing are a matter of mutual agreement (usually based on a contract) between the producer (tanner) and the consumer (leather products manufacturer). But, like many other materials traded internationally '*leather*' - including '*vegetable tanned leather'* - is defined in standards. ***'Leather'*** is '*Hide or skin with its original fibrous structure more or less intact, tanned to be imputrescible … and where any* ***surface coating*** *or surface layer, however applied, is not thicker than* ***0.15 mm'***. (IS0 15115;2019 Leather vocabulary). That is, anything more than a thin (less than 0.15mm[8]) film of pigment, binder etc. on the top of tanned hide or skin would normally disqualify it from being called leather. If the surface layer (finish) is more than 0.15 mm the material must be designated as ***'coated leather'***. And where:

- the coating exceeds one third of the full thickness, and/or
- the original hide or skin protein has been replaced or reconstituted.

a whole range of names may be used to describe the **non-leather** material, including: synthetic (faux, imitation or vegan) leather, leatherette, fleather and any one of a variety of proprietary names (Corfam©, Clarino©, Porvair©, Rexine©, etc.).

Within the category of 'leather' it is possible to qualify the material in a number of ways, but the most common are full grain and corrected grain.

Leather, Full grain. This is generally accepted to be material that has been tanned with retention of the original grain surface (only the pelage and epidermis removed) with no abrading of the surface and/or application of pigments and/or binders to obscure the grain pattern. The use of water soluble (originally *'aniline'* based) dyes provides aniline (full grain) leathers. Where very small amounts of pigment and/or binder are applied (without obscuring the grain pattern) the product is described as semi-aniline (full grain) leather.

Leather, Corrected grain. This is generally accepted to be material that has been tanned without retention of the original grain surface. In addition to removal of the pelage and epidermis, abrasion is commonly used; to reduce discrepancies (such as the protrusions of scars) in of the surface and/or facilitate the application and adherence of pigments and/or binders to obscure other irregularities in the grain pattern.

Leather; Corrected, Coated and Non-leather. When viewed from above – looking only at the painted (pigmented) surface of 'corrected/coated' leathers, and synthetic materials, it is essentially impossible to tell which is which. Closer examinations (using low power magnifications) and laboratory tests and analyses may be required.

[7] **ISO 17700:2019** Footwear — Test methods for upper components and insoles — Colour fastness to rubbing and bleeding

[8] About the same as the thickness of A4 paper; and equivalent to about 8% of the thickness of leather for men's shoe uppers.

5. LEATHER PRODUCTS

For thousands of years, vegetable tanned leather provided a convenient raw material for the manufacture of a wide range of items.

Table 1. Examples of products made using leather.

Category	Example	Category	Example
Binding	Books	**Miscellaneous**	Bag
	Boxes, etc.		Ball (cricket, soccer, etc.
Footwear	Boots		Belt
	Sandals		Cup
	Shoes		Gloves
	Slippers		Hat
	Socks		Key fob
Furniture (Upholstery)	Chair		Purse
	Pouf		Sheath (knife)
	Sofa		Strop
	Stool		Wallet
	Table (top, inlay)		Water bottle (skin)
Garments	Apron	**Horse tack**	Bridles
	Coat		Halter
	Jacket		Reins
	Shirt		Saddle
	Shorts		Stirrups
	Skirt		Whips
	Tie	**Souvenirs**	Miscellaneous
	Trousers		
	Waist coat (vest)		

Only relatively recently, did vegetable tanning lose it pre-eminence to mineral (chrome) tanning; because the later was: simpler, faster and provided a more heat-resistant material that was more suitable for industrial processing. Even though many traditional leather products have been replaced by mineral tanned material – or synthetics – all can still be made with vegetable leather. And vegetable tanned leather products are often considered more desirable, luxury items, and priced accordingly. And just as mineral tanned leather replaced vegetable tanned leather for the manufacture of many products, so too is mineral tanned leather susceptible to replacement; as in the case of footwear (where it is estimated a quarter of production (22.2 billion pairs in 2021) is based on synthetic materials

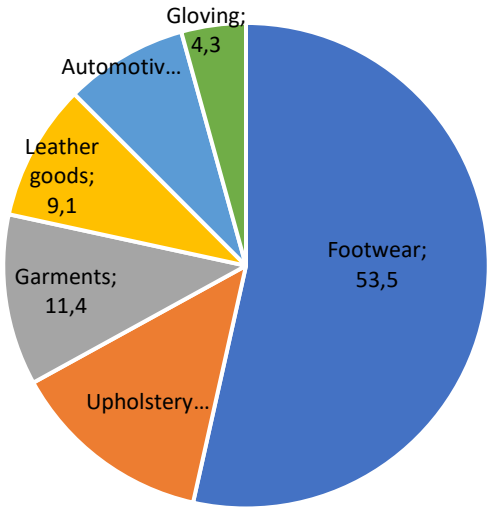


Figure 15. Leather products manufacturing, %. De Marchi, V. and Di Maria, E., 2019.

In theory, almost any type of hide or skin can be used to make any type of leather; and hence, any type of leather product. However, in practice, there are a number of considerations to bear in mind, such as:

- Larger hides and skins are generally preferred by tanners because they provide for efficient handling and may provide less waste during cuttingly of components for leather products. However, larger hides and skins usually come from older animal which are likely to have accumulated more pre-slaughter lesions.
- Heavy, thick hides are particularly suited to making shoe soles. A thin (grain) split from a thick hide would consist mainly of the weak (vertically oriented collagen fibres) of the papillary layer making it unsuitable for thin, shoe uppers.
- Large area cattle hides (especially those from intensive livestock production) are particularly suited for upholstery (where large panels are often preferred).
- Heavily wooled sheep skins are not suitable for making garment leather; the skin may exhibit wrinkles (due to the weight of wool), unattractive grain pattern (because of the very fine wool follicles) and the leather weak because of voids after degreasing.

Figure 16. Yak hide coracle in Tibet[9].

With vegetable tanned yak leather in Mongolia, the sorts of products that seem most suited for domestic production (initially at least) are smaller, more intricate, hand-finished items, such as: belts, sandals, bags, etc. Even something as simple as a leather belt can be designed with very different markets (and consumers) in mind. Belts are among the simplest leather goods to manufacture, and may be constructed from just one piece of material. However, using some ingenuity, and various other techniques, very complex and sometimes expensive variations can be produced. The following illustrations show a progression in some of the many designs available for men's belts.

[9] https:/commons.wikimedia.org/wiki/File:Airport5.JPG

Traditional buckle

Clasp fastening

Figure 17. Men's belts; simple to very complex designs.

Basic lacing

Advanced lacing

Intricate lacing

Braiding

Figure 17. Men's belts; simple to very complex designs. continued.

Braided belts require almost the same amount of material but – because of the extra labour involved – demand much higher prices. Other variations in the design and construction of belts include: use of debossing, embossing, engraving, colouring and so on. And similar comments apply to other leather goods, such as purses, bags, wallets, garments and so on.

Variations in the particular type of tanning process, provide a very wide selection of leathers; ranging from soft, thin lightweight fabrics, to hard, thick heavyweight board-like material. In some cases – such as the upholstery of traditional dining chairs – the vegetable tanning is deliberately incomplete; leaving a raw untanned middle layer which becomes very hard when dry (thereby contributing to the integral strength of the chair). The following illustrations show a range of chairs constructed with vegetable tanned leather for the seating component.

Traditional dining chair. [10]

Butterfly chair. [11]

Figure 18. Chairs constructed with vegetable tanned leather

Modern lounge chair. [12]

Modern armchair. [13]

Figure 18. Chairs constructed with vegetable tanned leather, continued.

One leather product that remains popular and useful in Mongolia is the traditional saddle. Almost all the quarter of a million herder households in the country possess some of the 4.8 million horses, many of which are working animals. Western saddles are increasingly popular in the country; especially for use by tourists engaging in trekking. Such saddles may require about 1.5 to 2.0m^2 of leather - preferably vegetable tanned – to make. The base prices of Western saddles are MNT15.7 to 26.1 million ($4,500 to 7,500) and, heavily decorated (embossed, debossed, and/or engraved) Western saddles may retail for considerably more.

Figure 19. Mongolian horseman and tradition saddle. Source; D. Miller.

[10] https://i.ebayimg.com/images/g/7p0AAOSwBFtbcy9I/s-l400.jpg
[11] https://i.etsystatic.com/iap/9c0c29/2162525041/iap_300x300.2162525041_kb2yxin0.jpg?version=0
[12] https://s7d1.scene7.com/is/image/Lumens/MATP205590_alt02?fit=constrain,1&wid=260&hei=260&fmt=jpg
[13] https://www.wisteria.com/Products/T21729_01.jpg?resizeid=3&resizeh=750&resizew=750

Figure 20. Western saddles … … on Mongolian horses. Source; S. Schmidt. Stone Horse Expeditions.

6. SORTING, GRADING AND QUALITY

References to '*sorting', 'grading'* and '*quality*' occur throughout the yak leather value chain; with comments ranging from '*what **sort** of hides are those?*' to '*those leather shoes are good **quality***'. But, in practice, proper attention to these is complicated by misunderstandings, related to:

- what the terms mean,
- how and when sorting and grading should to be undertaken, and
- how information from sorting and grading can (and should) be used.

'*Sorting'* and *'grading'* are often used interchangeably, but (in this document at least) the terms mean, classifying things based on only one - or more than one - characteristic respectively. For example, raw materials (hides and skins) are sorted by type: cattle hide, yak hide, sheep skin, etc. Moreover, one sort of hide (yak) can be re-sorted by size (large, medium, small, etc.). When raw materials are graded, the process involves consideration of two or more characteristics. For example, second grade hides will contain a variety of defects (holes, cuts, stretches, etc.) which – combined – make them better than a third grade hide, but not as good as a first grade hide. Different **sorts** of yak hides include, for example: ground dried hides, salted hides, large hides, small (calf) skins, etc. Among a particular **sort** of '*large, dried, yak hides',* for example, there may be different **grades**, such as: *Grade I* (free of - visible - lesions), *Grade II, Grade III, Grade IV*[14] and *Rejects*.

Sorting is very important to tanners because certain types of raw material are more suitable for making certain types of leather and leather products; e.g. heavy yak hides are very good for making vegetable tanned leather for shoe soles. Sorting is also important in providing for batches of similar material, which can be processed collectively. Tanners do not (or should not) process heavy, dried yak hides along with small, salted yak skins. Grading is very important to tanners because it affects the:

- type of leather, that may best be produced, and
- yield of leather.

Most hides and skins are processed to provide one of three main types of leather:

- full grain,
- corrected grain, and
- coated leather.

Only the best raw material – free of significant lesions – is used to make full grain leather; widely accepted to be superior to corrected grain leather. Hides and skins with significant lesions require more expensive processing ('*correction*') - including the application pigmented coatings and embossing - to obscure damage. And the worst lesions may even have to be trimmed and discarded; adversely affecting the yield.

No magnification

10x magnification; using phone's camera. Grain pattern (including hair follicles) very obvious.

Figure 21. Unfinished 'crust' leather

[14] Sometimes 1, 2, 3 and 4.

Though even bad leathers made from the worst hides and skins (third and fourth grades), can be corrected with additional (remedial) processing, including the application of pigments and binders (accompanied by embossing) the result is usually inferior (in terms of perception and price).

No magnification

10x magnification; using phone's camera. Grain pattern (including hair follicles) no longer obvious.

Figure 22. Finished 'corrected grain' leather

Given the common practice of using '*better*' grade raw material (firsts and seconds) to make '*better*' leather (full grain), it is easy to equate '*grading*' with '*quality*'; where '*quality*' is a vague, subjective opinion of a person's preference/s meaning '*superior/better*'. But, again, the two items are different, and '*quality*' is better understood as '*fit for purpose*'. For example, if a tanner wishes to make low cost leather, to manufacture industrial gloves, the best quality (best operational fit) would be lower priced Grade 4 raw material. Conversely, Grade 4 raw material would be the worst quality (worst operational fit) for a tanner expecting to make full grain leather for the high fashion market.

References to quality need to be used correctly, and in context, to avoid misconceptions and mistakes. For example, simplistic comments like '*the quality of yak hides is good*' are not very helpful because they prompt questions like:

- which particular sort of yak hides; large/small, frozen/dried, domestic/imported, etc.?
- which particular grade of yak hides; 1, 2, 3, 4 or Reject?
- for which particular type of leather; full grain, corrected grain, coated?
- for which particular type of leather product; footwear, garments, goods? and
- in terms of yield, tensile strength, etc.

For example, small skins of yak calves are not very suitable for making upholstery leather, destined for (large) items of furniture. In this case, the quality of small yak skins for making large upholstery leathers is inadequate; '*bad', 'unfit-for-purpose'*. There are many types of raw material, some of which are more (or less) suitable (better-fitted) for one or another of the many types of leathers and leather products. To provide for the best fit between the raw material and the leather (and leather goods) to be produced, it is necessary to sort and grade; and not just once, but throughout the tanning process.

Invisible Lesions

With the very limited time and effort available to examine and grade hides and skins, it is not possible to devote resources to time-consuming inspections and/or expensive tests and analyses.
An example of a serious pre-slaughter lesion that is invisible during grading is the highly soluble collagen of immature calf skins.
An example of a serious post-slaughter lesion that is invisible during grading is early stage (prior to '*hair slip*') putrefaction.

While sorting is relatively easy and accurate, grading of raw/preserved hides and skins is complicated because so many of the lesions that are likely to be present are obscured by the overlying pelage (on the top of the hide or skin) and flesh and fat of the hypodermis underneath. Typically, the only lesions to be seen on hides and skins are holes, deep cuts, serious abrasions and so on. Innumerable other things will not be obvious; e.g. small scratches, scars, wrinkles, etc.

Table 2. Guidelines for Grading Skins. UNIDO, 1991.

GRADE		Defects					
		Health, diseases, tumors, etc.	Marks, brands, paint, etc.	Insects, para-sites, cockle, ticks, etc.	Wounds, holes, cuts, scrat-ches, etc.	Putrefaction, hair slip, read heat, etc.	Dirt, dung, urine, seeds, sand, etc.
1st	Location	1-2	1-2	1-2	1	0	0
	Concent.	1	1	1	1	0	0
	Depth	1	1	1	1	0	0
	Surface	1	1	1	1-2	-	0
2nd	Location	3	3	3	2-3	1-2	1-2
	Concent.	1	1	1	1	1	1
	Depth	1	1	1	1	1	-
	Surface	1	1	1	1-2	1	1
3rd	Location	3-4	3-4	3-4	3-4	3	3-4
	Concent.	2	1	2	2	2	1
	Depth	2	2	2	2	2	-
	Surface	1	1	1	1-2	1	1
4th	Location	3-4	3-4	3-4	3-4	3-4	3-4
	Concent.	2	2	2	2	2	2
	Depth	2	2	2	2	2	2
	Surface	1-2	1	1-2	1-2	1-2	1-2

Many counties have adopted national standards for the sorting and grading of hides and skins. Most use four or five categories for the latter; namely: *Grade I* ('*perfect*'), *Grade II, Grade III, Grade IV* and/or *Grade V* ('*reject*'). Superficially, it seems very easy to specify the criteria for each of the grades. During project work in eight countries of Eastern and Southern Africa (Ethiopia, Kenya, Malawi, Somalia, Sudan, Tanzania, Zambia and Zimbabwe) a 44- page grading guideline was developed (UNIDO, 1991).

Unfortunately, the *Guideline* was an incredibly complicated combination of different '*defects*' and different locations; and it seems not to have been adopted. Even if hides and skins traders had the time and inclination to use such a system there would be many lesions they could not possibly observe. Accordingly, in practice, when grading is used for raw materials, it is inevitably:

- very quick,
- very crude,
- norm-referenced, rather than criterion-referenced, and
- ultimately only a very rough indicator of leather making potential.

Despite the potential value in grading raw material, it is rarely worth spending more than a few seconds scrutinizing each piece, because most significant lesions (those affecting the leather-making potential) will not be visible even with careful examination. Accordingly, most hides and skins (if they are graded) are done so on a relative basis; with the best ones categorized Grade I, and the worst

Grade IV (or Reject), and the rest in-between. During processing of yak hides in a tannery (personal communication), it was reported that only 8% of raw materials on offer at a hides and skins market in Ulaanbaatar, were acceptable for tanning. Most (85%) were adversely affected by deep cuts and holes.

During the course of tanning, grading becomes more useful, because the overlying hair/wool and epidermis are removed and the '*grain*' is easily visible. At this point, it becomes worth spending more time examining the materials; selecting those without significant lesions (Grade Is) for the manufacture of full grain leathers, and the rest for production of corrected grains (to obscure the defects). Because the lesions on the pelt or leather are clearly visible, it is common to use absolute grading, rather than relative methods. Moreover, computer-based optical scanning systems provide scope for very rapid grading of semi-processed and finished leather Because so many more of the lesions can be seen (affecting different areas) during tanning, it is common to use more classes (Grade 1 to Grade 7) as well as '*Rejects*'. Accordingly, it is possible for tanners (such as those receiving hides and skins with widespread pre-slaughter defects) to never have a leather that qualifies for Grade I during processing; while most of their materials are lower grades.

There are four ways that tanners can mitigate problems associated with the inaccuracies of the grading of their raw material:

- receive small (test/trial) batches of raw material, and (if acceptable) require future supplies to be similar,
- purchase raw materials from regular suppliers, where the characteristics of the raw material are better known and unlikely to change much,
- purchase larger quantities of raw material than they really need (to obtain the portion of a particular grade they require) and use the rest for other purposes (or sell on to others), and
- purchase semi-processed materials (without the overlying hair or wool) where the grading is much more likely to be correct/accurate.

There are no documented examples – in Mongolia – of the grades of leathers provided by particular grades of raw material. In other countries, the results have shown (counter intuitively) that Grade I hides, do not always provide only Grade I leathers, or vice-versa. Grading of raw hides and skins, is acceptable for confirming the presence/absence, prevalence and location of obvious lesions (such irregular shape, perforations, brands, etc.) but it is of little value for confirming the presence/absence, prevalence and location of equally important – but less obvious - leather making features (such as fine scratches, most parasite damage, age-related wrinkles, etc.)

In Mongolia, during 2018 to 2019, 662 pieces of yak hides – in various stages of processing – were inspected at two of the country's major tanneries.

Table 3. Lesions observed while grading yaks, during tanning. UNIDO, 2019.

Material	**Tannery**		**Lesion, origin**		
	Darkhan Nekii	**Darkhan Minj**	**Pre-slaughter**	**Peri-slaughter**	**Useable area**
Hides, defrosted	130			68.0%; tears, cuts, holes and/or fleshing damage.	
Hides, lime split		80	1.3% parasites, 1.3% scratches, & 71.0% wrinkles.	95.0%; tears, cuts, holes and/or fleshing damage.	

Leather, wet blue	114		22.0% parasites, & 4.4% wrinkles.	46.0%; tears, cuts, holes and/or fleshing damage.	
		188	11.0% combing, 2.7% wrinkles & 33.0% scratches.	61.7%; tears, cuts, holes and/or fleshing damage.	
Leather, crust	150		4.0% parasites, 3.0% combing & 21.0% wrinkles.	53.7%; tears, cuts, holes and/or fleshing damage.	64.3%
Total	**394**	**268**			

Pre-slaughter lesions - parasites, scratches, combing scars and age-related wrinkles - were prevalent on up to 71.0% of all pieces. Tears cuts and holes, attributable to improper flaying and fleshing, were visible at all stages of the tanning process, and affected at least a half (46.0%) of all pieces. Overall, as much as one third (35.7%) of the crust leather surface was adversely affected by lesions. Inspections of batches of sheep skins and cattle hides being processed during the same time revealed lesion-related damage across 15.1 to 24.0% of the area, and 13.0% respectively.

Examples of some of the lesions commonly observed on yak leathers are as follows.

Figure 23. Vegetable tanned yak leathers; with age-related wrinkles, and miscellaneous scars. Photographed with phone camera

These are more often referred to as '*defects'*; and widely considered to be avoided, and or rejected. But their impact upon leather quality - and the marketing of products derived from affected leathers - is not so obvious. For example, most perforations, holes and deep cuts, are certainly defects, and will render affected areas of leather unusable. But, a perforation in the area of the backbone of a hide may '*disappear*' when the piece is cut into two sides, and may therefore not be a defect (as it would anywhere else on the hide). Similarly, cuts will only be defects if they are deep enough to penetrate what will ultimately become a grain split (the upper two millimetres or so of a leather). The significance of other lesions will depend mainly upon their location, size and how recently they were incurred. For example, large, unhealed marks (brands, insect bites, scratches, etc.) are likely to be unsightly in the finished leather and would therefore be considered defects. However, smaller, healed scars of various types might not be considered defects.

Scars often become more visible during tanning (because of their different uptake of chemicals) and are likely to affect the results of some physical tests. However, their appearance is often appreciated by consumers, as a sign of the naturalness of the leather. Signs of some parasite damage on leathers may even be considered evidence of the limited use of (sometimes) environmentally harmful chemicals. This is not to say that pre-slaughter treatment of livestock (with appropriate chemicals) to control pests should be avoided. On the contrary, proper animal husbandry is essential for animal

welfare and public health. From the tanners' point of view, it is important to consider objectively, whether a lesion on a hide, skin or leather, is:

- a defect, likely to detract from utility and value in the finished product, or conversely
- a potentially attractive feature of a product's naturalness.

The '*natural*' look – of products with features which might previously have been considered defects – has long been exploited in the furniture business (e.g. wood with artificial, worm holes, etc.) and clothing (e.g. stressed fabrics, etc.). Interestingly, an internet search of *'aging'* – an issue that affects all products – currently provides more items on how to promote it in leather, with very few on how to prevent or reverse it. In many leathers age-related '*patina*' is highly appreciated and valued.

In conclusion, sorting and grading allow tanners to manage their operations more efficiently and effectively. But, to be undertaken properly, grading in particular requires knowledge of what is desirable and/or undesirable in finished leather products; i.e. quality. This requires feedback based on marketing requirements coupled with quality assurance.

7. QUALITY ASSURANCE; CHEMICAL ANALYSIS AND PHYSICAL TESTING

Historically, attention to simplistic, contemporary understanding of quality was often limited to the identification and removal of defects, or defective products; i.e. *quality control*. This developed into a much more proactive system, concentrating on preventing defects before they occur - i.e. quality assurance – and ensuring conformance with specification and/or standards. This implicit, broader attention to markets in general and customer satisfaction in particular, is now described as total quality management (TQM). It is generally accepted that quality is no longer the responsibility of a quality control department alone; most people within a company (directly or indirectly) affect the company's quality of production and products.

Figure 24. Components of TQM.[15]

Throughout developments in the scope of quality, information from chemical analyses and physical testing has remained fundamentally important. Such information is important for:

- basic science of materials,
- identification of any special attributes of yak leathers,
- certification of conformance to specification and standards, and
- research and development (R&D), and innovation.

These and many other studies have revealed many important features of hides and skins, including:

- patterns of topographical variation; such as the higher density of leather-making collagen around the area of the backbone,
- patterns of stratigraphic variation; such as the fineness of collagen fibres in the upper papillary layer of the dermis,
- increased prevalence of preslaughter lesions in materials from older animals and/or animals from subsistence production systems,
- breed-related effects such as the superior grain pattern of hair sheep compared to wool sheep, and
- impacts of nutrition, such as the utility of leathers made from hides and skins of early *vs* late-maturing breeds.

Historically, knowledge of such things has led to special attention for certain types of raw material used for certain types of leather, such as:

- the butt areas of horse hides for men's '*shell cordovan'* upper leather,
- Ethiopian hair sheep skins for sports gloves,
- goat skins for ladies' shoe uppers, and
- dairy cattle's hides for upholstery.

[15] https://www.gbtec.com/resources/total-quality-management/

Yak Leather; Attributes or Anecdotes
'*Due to the adverse living conditions of the animals in Tibet (cold, wind, snow), yak leather is denser in the fibre structure than typical cow leather. Therefore, yak leather requires only half of the thickness to achieve the same heat insulation and toughness of bovine leather.'*
https://www.leather-dictionary.com/index.php/Yak_leather

'Yak hide is generally inferior to that from ordinary cattle. It is loose and uneven in texture and often has holes from gadfly (warble fly) in it.' FAO, 2003.

Is yak leather strong?
'*Yes, yak leather is a very strong leather. Due to the density and strength of its fibers, it is one of the strongest leathers available, similar to kangaroo leather. It can be split thin and still retain much of its strength.'*
https://www.libertyleathergoods.com/yak-leather/

'*Due to the extreme weather conditions the hide of a Yak is more denser in structure than a typical cow. Processing Yak leather is not easy as it has large grease deposits, with the leather becoming more unstable deeper within the hide this results in higher production costs, hence why yak leather is not a cheap product to buy.'*

https://prorestorers.co.uk/knowledgebase/yak-leather/

For some leather products, the differences in raw materials are deliberately exploited, but for the greater part of generic shoes manufacture (specifically the shoe uppers), tanners aim to take a fairly heterogeneous biological material (even after sorting) and produce consignments of more homogenous, sheet-like products that are uniform in terms of:

- physical characteristics: thickness, tensile strength, stretch, rub resistance, water resistance, etc.
- chemical characteristics: tannin content, water content, water resistance, etc.
- aesthetics: colour, appearance, handle (fullness, feel, etc.), smell, etc.

And, all within an increasingly global environment with more attention to fair trade and sustainability. Inevitably, in the quest for consistency, some of the products are at risk of becoming less like full grain leather (or coated leather) and more like synthetic non-leathers.

Despite innumerable opinions - on the possible attractions, and/or special features of yak leather in general, and vegetable tanned yak leather in particular - there is no readily available data or physical and chemical characteristics to support such claims. This is a serious constraint upon the improved promotion and marketing of vegetable tanned yak leather. Pending the provision of such objective information, it is useful to look at some data that is available from the testing and analysis of other leathers.

For example, in one particular study (Ork, et al., 2014) thirty pieces of sheep skin leathers destined for the manufacture of garments, were procured from each of two suppliers. Each supplier provided ten pieces that had been mineral (chrome), ten pieces that had been semi-vegetable tanned, and ten

that had been vegetable tanned. The tanning methods used were reported to be the same. Samples were collected and prepared - according to prescribed laboratory procedures - and then subjected to a range of ten popular tests of leather performance. The results of just one of these - the tensile strength - were as follows.

Table 4. Physical test results of different sheep skin leathers. Ork, et al., 2014.

Measure		**Supplier 1**			**Supplier 2**		
		Mineral	**Semi-veg.**	**Vegetable**	**Mineral**	**Semi-veg.**	**Vegetable**
Sample size (n)		30	30	30	30	30	30
Thickness, mm		0.51	0.59	0.64	0.66	0.56	0.62
Tensile strength N/mm^2	Minimum	3.82	5.81	6.42	3.13	3.91	2.36
	Maximum	9.45	14.83	11.18	14.32	8.04	6.26
	Mean	**6.86***	**10.93**	**8.72**	**5.74*‡**	**6.03‡**	**4.01**
	SEM	0.23	0.37	0.23	0.55	0.17	0.19

Initially, perhaps the most obvious conclusion is that only one of the batches (semi-vegetable tanned leather from Supplier 1) satisfied the generally-accepted minimum tensile strength of $10N/mm^2$ required for garments manufacture.

The second conclusion might be that all three types of leather provided by Supplier 2 were weaker than those provided by Supplier 1. However, use of statistical methods – such as *Student's t-test* – reveals that the tensile strengths of mineral tanned leathers from both suppliers were not '*significantly*' different. Similarly, mineral tanned and semi-vegetable tanned leather from Supplier 2 were not '*significantly'* dissimilar.

Even though both suppliers were reported to have used the same three tanning procedures, it is very possible that the raw materials they used were not equivalent. Certainly, on the basis of these results alone it would be incorrect to conclude things like:

- tanning operation of Supplier 1 are superior to those of Supplier 2, or
- semi-vegetable tanned leathers are stronger than mineral or vegetable tanned leathers.

Tensile strength is only one of a number of important physical characteristics of leathers. Some others – used in another study (Ali, et al., 2020) to identify the existence of any difference between three types of leather from cattle and goat were as follows.

Table 5. Physical test results of cow hide and goat skin leathers. Ali et al., 2020.

Leather	**Raw material**	**Measure**	**Tensile strength, N/mm^2**	**Elongation at break, %**	**Stitch Tear Strength, N/mm**	**Tear strength, N/mm**
Upper	Cow	Test #1	27.8	52.7	95.6	150.0
		Test #2	34.6	31.6	150.9	116.1
		Mean	**31.2**	**42.1**	**123.3**	**133.0**
	Goat	Test #1	25.8	56.8	110.1	60.8
		Test #2	30.1	37.3	69.1	72.2
		Mean	**27.9**	**47.1**	**89.6**	**66.5**
Lining	Cow	Test #1	26.0	31.1	90.2	125.8
		Test #2	25.4	32.0	68.6	134.5

		Mean	**25.7**	**31.5**	**79.4**	**130.2**
	Goat	Test #1	11.3	46.7	62.9	51.4
		Test #2	17.6	41.3	101.4	39.4
		Mean	**14.5**	**44.0**	**82.2**	**45.4**
Suede	Cow	Test #1	23.5	50.0	150.6	139.5
		Test #2	19.4	56.8	214.7	168.1
		Mean	**21.5**	**53.4**	**182.7**	**153.8**
	Goat	Test #1	10.8	50.7	125.1	56.8
		Test #2	13.0	48.7	118.7	45.3
		Mean	**11.9**	**49.7**	**121.8**	**51.0**

Initially, all the results appear to be different to a greater or lesser extent. However, when statistical analyses are conducted only three of the comparisons between cattle and goat leathers reveal '*statistically*' significantly differences; namely:

- elongation at break (cattle and goat lining leather),
- tear strength (cattle and goat lining leather), and
- tear strength (cattle and suede leather).

Three other comparisons look as though they might be different, but (statistically) are not, namely:

- Tensile strength, cattle and goat lining leather
- Tensile strength, cattle and goat suede leather
- Tear strength, cattle and goat upper leather

Based on the above, unsubstantiated comments like '*yak leather is stronger and/or more durable …*' invite questions like:

- What type of yak leather; mineral tanned, vegetable tanned, etc.?
- What type of raw material; bull, cow, calf, old, etc.?
- Stronger and/or more durable than what: cattle (what breed, type, age, etc.)?
- Stronger and/or more durable in what way; tensile strength, tear strength, abrasion resistance, flex resistance, etc.,
- How much stronger and/or more durable; statistically significantly stronger and/or more durable?

Even if it were determined that, for example, in terms of its tensile strength vegetable tanned yak leather was significantly stronger than vegetable tanned leather made from domestic cattle, how useful is this? A widely used minimum requirement for leather to be used to make shoe uppers, is a tensile strength value of at least 20N/mm^2. If vegetable tanned yak leather had a tensile strength value of 30N/mm^2 this might seem very attractive; but is it? Tensile strength is not the only measure of good performance in the manufacture of shoes; other physical test (and chemical analysis) results need to be considered as well. Sometimes, superior performance in one particular measure of leather can be at the expense of another. For example, tensile strength is sometimes (not always) inversely related to elongation at break; as the tensile strength increases the elongation deteriorates.

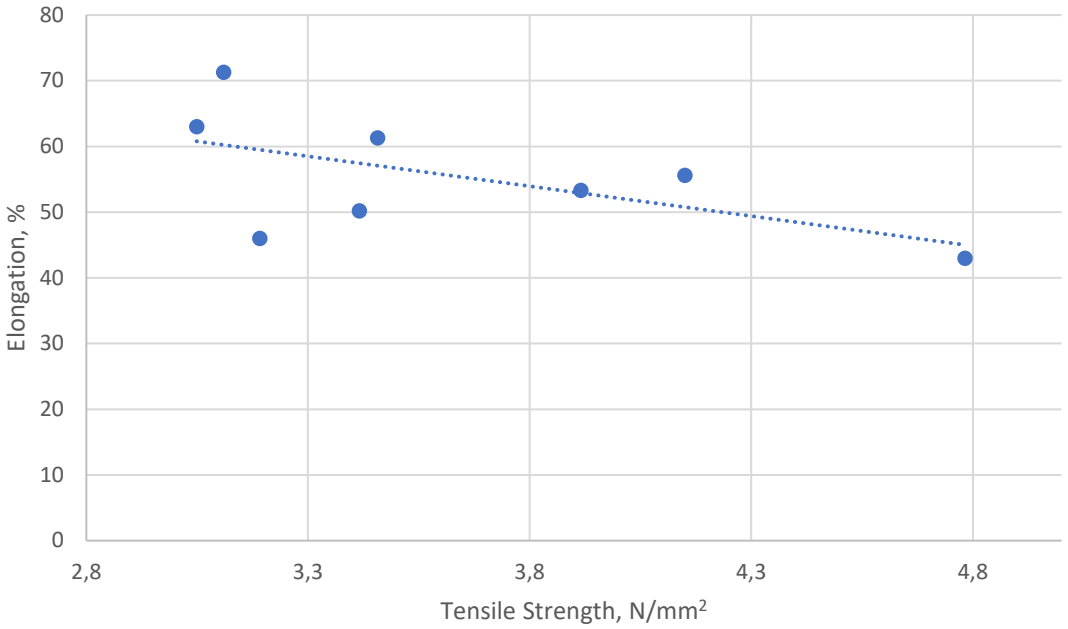


Figure 25. Example of inverse relationship between tensile strength and elongation at break. Ventre, et al., 2006.

The results of testing and analysing relatively small numbers of leathers in a laboratory setting are fundamentally important in the research, development, monitoring and control of tanning operations. This becomes even more important with larger, commercial batches of hides, skins, and leathers (semi-processed and/or finished). Accordingly, recommended procedures include not just the preparation of samples and the way they are tested/analysed, but also the way the samples are obtained. For example, it would be very unwise to base the acceptance (or rejection) of a container load of semi-processed yak hides on the basis of a few samples taken from near the open door. Shipping containers (20 ft or 40 ft) can hold thousands of pieces, and may have been loaded in line with production over a period of week; making pieces at the back of the container much older than those at the front.

For conformance to specifications and standards, there are innumerable prescribed analyses and tests described in International (ISO) and national (MNS) documents. These documents describe:

- how many samples are required to be analysed or tested,
- how samples should be collected for analysis or tested,
- how samples should be prepared for analysis and testing,
- how the sample should be analysed or tested,
- how the results of analysis and testing should be documented, etc

Subject to the availability of more information on the topic, most of the physical and chemical characteristics of yak hides and leathers are likely to be similar to those of cattle, for example. However, one very prominent feature (sometimes fault, or defect) of many vegetable tanned leathers is that of changes in colour. Whereas mineral tanned leathers in general, are usually quite resistant to colour change, vegetable tanned products are well known for fading or (more commonly) darkening over time, and during the course of use. Whether the colour change is to be considered an attractive feature (e.g. patina) and promoted, or an unattractive defect, fault or flaw (e.g. discolouration) to be avoided, will depend mainly upon whether it is an inherent property of the material, or an accident.

Colour changes may occur in leathers due to the deterioration of chemicals (dyes, pigments, fat liquors, etc.). But these are quite rare when proprietary chemicals are used properly (according to manufacturers' recommendations). The exception are vegetable tannins, which – like many complex organic materials – are susceptible to changes related to: age, temperature, humidity, reaction with other chemicals, etc. Irrespective of changes in the vegetable tannin itself, all leathers are susceptible to colour changes caused by: light, abrasion, washing, etc. Accordingly, colour changes can be classified by '*fastness'* (resistance to change) of different types, as follows:

- age-related,
- light; bleaching or darkening,
- rubbing,
- water, etc.

Prescribed procedures for conducting colour fastness tests are described in many relevant standards. In most cases, the final results are determined by comparing the original (untested) sample, against a sample of the same material after testing. The result is usually determined using standard greyscales. The scales consist of nine pairs of references; one of which is always the same. The scales provide half-step ratings: 1, 1/2, 2, 2/3, 3, 3/4, 4, 4/5, and 5. Greyscales provide a simple and convenient measure of differences in colour in terms of shading or contrast.

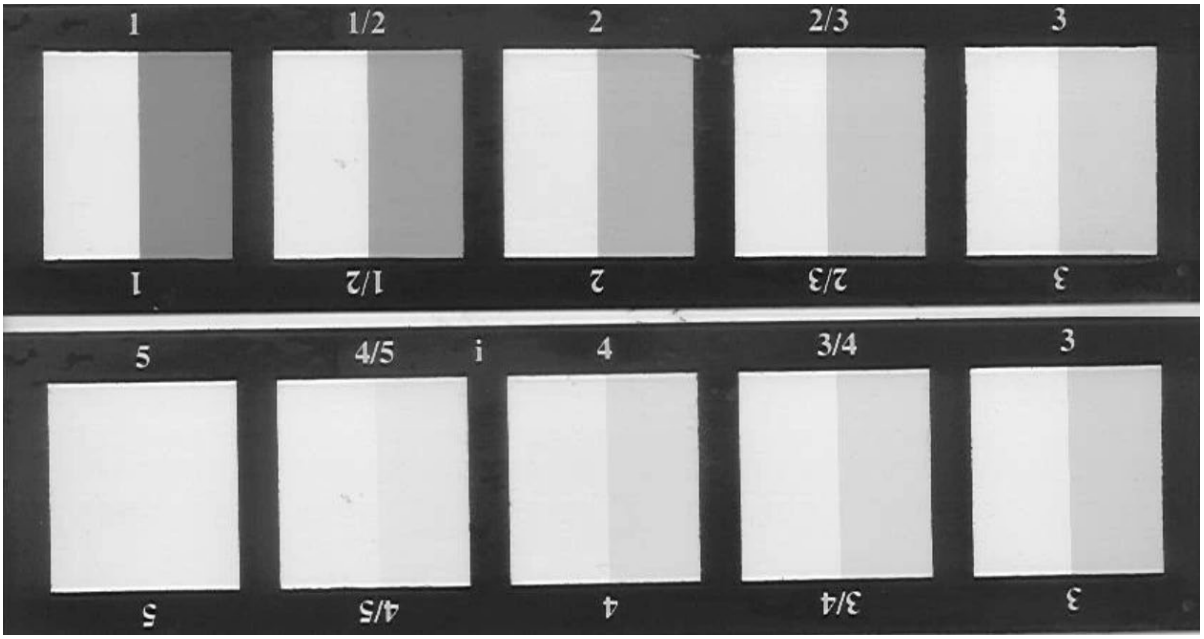


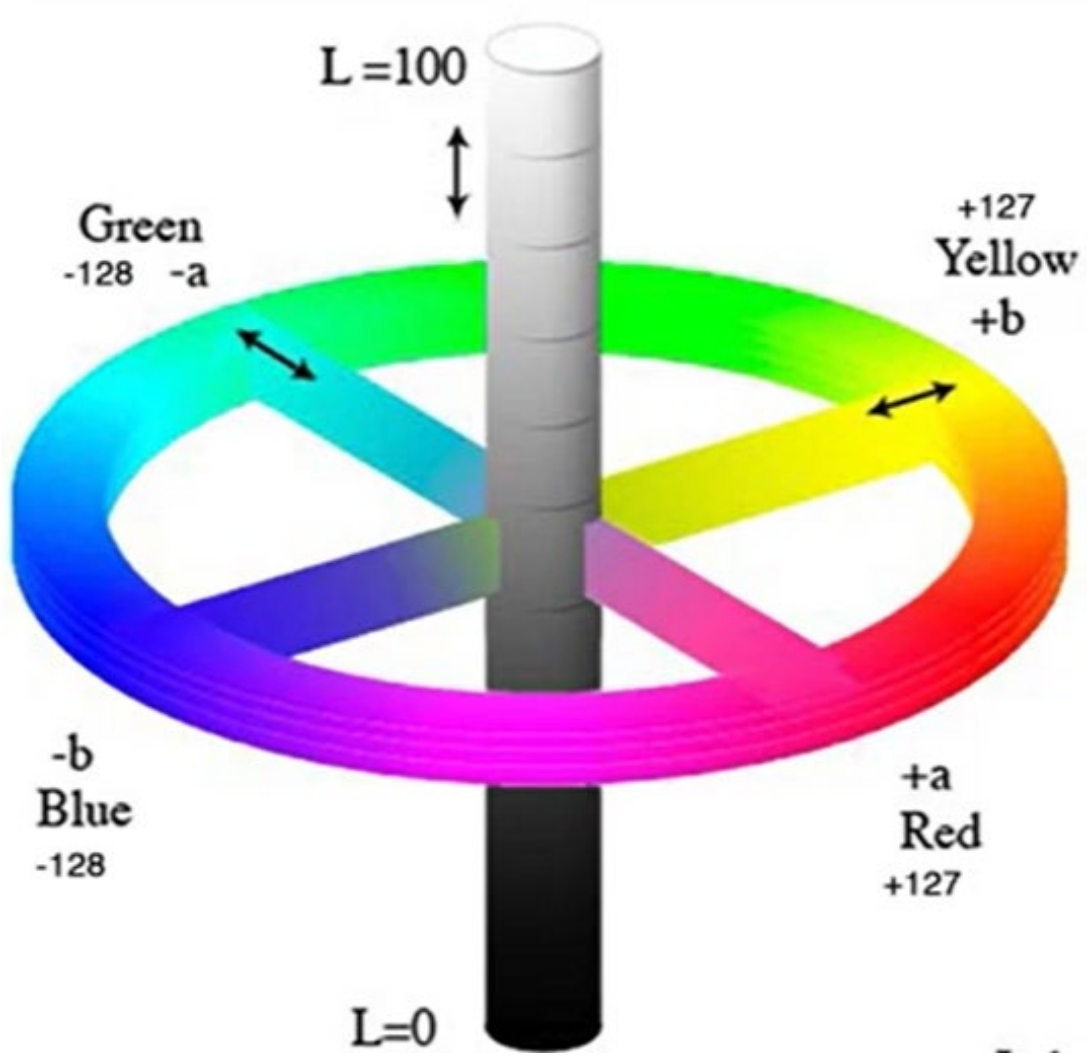
Figure 26. Grey scale.

For more advanced information about colour and colour changes, the *CIELAB colour space* (also referred to as *L*a*b**) is more useful. The *CIELAB colour space* measures colour in three dimensions:

- *L*,* the lightness value, goes from black (0) to white (100),
- *a*,* goes from green (negative values) to red (positive values), and
- *b*,* goes from blue (negative values) to yellow positive values.

Readings around the circumferences indicate different hues, and reading from the centre indicate differences in saturations.

Figure 27. CIELAB colour system.



Measurement of colour using the CIELab system can be conducted very easily and quickly using hand-held devices.

The table below provides the results of experiments where leathers were produced with regular tannins, and tannins that had been chemically modified (to reduce age/light-related colour changes). L* values of the leathers made with unmodified tannins show very little difference in their initial level of lightness/darkness; 69.42 for mimosa and 67.07 for quebracho. All the leathers made with modified tannins are somewhat darker than the same leathers made with unmodified tannins (L* values are decreased). After exposure to light, most of the leathers become darker (L* values decreased). However, leathers produced with modified tannins darkened less (than those made with untreated tannins) and leather produced with mimosa tannin modified by sulphitation) actually became lighter (L* value increased).

Figure 28. CTI colorimeter.

Table 6. Colours of vegetable tanned leathers. Omur and Mutlu, 2016.

Leather	Before			After			dE
	L	a	b	L	a	b	
Mimosa, 0	69.42	8.28	12.21	55.85	17.18	29.51	23.72
Mimosa, 1	46.24	12.25	18.35	42.47	17.94	25.28	9.72
Mimosa, 2	64.28	12.74	19.51	46.59	20.46	29.90	21.91
Mimosa, 3	50.94	10.39	14.56	53.43	13.19	28.45	14.38
Quebracho, 0	67.07	12.20	20.59	51.61	18.63	28.99	18.73
Quebracho, 1	45.77	13.53	19.8	43.1	20.7	27.93	11.16
Quebracho, 2	44.03	17.37	23.34	30.06	16.97	12.75	17.54
Quebracho, 3	63.63	12.30	21.71	51.84	19.27	29.76	15.89

Note. 0 = untreated, 1 = sulphomethylated, 2 = novalac, and 3 = sulphitated.

As with the L* values, data from determinations of a* and b* can also provide valuable information about colour changes. To simplify comparisons, it is convenient to look at the *total colour difference* (dE, or DE) – the three-dimensional separation between samples which is the square root of the sum differences – as in the following equation:

$$dE^* = SQRT[(dL^*)^2 + (da^*)^2 + (db^*)^2]$$

Because the CIELAB colour space is closely related to the way the human eye perceives colour,

- differences in dE values of about 0.5 can sometimes be seen unaided,
- differences in dE values of about 1.0 would normally be visible in regular inspections, and
- differences in dE values of about 5.0 will normally be visible during a casual glance.

Calculation of total colour difference is usually provided by colorimeters and the results can be analysed statistically to determine whether results are *'significantly'* different. In the preceding table, the dE values of leathers tanned using sulphomethylated mimosa or sulphomethylated quebracho are considerably lower than other results. That is, leathers produced using sulphomethylated mimosa or sulphomethylated quebracho exhibited less colour change than others, and the difference was statistically significant.

8. MARKETING

Organisationally, the structure of companies can be divided into a number of core and non-core functions. The nature and scale of the latter – such as human resources, information technology and communications, legal, and so on – are likely to vary according to the particular type and size of the company. Similarly, the core function of companies' **operations** will be very diverse, ranging (in the leather sector) from various types of tanning, to the manufacture of footwear, garments, and miscellaneous goods. Conversely, the core function of **finance** - typically involving payroll, bookkeeping, accounting, etc. – is rather similar in all organisations; though the scale of the work will vary considerably. Uniquely, despite a number of common objectives, the nature of the **marketing** function is likely to be very different even between companies engaged in similar types of business. Reasons for the differences include:

- variations in manager's understanding of marketing requirements, and
- variations in manager's application of marketing methods, etc.

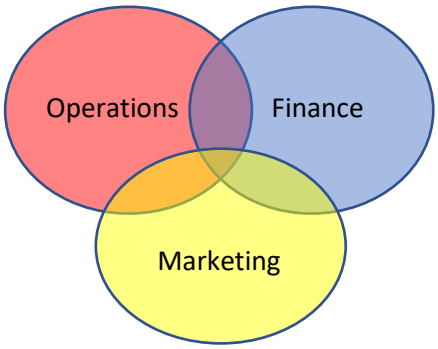


Figure 29. Core functions of companies.

Some of the scope for diversity in marketing is revealed in definitions from different sources. For example, the American Marketing Association states:

- '*Marketing is the activity, set of institutions, and processes for creating, communicating, delivering, and exchanging offerings that have value for customers, clients, partners, and society at large.'*

Maybe a better known opinion is that:

- *'Marketing is selling products that don't come back to customers that do.'*

Marketing is probably the subject of more publications than any other business topics, and comprehensive understanding will include knowledge of psychology, sociology, economics, mathematics, communications, etc. Because of the scope for misunderstanding, and the uncertainly associated with presenting (maybe) new products in new markets, marketing is usually the most difficult part of and business to get right, and the most expensive if it goes wrong. To provide for the best possible results, companies' marketing functions usually include attention to most of the following activities.

Figure 30. Functions of marketing.

Despite the above, a commonly accepted concept of marketing is that of the four Ps, namely:

- product,
- price,
- place, and
- promotion.

Not surprisingly, most businesses initiatives, begin with the product, and this was the case in the SYL project. The identification of vegetable tanned yak leather – as a target for focused attention in enterprise development in Mongolia – dates back to 2020 when the TRAM project was seeking to establish product-based clusters of related businesses. For a long time, utilisation of the country's livestock resources has been considered well below the potential, in terms of:

- generation of gainful employment,
- production of value-added items (for domestic consumption and export), and
- reduction of waste,

The country's livestock resources (including cattle, hoses, sheep, goats and camels) provide a very large range of products, and by-products - meat, milk, fibres, and hides/skins – that might be developed. From among these, yak hides in general, and vegetable tanned yak leather, and yak leather products in particular, were chosen because:

- Distribution of yaks is very limited (only China has more animals) making yak products more unique.
- Location of yaks in Mongolia is very limited, providing increased scope for traceability, and GIP.
- Yaks are emblematic of a nomadic way of life that increasingly appreciated as worthy of support and protection,
- Vegetable tanned leather is widely appreciated as a '*natural'* alternative to mineral tanned leather.
- Vegetable tanned leather is increasingly appreciated as a raw material for innumerable (often high value) products.
- Circular economy, bio leather
- When complimented with indigenous sources of vegetable tannin (from sea buckthorn, for example) yak leather provide even more advantages.
- Yak hides derived from older animals raised extensively (rather than younger, intensively produces commercially livestock) are commonly perceived as more '*acceptable'* by conscientious consumers.
- Pre-slaughter lesions on hides (e.g. miscellaneous scratches and small scars, commonly described as *'defects'*) can be seen as accepted as part of the natural patina of full grain yak leathers.
- Vegetable tanned yak leather can be used to manufacture a range of often premium priced goods.
- Vegetable tanned yak leather products provide scope for Mongolia to complete with considerable advantages compared to the bulk of Mongolian leathers (from cattle sheep and goat) which commonly end-up as anonymous, corrected grain leather destined for high value, low-cost footwear manufacture.

Successful marketing of vegetable tanned yak leather and yak leather products will benefit from a wider understanding of trends among consumers, and developing fashions.

9. LEATHER FASHION

Awareness of (and attention to) fashion, is probably as old as the history of leather itself. In recent years the image of the '*fashion industry*' in general has sometimes become adversely affected by increasingly perceptions of association with:

- environmental impacts (resource depletion, pollution, and waste), and
- social issues (exploitation of – child – labour, and poor working conditions.

The leather industry was, for a very long time, a particularly dirty one – certainly when compared to other types of light manufacturing – but for some decades it has been responding to the need to change. But while the physical and chemical processes of tanning have improved considerably, other challenges remain. Some of the challenges were previously dismissed as short term '*fads*'; such as the popularity of synthetic components in footwear. But increasingly, consumer demands (and social requirements) cannot be ignored. Examples include:

- concern for animal welfare,
- version to use of some/all livestock products,
- aversion to fast (and disposable) fashion items, and
- promotion of fair trade and decent labour, etc.

This has led to the establishment, and increased influence, of organisations that promote topics related to animals in general, leather manufacture, and leather products in particular. Some such organisations include the following.

ChromeFree®Leather Alliance works with leading chemical suppliers, leather tanneries in China, and International brands to make chromium-free leather more accessible and the primary choice for leather goods. Connect with us on our socials to become part of a global movement making leather more circular. See *https://www.chromefree.org/*

Leather Naturally association focuses on education and the promotion of leather as a material. They promote the use of sustainable leather and seek to inspire and inform designers, creators, and consumers about its beauty, quality and versatility.

The **Leather Working Group** (LWG) Setting standards, recognising best practice, driving positive impact. LWG sets Audit Standards against which leather manufacturers and traders can be assessed and certified. It is central to our objective of measuring and recognising best practice and driving improvements in the leather industry. Over a third of global finished leather production is assessed and certified against the LWG Audit Standard.
https://www.leatherworkinggroup.com/

Material Exchange is a digital platform designed to help brands, designers, materials teams, product developers and material vendors source materials, connect with suppliers, and provide transparency in material supply chains. Material Exchange includes LWG as recognised sustainability accreditation so leather produced by LWG-certified manufacturers will be recognised to give brands an indicator of their suppliers' audit status.

The **National Wildlife Federation** (NWF) is one of the world's best known conservation organizations, with more than six million members. The NWF aims to restore and protect environments, and promote wildlife management. The NWF has collaborated with the LWG on improving traceability within the global leather industry. In 2020, the NWF joined the LWG ***Traceability Working Group***; a forum to address traceability concerns within the leather supply chain. In the future, the NWF and LWG will collaborate to identify solutions for reducing deforestation in the leather supply chain. See *https://www.nwf.org/*

OEKO-TEX® is a registered trade mark of the *International Association for Research and Testing in the Field of Textile and Leather Ecology*. The Association provides a testing and certification system for leather and leather goods at all production levels, including accessory materials. OEKO-TEX labels and certificates confirm the safety of textile products and leather articles from all stages of production. Some also attest to social and environmental conditions in production facilities. See https://www.oeko-tex.com/en/

The **Responsible Round Leather Table** (RLRT) is an initiative of the Textile Exchange. It focuses on sustainability and ethical sourcing in the leather industry, engages various stakeholders (including manufacturers, suppliers, and NGOs) and aims to set industry standards and promote best practices.

The **Solidaridad Network** is an international civil society organization that works to develop solutions to make communities more resilient. They currently work in over 40 countries, on five continents, through eight independently supervised regional offices. Working throughout the whole supply chain to make sustainability the norm and enable farmers and workers to earn a decent income, produce in balance with nature, and shape their own future. Solidaridad works with the Leather Working Group to provide financial support and knowledge sharing for the **LWG Tannery of the Future** (TOTF) self-assessment tool, facilitating capacity building for leather manufacturers across the globe. A representative of the organisation also sits on the Tannery of the Future Sub-Group to provide invaluable insight for the direction of the tool.

The **Sustainable Leather Foundation** (SLF) covers the whole value chain; from farm to product. The SLF links Partner Profiles and QR Technology, in order to extend the work of the industry out to the consumer through each connected value chain partner. Its *Transparency Dashboard*™ gives customers and consumers an easy-to-understand picture of sustainability performance across environmental, social and governance issues.. See https://sustainableleatherfoundation.com/

Textile Exchange focuses on fibres (from farms, forests, or fossil fuels) supply networks. Their strategy is the goal of helping the fashion, textile, and apparel industry to reduce the greenhouse gas emissions that come from fibres and raw materials production by 45% by 2030. The Textile Exchange has collaborated with the LWG promotion of environmental improvement within the leather industry. The collaboration will foster alignment to ensure cross-fertilisation of knowledge and avoid duplicative activities. https://textileexchange.org/

The **United National Industrial Development Organisation** (UNIDO) a specialized agency of the United Nations (UN). UNIDO has been active in Mongolia since 1970, with the long-term objective to support export competitiveness by diversifying livestock products (wool, cashmere, leather, meat, dairy, etc.). Recent interventions have included projects like, *Support to Employment Creation in Mongolia* (SECiM), *Trade Related Assistance for Mongolia* (TRAM) and (currently) *International Trade Development in Mongolia* (ITDM). UNIDO's assistance provided for the LWG registration of two of the countries tanneries, the promotion of the clusters, and provided some inputs to this document. Readily available information resources include online training such as:

- Introduction to the Treatment of Tannery Effluents
- How to Deal with Hydrogen Sulphide Gas
- Benchmarking in Tanneries
- Framework for Sustainable Leather Manufacture
- Occupational Health & Safety Aspects of Tanneries

Available, via https://www.unido.org/

The **World Wildlife Fund** (WWF) is one of the world's best known conservation organizations. The WWF works with producers and processors throughout supply chains to improve the sustainability of beef and leather production; helping to ensure that consumers safe, affordable and sustainable choices. The WWF works with the LWG in the development of traceability criteria, to improve traceability, and reduce deforestation. See https://www.worldwildlife.org/

Zero Discharge of Hazardous Chemicals (ZDHC). Aims to raise environmental standards in the fashion, textiles and leather industries. Operates a certification scheme to confirm products contain no hazardous chemicals. Its 320 signatories includes chemicals suppliers, manufacturers, and brands. The ZDHC's ***Roadmap to Zero Programme***, aims to eliminate harmful chemicals from global supply chain by providing for more sustainable materials. The ZDHC's ***Manufacturing Restricted Substances List*** (MRSL) and ***Wastewater Guidelines*** have received inputs from the LWG. Similarly, the ZDHC has provided to development of the ***LWG's Chemical Management Module*** (CMM). See *https://zdhcfoundation.recruitee.com/*

Details of more organisations that are connected to developments in tanning and leather products manufacture, are listed in *Appendix 3. Other Sources of Information.*

10. TANNING AND LEATHER PRODUCTS CLUSTERS

The concept of clusters '*Geographic concentrations of interconnected companies sharing a common interest; seeking to increase and/or improve productivity, innovation, and competitiveness'* was made famous by the businessman and academic Michael Porter in 1980. Though examples had existed in all but name for centuries – especially in leather trades - Porter promoted renewed interest and re-examination of clusters as way of improving competitiveness in many other areas.

Historically, commercial production of (vegetable tanned) leather relied mainly upon easy access to:

- water; e.g. rivers,
- tannins; e.g. forests,
- hides and skins, e.g. urban – meat-consuming – populations, and
- market/s; e.g. leather products consumers (such as urban populations).

This inevitably lead to the clustering of businesses related to making leather and leather products. Historically, there are many examples of tanning clusters that flourished for many years; though sometimes ceased to exist because one or more of their initial triggers disappear. For example, a cluster in Walsall (UK) developed around lorinery[16] works, that became established in the locality more than thousand years ago; taking advantage of the easy access to raw materials (like iron, coal, charcoal and limestone) required for metalwork. Escalating numbers of horses in Britain after the Industrial Revolution (for transport, draught power, warfare, etc.) to 3.3 million[17], increased the demand for lorinery products and attracted related trades. By 1851, 75 companies engaged in manufacturing bridles, saddles and harnesses (approximately one third of the UK's total) were clustered in Walsall. Lorinery and the manufacture of horse tack in general declined in the twentieth century - with the prevalence of motorized transport[18] - but Walsall still accounts for some high end leather products (Walsall Leather Museum).

Figure 31. Horse tack[19]

[16] The manufacture and marketing of metalwork for horses; including bits, spurs, stirrups, fittings for bridles and saddles, etc.

[17] Compared to 4.8 currently in Mongolia.

[18] Which in its turn created a demand for upholstery leathers

[19] https://www.istockphoto.com/vector/equestrian-sport-accessories-cartoon-illustration-set-gm1408464111-459314641

In London (UK) tanning used to be undertaken within the City of London itself (an area of just 2.9km^2) until it was prohibited in 1576 in response to the increasingly unacceptable offensive smells. The tanneries relocated 4.7 km south of the Thames to nearby Bermondsey; where there was plenty of space, water, labour and access to (vegetable) tannins. By the end of the eighteenth century, the Bermondsey cluster was producing a third of the country's leather. However, the cluster declined in the twentieth century due to:

- changing demands for leather products,
- damage to infrastructure during World War II, and
- increasingly stricter environmental constraints.

The last tannery in Bermondsey closed in 1997.

Elsewhere in Europe some long-established clusters persist; like that in Barcelona, established in 1079[20]. Also in Spain, a leather cluster developed Cordova – based on the tanning of horse hides in the seventh century - and gave its name to the shoe upper material that is known worldwide today.

Figure 32. Shoes uppers made with Cordovan leather.[21]

Today, the development of clusters is generally accepted to be based on:

- labour-market effects,

20 https://leatherbarcelona.com/en/#:~:text=The%20Leather%20Cluster%20Barcelona%20is,%5BRead%20+%5D

21 https://www.google.com/url?sa=i&url=https%3A%2F%2Fwww.heddels.com%2F2017%2F09%2Fshell-cordovan-king-leathers%2F&psig=AOvVaw2eA9JiAwFkT4zE0Xt_fmzV&ust=1744111618792000&source=images&cd=vfe&opi=89978449&ved=0CBQQjRxqFwoTCODeh8PoxYwDFQAAAAAdAAAAABAE

- input-output dependency, and
- knowledge spillovers

Which provides advantages that include:

- increased productivity of companies in the cluster,
- greater innovation, and
- stimulation of new business/es.

Basically - according to their composition at least - there are four types of cluster, namely:

- *Geographical*; e.g. Macau (gambling).
- *Sectoral*; e.g. City of London, UK (financial services).
- *Horizontal;* e.g. Silicon Valley, California, USA (information technology).
- *Vertical*; e.g. California wine industry (supply chain).

Though it is rarely easy to categorise particular clusters simplistically, successful ones do exhibit some common features such as:

- geographically bound,
- single core activity,
- vertically integrated with suppliers and buyers,
- horizontally integrated with significant institutions (for R&D, training, etc.) and
- strong and homogenous cultural and social background.

Despite their identification by name, clusters usually lack any formal organizational structure, but tend to operate through networks (trade associations, social media, etc.), business-to-business linkages, and reputation/s. Moreover, in practice, most modern (and successful) clusters are subject to evolution in fast changing business environments.

Among the most famous and successful leather clusters operating today, are those of Italy. The country provides 66% of EU production of tanned leather (15% worldwide), it is the most important location in EU. The Italian clusters include:

Santa Croce sull'Arno (Pisa province)[22]. A major centre for vegetable-tanned leather production, known for its traditional methods and high-quality craftsmanship. It is the biggest tannery cluster in Italy, providing 35% of the country's production of leather in general, and 98% of the sole leather in particular. The cluster extends to 240km^2, includes 800 companies[23] and employs 10,000 people.

Arzignano (Vincenza province). Known for its specialization in leather for particular industries, including automotive and high fashion.

Solofra (Avellino Province). Known for its focus on sustainable manufacturing and high-end fashion leather.

Successful clusters inevitably attract attention, and the concept can become the subject of imitation and emulation; but – as with any enterprise - there are potential problems and risks. Many deliberate attempts to initiate clusters fail, in spite of the time and expense invested in them. Problems can include the absence of the fundamental drivers required to justify the cluster's origin and development. Other problems – even for established clusters - may include:

[22] https://projects2014-2020.interregeurope.eu/fileadmin/user_upload/tx_tevprojects/library/file_1521191522.pdf

[23] 90% of enterprises have less than nine employees.

- unreliable and/or inconsistent national policy,
- inability/unwillingness to adapt,
- inadequate investment (finance, R&D, technology, innovation, etc.), and
- poor networking.

Historically, in Mongolia, artisanal tanning and dressing techniques were essential skills among the predominantly rural, herding community. Industrial tanning originated in 1960 with the establishment of Soviet-styled '*combinats*' in the Khan-Uul area of Mongolia. Under the command economy, these *combinats* processed most of the country's production of hides and skins, supplying most of their output to the Soviet Union.

Though clusters have long existed in the tanning industry - in all but name – the concept has attracted more interest recently; along with other forms of cooperation and integration, including:

- **Special economic zone (SEZ).** A designated area within a country where different business and trade laws are used to attract investment, and to foster economic growth in general.
- **Industrial park**. A type of SEZ that provides specialized services to specific (heavy) industries.
- **Business park**. Like an industrial park, but for light industry, with office space, meeting rooms, public transport links, etc.
- **Technology/Science park park.** A property-based development that promotes applied R&D involving (most often) a university and private enterprises.

From among these options Ulaanbaatar Municipality has for a long time been considering relocation of tanning operations out of Khargia; a (formerly) industrial area of the city that is increasingly within residential development of the expanding city. In 2015, the suggestion was a self-contained residential and commercial suburb.

According to the 2030 Development Plan, the Emeelt settlement area will be developed into a satellite city with 3,081 ha of land characterized by industrial park associated with logistics, transportation and storage facilities. It will inhabit (sic) a total of 14,000 residents living in a residential area.

Project objective

- *Promote clusering and concenratin of export oriented light industry*
- *Establih reaeach centre and apply high-tech know-how to produciton*
- *Devlopemt satelite city based on indsrial park*

Ulaanbaatar Wastewater Expansion Programme Feasibility Study; Final Report. IBRD, 2015

And in 2017, the tanneries were expected to relocate, out of Khargia, to the new facility in Emeelt.

Tannery factories to be re-instructed to moved out of Ulaanbaatar

October 16, the Parliamentary Standing Committee on Petition held a hearing on implementation of the parliamentary resolution N74, particularly on works to move tannery factories to new zone and current condition of Khargia sewage treatment plant.

According to the Parliamentary resolution N74, all tannery factories, running operation in Ulaanbaatar should be moved out by December 31 of this year, as the factories deliver unfiltered or not properly filtered wasted water to the sewage plant, being one of sources that pollutes the Tuul River.

J. Batbayasgalan, Deputy Mayor of Ulaanbaatar in charge of green development and air pollution, made a report and answered to questions of MPs. He said that land of 160 hectares was allotted in Emeelt to establish a light industrial and technological park by an order of Ulaanbaatar Mayor in 2015

MONTSAME 17 October, 2017

Details of the current status of the Eco-Industrial Park are as follows.

Feasibility study for the leather zone being developed

The development of the feasibility study for the leather zone of Emeelt Eco-Industrial Park has begun. It is planned to complete the work in February 2024. After the relocation of leather factories operating in 20th khoroo of Khan-Uul District, it is necessary to prepare for the cleaning of soil and water pollution, recovery and re-planning of the environment.

The total planning of "Emeelt Eco-Industrial Park" is being implemented on an area of 539 hectares. Under the World Bank project, the infrastructure and factories of the 20th khoroo of Khan-Uul district will be relocated in the leather zone. Related units are preparing for the development of other industrial areas such as meat processing, by-products, wool, and greenhouses, and conducting research for the implementation of projects through public-private partnerships. The main policy of "Emeelt Eco Industrial Park" is to meet international standards, support exports, and increase employment. In this context, environmentally friendly and waste-free planning is being carried out.

https://visitulaanbaatar.net/p/502

According to the EBRD Feasibility Study[24], the main reason for developing the Emeelt Eco-Industrial Park was to relocate most of the trading of hides and skins, tanning, wool and cashmere industry (then in the Khargia industry area). The situation of the Park is 6km from the village of Emeelt, 42km from the centre of Ulaanbaatar and 61km from the international airport. Apart from tanning, the Park is expected to accommodate wool and cashmere processing. At the time of completing this document, details of the construction and completion of the Emeelt Eco-Industrial Park were unavailable, nor

[24] EBRD, 2015. Ulaanbaatar Wastewater Expansion Programme Feasibility Study. 310 pages.

was it known which of the Vegetable Tanned Yak Leather Cluster's members (*Appendix 4. Vegetable Tanned Yak Leather Cluster Members*) planned to relocate.

11. VALUE CHAINS AND LEATHER

Value chains and industrial clusters are interconnected (complementary) concepts, where value chains represent the stages of production and distribution of a product or service, while clusters are geographically concentrated groups of interconnected businesses and institutions. While the analysis of **industrial clusters** is focused on the role of local linkages in generating competitive advantages and sustaining the upgrading of SMEs, the analysis of **value chains** emphasises linkages with key external actors. Unfortunately, much of the tanning and leather products manufacturing in Mongolia is still most accurately described as a supply chain, rather than a value chain

Table 7. Distinguishing characteristics of a typical supply chain and value chain

Supply chain	**Value chain**
Product driven	Demand driven
Extracts value	Generates value
Skewed	Mutually beneficial
Opaque	Transparent
Contentious	Cooperative

In the tanning supply chain for example, two-way traffic is limited to:

- hides and skins downstream to tanneries, and
- cash upstream to traders and merchants.

In a value chain, the traffic is considerably more, consisting of:

- market informaiton,
- quality feedback
- provenance records (traceibility), and
- more cash, as a result of added valuse

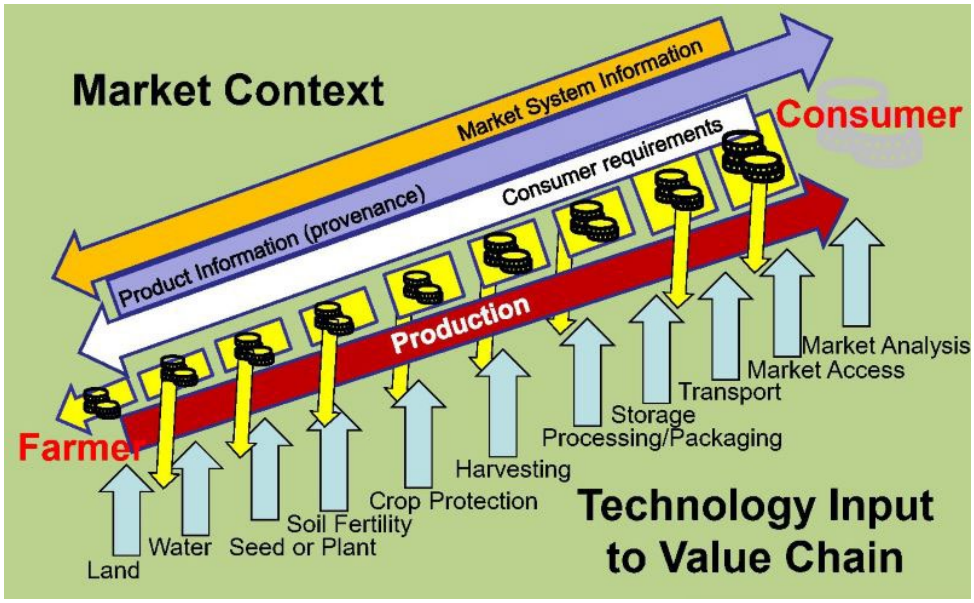


Figure 33. Outline of an agricultural value chain.[25]

[25] https://research.aciar.gov.au/aik-saath/value-chain-approach

The above figure can be imagined to illustrate the leather value chain; with, for example:

- herders (rather than farmers) producing livestock,
- slaughterhouses '*harvesting*' the hides and skins,
- tanning at the stage of '*processing/packaging'*, etc.

In which case, the cluster and the value chain interconnect around the point of tanning; giving rise to the '*hub-and-spoke model'* for the interaction between the two. In practice, more than one cluster and value chain may interconnect.

If the tanning and leather products manufacture value chain in general - and the Vegetable Tanned Yak Leather cluster in particular - are to flourish, improvements must be identified and undertaken. Relocation and reorganization (as cluster, industrial park, etc.) of tanning and at least some of the associated leather products manufacturing out of central Ulaanbaatar – though long overdue – seems increasingly inevitable; if only because of escalating pressure of residential development round the existing site. Accordingly, it is appropriate to analyse the current status of the sector – in terms of strengths, weaknesses, opportunities and threats (SWOT) – based on:

- previous sector studies/reports,
- SYL project experts' opinions,
- contents of recent surveys, etc.

Most of the issues examined here are applicable to tanning and leather products manufacturing in general, but a few are specific to yaks and vegetable tanning in particular.

The various sources consulted provided suggestions for a number of strengths, weaknesses, opportunities and threats. However, the initial lists were subject to contradictions, and not always entirely consistent, correct or complete. For example, in a questionnaire provided to tanneries and leather products manufacturers, most responses to the question *How do you rate your company's access to: raw materials, affordable finance, etc.*[26] were '*normal/okay'*. But the same questionnaire, also prompted responses complaining about the same particular issues. Most of the respondents that mentioned problems related to accessing finance, failed to identify the weakness of not having a Business Plan. Most (maybe all) banks expect to see a company's business plan with a loan application, but very few tanneries and leather products manufacturers had one (documented). Accordingly, it is difficult to accept suggestions that '*access to finance'* is really a weakness

Similarly, many people mentioned Mongolia's large numbers of hides and skins (from its very big livestock resources) as a '*strength*', and then highlighted the prevalence of defects in much of the raw material as a '*weakness*'. Under such circumstances large numbers of '*unsuitable*' hides and skins is hardly a strength; but such resources may be considered an '*opportunity'* (for increased access to improved material in the future). Interestingly, none of the respondents to the questionnaires considered the seasonal nature of their access to hides and skins as a problem or weakness. And, very few of the respondents mentioned membership of a cluster as a strength (or opportunity).
The following summarises the author's prioritisation of issues identified in the SWOT analysis.

[26] *A.2.1. Needs assessment of Cluster members regarding sourcing of raw materials and product safety,* and *Activity A.2.2. Needs assessment of Cluster members regarding the process control and traceability systems requirements.*
A.3.2. *Raw materials, Affordable finance, Skilled staff, New designs, New technology, Product development, Equipment/machines, Chemicals, Information (general), Market intelligence, Chemical analysis, Physical testing, Market research & testing, Other (specify)*

Table 8. Tanning and leather products manufacturing in Mongolia; SWOT analysis

Strengths	Weaknesses
• **Unique access to yak hides.** • Access to other hides and skins (for vegetable tanning). • Image of '*Free range*' (extensive) production of livestock. • Traditional nomadic heritage of Mongolia • Labour force. • Increased available of green economy funding (e.g. White Gold)	• **Insecure (irregular/seasonal) access to raw material**. • **Prevalence of the '*supply*' chain, rather than '*value*' chain.** • Prevalence of avoidable pre- and peri-slaughter lesions in raw material. • **Unreliable information on quantity and quality of raw material.** • **Failure to capitalise on membership of the SYL Cluster.** • **Absence of business plans** • **No (proven) domestic sources of commercial vegetable tanning.** • Inadequate institutional support/collaboration. • Absence of related, sub-sector strategy. • **Limited access to TA, R&D, trade journals.**

Opportunities	Threats
• **Stricter effluent treatment standards** • **Relocation to Emeelt Eco-Industrial Park.** • **Consumer aversion to mineral tanning (and preference for vegetable tanning).** • Newly reorganised MALI • Newley equipped and certified CLTL • Improved productively (in the quantity and quality) of raw materials. • Leapfrogging; into latest technologies. • Green financing, and FDI	• **Uncertainty about timing of relocation to Emeelt Eco-Industrial Park.** • Environmental impacts of (bad) technologies. • Dependence upon supply chain; not value chain • Failure to address consumer demands relating to traceability; for quality assurance, good '*animal welfare*' practices, *'free-range', 'fair trade', 'organic', 'leather'* etc. • The '*insatiable*' demand and status of the Chinese leather and leather products industries.

Note. Bold text highlights most important issues and/or those often ignored.

As is often the case, certain things can be seen as an opportunity or a threat, depending upon one's perspective. '*Stricter effluent treatment standards*' is an obvious example. Often seen as an obstruction to traditional working practices, it should really be seen as an inevitable development in the progress to more sustainable operations and business, and therefore an opportunity to engage with new technology.

Analysis of the strengths, weaknesses, opportune and threats, presents a variety of initiatives that are recommended for attention; ranging from the very simple, quick and inexpensive:

e.g. companies' preparation of their own business plans to facilitate access to finance.

to the much more complex, protracted, and expensive:

e.g. provision of teaching and training to the staff of slaughter facilities (to reduce the prevailing of pre-slaughter defects in hides and skins).

Neither of these two examples, nor most of the likely recommendations in general, are specifically for the improvement of the Vegetable Tanned Yak Leather Cluster in particular. Many (e.g. business plans) are applicable to tanning and leather products manufacturers in general. And, it is widely accepted that most inputs to the improvement of hides, skins and leather (for the leather industry), are equally beneficial to animal husbandry in general and meat production in particular: e.g. control of parasites, improved animal welfare, improved flaying techniques, and so on

The strengths, weaknesses, opportunities and threats (SWOT) analyses of the value chain and the associated development of strategic options that might be adopted, provides scope for a range of interventions to the subsector. These options can be classified by time (short-term to long-term) and level (microeconomic to macroeconomic). Examples include:

short-term, microeconomic:

- preparation of company business plan,
- survey/s to provide statistics on the availability of hides and skins, tanning capacity, etc.

medium-term, meso-economic:

- development of networking within the Cluster,
- development of transition from a supply chain to a value chain,
- completion of the Emeelt Eco-Industrial Park,
- institutional support for raw materials (hides and skins) improvement e.g. the Research Institute of Animal Husbandry (RIAH), Mongolian University of Life Sciences (MULS) etc. to develop tertiary level education related to the industry,

long-term, macroeconomic;

- development of sector strategy with all stakeholders' engagement,
- support to technical and vocational education and training (TVET) establishments,
- development of a leather industry park

These are just a few of the suggestion for development of tanning and leather products manufacturing in genera and the Cluster in particular (see cells A.1., B.2. and C.3. in the following table).

Table 9. Schema for development of tanning, leather products manufacture and clusters.

		PRACTICE/POLICY		
		Micro-economic Company	**Meso-economic Cluster, Business Park, etc**	**Macro-economic Policy, Legislation etc.**
TIME FRAME	**1. Short (<l year)**	**A.1.** INPUT ONE 1. Preparation of company business plan. 2. Survey/s to provide industry-related statistics. 3. Increased engagement within the Cluster. 4. Increased engagement with MALI. 5. Access trade-related (scientific and technical) journals.	**B.1.** INPUT TWO 1. Strategic (sector) planning. 2. Collaborations (e.g. PPPs). 3. Introduction of traceability. 4. Consultation/s on current status. 5. Labour needs assessment and skills survey, 8. review and (if necessary) revision of national standards and legislation.	**C.1.** INPUT THREE 1. Advocacy and lobbying/campaigning. 2. Engagement in working groups. 3. Development of trade policy and legislation. 4. Development of standards (SSMO, ISO, etc.)
	2. Medium (1 - 3 year)	**A.2.** 1. Evaluation of tannery processing and leather products. 2. Teaching and training on hides and skins production. 3. Inputs to raw materials (hides and skins) improvement.	**B.2.** 1. Development of networking within SYL cluster. 2. Development of transition from a supply chain to a value chain 3. Completion of the Emeelt Eco-Industrial Park, 4. Institutional support for raw materials (hides and skins) improvement. 5. Development of traceability.	**C.2.** INPUT FOUR 1. Inputs to GoM Action Plan 2. Resolution of PPPs. 3. Develop international network
	3. Long (≥ 4 year)	**A.3.** 1. Monitoring and evaluation 3. Applications of the I&R system. 4. Geographical Indications.	**B.3.** 1. Adoption/dev. of marketing philosophy. 2. Development of brands 3. Attention of environmental concerns.	**C.3.** INPUT FIVE 1 Development of sector strategy with all stakeholders' engagement, 2. Support to technical and vocational education and training (TVET) establishments, 3. Development of a leather industry park 4. Revision of national strategy document

Note. Inputs are expected to overlap. '*INPUT*' numbers refer to order of completion.

Many other initiatives are also possible - only a few of which are shown in other cell - but all require some level of consensus and collaboration from among the stakeholders involved. Many of the suggested initiatives have already been targeted by the SYL project, including:

- Development and distribution of (needs assessment) survey questionnaires,
- Development and implementation of training courses,
- Provision of technical assistance,
- Preparation of guides (for exports, technicians and certification)
- Preparation of market studies,
- Preparation of this document, etc.

Other activities are due for completion before the end of the SYL project (December 2025) , namely:

- techno-economic feasibility study was to identify viable options for the installation of an effluent treatment system
- Preparation of a business case, for presentation to public and/or private investors.

Tanning, and leather products manufacturing have been around for a very long time, and developed considerably; especially more recently. There are many opportunities to continue these developments and prolong the business in line with current demands.

Leather Technology as Biotechnology

The manufacture of leather is commonly presented as one of humankind's oldest technologies - dating back about 10,000 years – comparable to brewing, and only outdone by baking. But despite its long history, tanning seems to have benefited rather less from advances in biotechnology. The traditional use of dog and pigeon faeces for **bating**, urine for **puering** and contaminating bacteria (and autolysis) for fellmongering have all been replaced by commercial preparations of the biologically active components (enzymes). These development in the biotechnology involved have contributed to:

improvements in the product,
reductions in the input of energy, and
alleviation of the environment impact of tannery effluents.

However, there is undoubtedly scope for more, especially in regard to effluent treatment, and the recyclability of disposed leather products. Most scope is in the dirty beamhouse and tanning, providing for the replacement of the chromium, with vegetable tannins and aluminium sulphate for example.

https://pubmed.ncbi.nlm.nih.gov/32339802/

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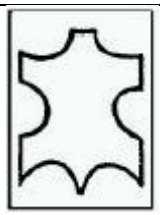
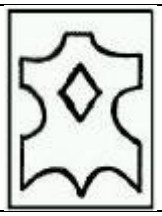
Appendix 2. Glossary

Abattoir	A place specifically designed for the slaughter of large numbers of animals; with all necessary facilities, equipment, machines and a high level of supervision.
Artisan/al	Craft-based (activity) highly dependent on manual skills.
Beamhouse	The part/s of tannery engaged in the preparation of hides and skins for tanning (e.g. soaking, liming, fleshing, etc.)
Bio-leather	A green (eco-friendly) ideal of a product; made in an environmentally-friendly way, that does not harm the consumer and can be disposed of without damaging the environment.
Brand, generic	1. An item that is widely distinguished from others; e.g. Braun Buffel leathergoods. 2. An item that is marketed (described) using a manufacturers' or distributor's label.
Brand, Heritage	Accumulation of provenance, values, philosophy, reputation, and more, gained over a long period of time by a company.
Brand, Luxury	A high-priced product provided by a particular company with a reputation for high quality; and sometimes exclusivity.
Brand, Mass	A product that appeals to a very broad spectrum of consumers.
Brand, Premium	A product that appeals (due to design, perception, and price, etc.) to a smaller group of consumers.
Butcher	Specifically, someone engaged in cutting and selling meat; e.g. in a retail shop ('*butchery*'). Commonly used to described someone who works in a slaughter facility.
Carcase	Body of a dead animal.
Carcase, Dressed	Body of a dead animal; after bleeding, evisceration and trimming (to remove head, and feet).
Cattle	Bovines generally; but in this document, those other than yaks.
Chain, Supply	The movement of goods and services.
Chain, Value	The changes (addition) of value of goods and services within a supply chain.
Cluster, Business	Geographic concentration of interconnected companies sharing a common interest; seeking to increase and/or improve productivity, innovation, and competitiveness.
Commodity	1. In commerce and finance, '*commodity*' is a rigorously defined and interchangeable (fungible) product; e.g. contract specifications. [27] 2. More generally/loosely, '*commodity*' is interchangeable with '*product*'. 3. Sometimes, pejoratively, '*commodity*' is used as the antonym of '*branding*'.
Commodity, Hard	Material that is mined; e.g. coal.
Commodity, Soft	Material that is grown; e.g. coffee, sugar.
Crust	Semi-processed (dried, but not dyed) leather.
Cuirass	Armour (breastplate) made originally of leather - hence French '*cuir*' (for leather).
Cuir bouilli	Vegetable tanned leather hardened by deliberate heating; hence '*boiled leather*'.

[27] After oil, second most valuable commodity internationally at $100 billion.

Defect	An imperfection. A deviation from expectation, commonly associated with rejection.
Dressed	Material (like furskins) processed for use in the manufacture of garments and goods, but without proper tanning.
Gelatin	Heat treated collagen (from hides, skins and/or bones) used in the food industry, pharmaceuticals and cosmetics.
Gelatine	Interchangeable with '*gelatin*'; or '*gelatin'* dispersed in water.
Generification	The process of a brand name becoming a common name; e.g. aspirin, escalator, heroin, hoover, thermos, zipper and cashmere
Glue	More extensively heat-treated collagen (from hides, skins and/or bones) used as an adhesive.
Good, Giffen	An item for which demand rises as the price increases - because of the absence of substitutes – even when poor quality.
Good, Veblen	An item for which demand rises as the price increases; because of its appeal as a status symbol.
Grading	Classification of things based on more than one characteristic; e.g. weight (kg) of hides and area (dm^2), or weight (kg) and pelage (amount of hair or wool), etc.
Haptic	Relating to the sense of touch.
Leather[28]	'*Hide or skin with its original fibrous structure more or less intact, tanned to be imputrescible … and where any surface coating or surface layer, however applied, is not thicker than 0.15 mm'*. IS0 15115;2019 Leather vocabulary. 
Leather, Coated	'*Leather'* with a painting or film thicker than 0.15 mm, but no more than 1/3 of the total thickness 
Leather, Synthetic	'*Leather'* where more than 1/3 of the total thickness is non-leather.
Patina	Signs of age and/or wear considered aesthetically attractive in some items; e.g. antiques, furniture, leather, etc.
Pelage	The hair, wool, fur, etc. of an animal.
Pelt	Hide or skin during the course of processing in a tannery prior to it becoming leather; e.g. limed pelts, pickled pelts, wet blue pelts, etc.
Pickled	Semi-processed material; hides and skins that have been processed (de-haired etc.) to a point where they can be tanned immediately, or stored long-term.
Product	Item[29] that is relatively undifferentiated; e.g. '*tea'*
Product, Branded	Item that is marketed (described) by differentiation from similar/ alternative producers' products; e.g. '*Lipton (green) Tea'* v. *'Ahmad (green) Tea'*
Product, By-	A subsidiary item, incidental to provision of the main/principal product/s; e.g. bran, from flour production.

[28] https://www.leather-dictionary.com/index.php/Leather_shoes

[29] 'Item' can be a conventional product, service or a combination of both.

Product, generic	Item that is marketed (described) according to what it is; e.g. '*green tea'.*
Product, Joint	Another item provided alongside the main/principal product; e.g. milk, cream butter and cheese from dairy production
Quality	Specifically, 1. '*… degree to which a set of inherent characteristics fulfils requirement'*. (ISO) 2. *'Fitness for purpose',* in business generally. More generally, 3. Equivalent to 'p*rice',* in economics generally. 4. '*Value for money'*. 5. Equivalent to '*luxury'* for many people.
Quality assurance	Proactive prevention of defects or issues within a product or service; with emphasis on customer satisfaction and improvement.
Quality control	Reactive (or retroactive) identification of defects or issues within a product or service; with emphasis on conformance.
Slaughter house	A place for the slaughter of large numbers of animals; with a concrete floor slab, roof, walls and some other facilities, equipment and machines.
Slaughter shed	A place for the slaughter of medium/large numbers of animals; with a concrete floor slab, roof, and some other facilities and equipment.
Slaughter site	A place for the slaughter of very small numbers of animals; with very few facilities or equipment.
Slaughter slab	A place for the slaughter of small/medium numbers of animals; with a concrete floor slab, and some other basic facilities and equipment.
Sorting	Classifying things based on only one characteristic; e.g. size of hides (kg, or dm^2), preservation (salted, dried, or frozen, etc.).
Wet Green®	Semi-processed leather made using vegetable tannin (olive leaf extract).
Wet blue	Semi-processed (pickled and tanned with chromium) leather; but not dyed or dried.
Wet white	Semi-processed (pickled and tanned without chromium) leather; but not dyed or dried.

Appendix 3. Other Sources of Information

As stated in the Preface, the objective of this document is to provide insights on:

- yak hides as raw material,
- hides production and preservation,
- vegetable tanned leather,
- leather products, and
- marketing.

This publication is the first (in English or Mongolian) to bring together some of the relatively few, and disparate bits of information that can be found on yaks. More importantly, it concentrates on evidence-based information, and avoids anecdotes, assumptions and suggestions.

More information on the activities of the SYL project in general can be accessed on the Project's website (www.sustainableyakleather.eu) and the Project partners' websites:

ELSEVIE	https://www.elsevier.com/
European Profiles	https://www.europeanprofiles.gr/
INESCOP	https://www.inescop.es/es/
MALI	https://leather.mn/
MNCCI	https://www.mongolchamber.mn/
Vakakis	http://www.vakakis.gr/

Among international development organisations, the EU (via the EU Delegation in Mongolia, and SwitchAsia) continues to provide support to various activities related to improved utilisation of natural resources in general. More specifically, UNIDO (the UN agency responsible for promoting economic and industrial development) has been assisting the leather sector in Mongolia since 1961 and (for example) hosts a range of leather-related training courses (some of which are in Mongolian) on its website; https://www.unido.org/.

Obviously, many aspects of current commercial practices in the tanning sector (in Mongolia, and elsewhere) are not publicly available. However, some international suppliers of chemicals and equipment to the leather sector are keen to work with partners (e.g. sharing details of recommended tanning procedures) subject to the protection of intellectual properties rights and commercial confidentially. Such technical assistance may be available at no cost; as part of a package involving the future supply of materials over a fixed term contract.

Information on pure and applied research, and developments within the tanning sector, is available from a number of subscription-based journals; a few of which are:

- Journal of the American Leather Chemists Association (JALCA),
- Journal of Footwear Science,
- Journal of Leather Science and Engineering,
- Journal of the Society of Leather Technologists and Chemists (JSLTC), etc.

Leather products of all sorts appear in innumerable fashion magazines; depicting latest ranges of footwear, garments and goods. Quantitative information, describing market size, and developing trends is available in various (usually irregular) publications; but these are quite expensive.

Figure 34. Excerpt from home page of 'Leather Good Market Size', 2025.

Larger companies with a dedicated research and development department, may be able to undertake their own studies '*in-house*' or, alternatively, sub-contract the work to external organisations. There are a number of institutions in Mongolia able to undertake market research (e.g. Independent Research Institute of Mongolia, IRIM), and some trade-related associations – and miscellaneous other organisations - that might be able to assist with data, statistics, technical issues, e.g.

- Mongolian Agency for Standardization and Metrology (MASM),
- Mongolian University of Life Sciences (MULS),
- Mongolian University of Science and Technology (MUST), and
- Research and Development Centre of Food, Agriculture and Light Industry

For detailed information and assistance on more advanced issues, international institutions are likely to be more useful, such as:

- BLC Leather Technology Centre Ltd (https://www.blcleathertech.com/), and
- Leather Institute Tanning School Reutlingen (www.facebook.com/gerberschule/?locale=de_DE)

After publication of this document, more information related to vegetable tanned yak leather will be made available before the end of the SYL project in January 2026. Examples include:

- techno-economic analysis (TEA) of an effluent treatment plant,
- workshops on green financing opportunities,
- provision of equipment and training related to CAD/CAM, and
- preparation of at least one business proposal for presenting to private and/or public investors.

The latter – in particular - provides a valuable opportunity for members of the Vegetable Tanned Yak Leather Cluster to pursue and promote initiatives for adoption by investors. Based on some of the issues, opportunities and constraints, already identified in this document, it is possible to list some of the issues that might be prioritised for consideration within any investment proposal or partnership. These include:

- quantitative data on vegetable tanned yak leather, and associated products,
- data on prospective/target consumers,
- establishment and consolidation of identifiable value chain,
- membership of (certification by) significant association/s,
- exploration of novel sources of domestic tannin material/s (e.g. sea buckthorn),
- establishment of international partnership/s, etc.

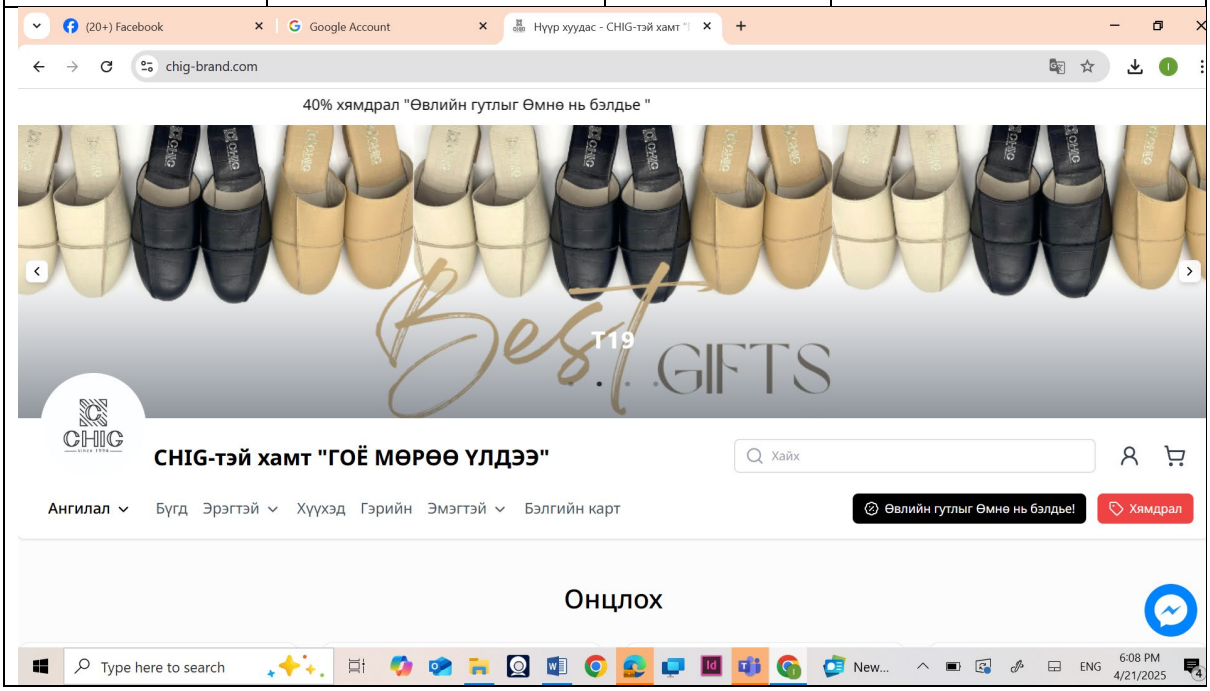
At the time of completing this document, preparation of the investment proposal had just started. Coincidentally, the Research and Development Centre of Food, Agriculture and Light Industry provided what are thought to be the first results of physical testing of vegetable tanned yak leather produced in Mongolia. The results were as follows:

MNS ISO 3376:2016	Tensile strength (N/mm^2)	25.4
MNS ISO 3376:2016	Elongation at break (%)	10.5
MNS ISO 23910:2016	Stitch tear resistance (N/mm)	170.0

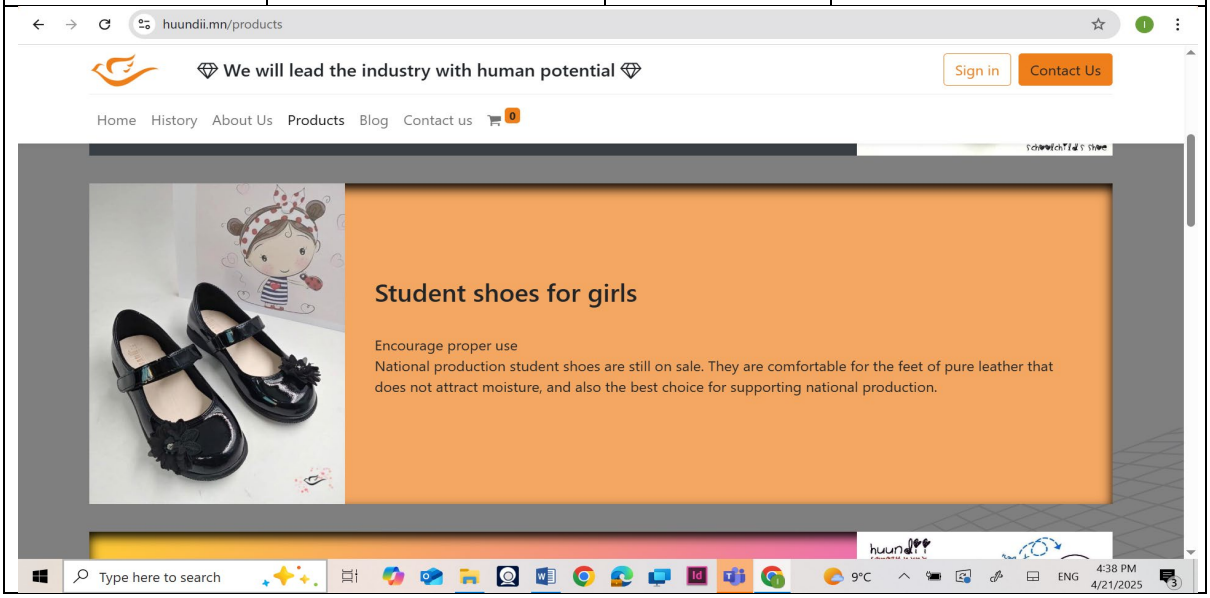
The leather tested was one piece (1.96m^2 in area, and 3.4mm thick) of a batch of unfinished sides, produced by a tannery in Ulaanbaatar. The results are similar to what might be expected from the same type of leather made from cattle hides. With the results of repeated testing, and information from other tests, the results should provide for objective comparison of yak leather with other types of material in the future.

Appendix 4. Vegetable Tanned Yak Leather Cluster Members.

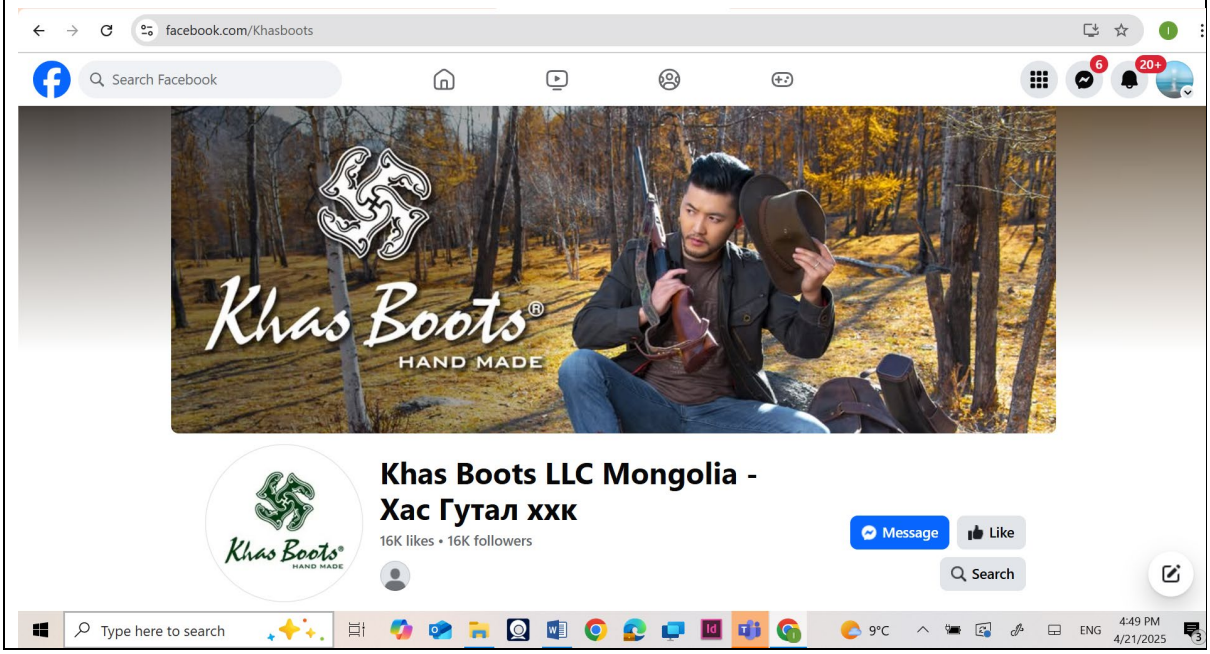
Company name	Address	Product/s	Contacts
Brand Gutal	4th floor Mongol Shevro Building 20th Khoroo Khan-Uul District, Ulaanbaatar	Footwear	www.chig-brand.com 976 7505 0520



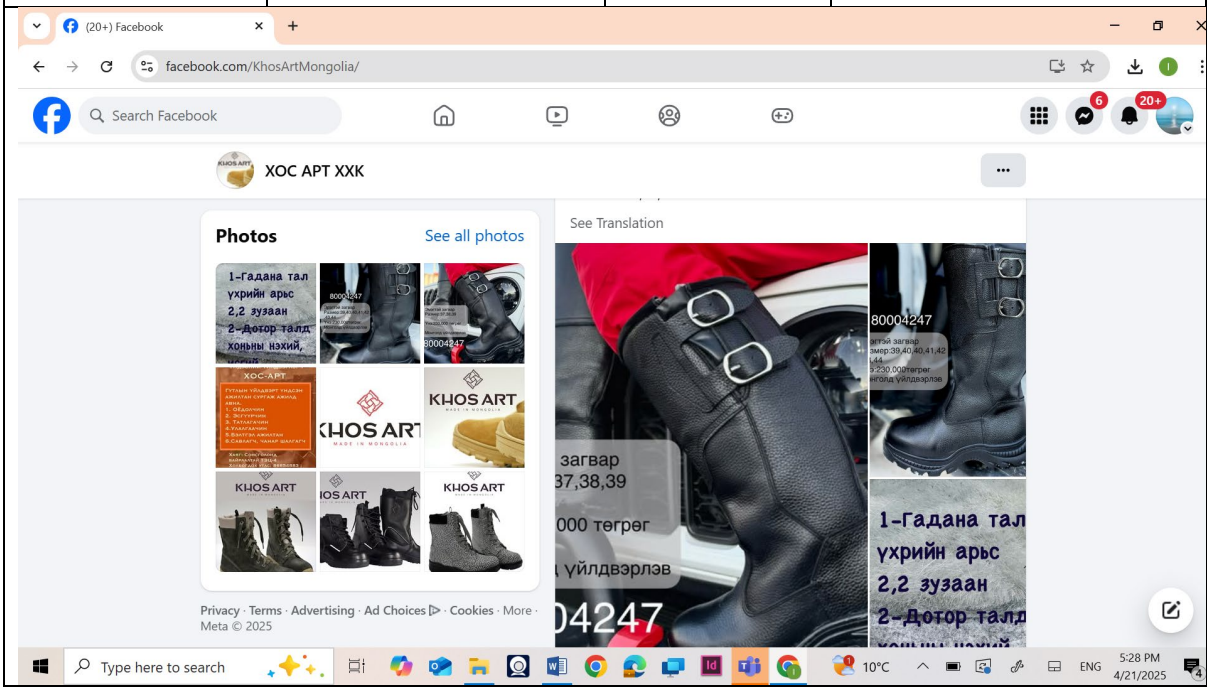
Horol Collection	Room 33 Manufacturing building Tsaiz 3th street, 19th Micro-district Bayanzurkh District Ulaanbaatar	Footwear and other products	info@huundii.mn https://huundii.mn/ 976 7577 7723



Khas Gutal	Apartment 77/2 Next to Gurvan Hospital Bayangol District Ulaanbaatar	Footwear	khasbootsllc@gmail.com https://www.facebook.com/Khasboots 976 9915 8149

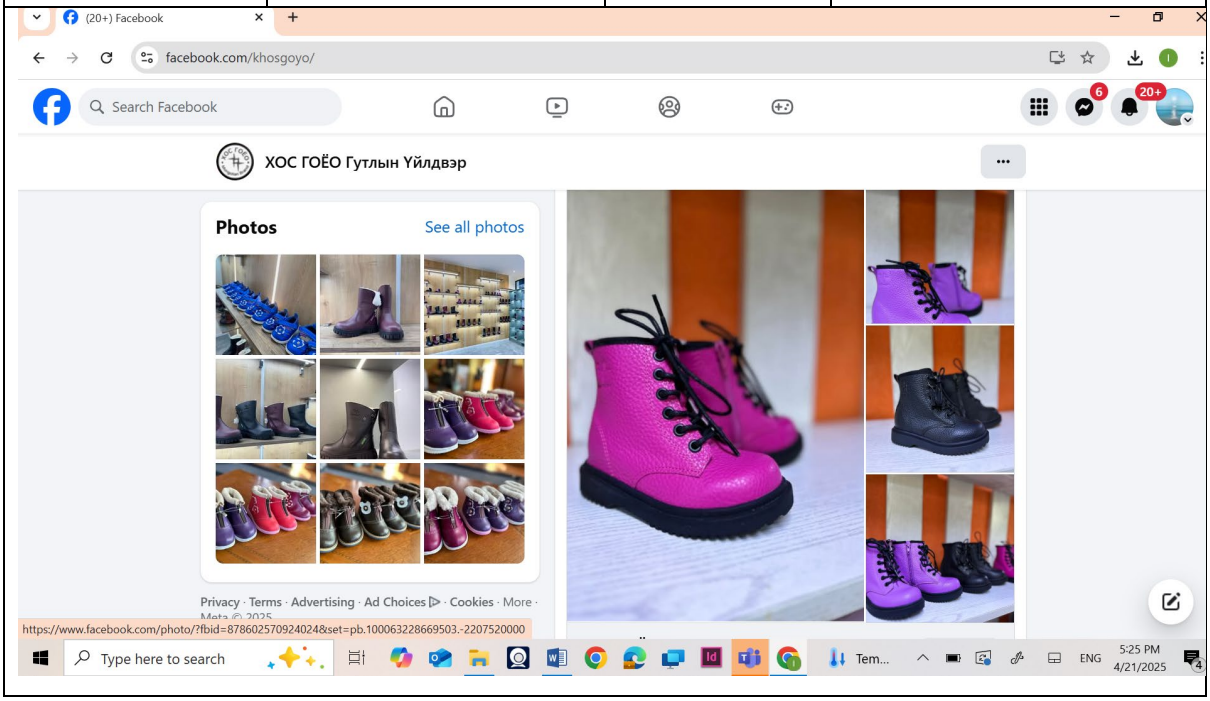


Khos Art	Next to Hides & Skins Factory 19th Micro-district Ulaanbaatar	Footwear	khosartmongolia@gmail.com 976 9190 4883

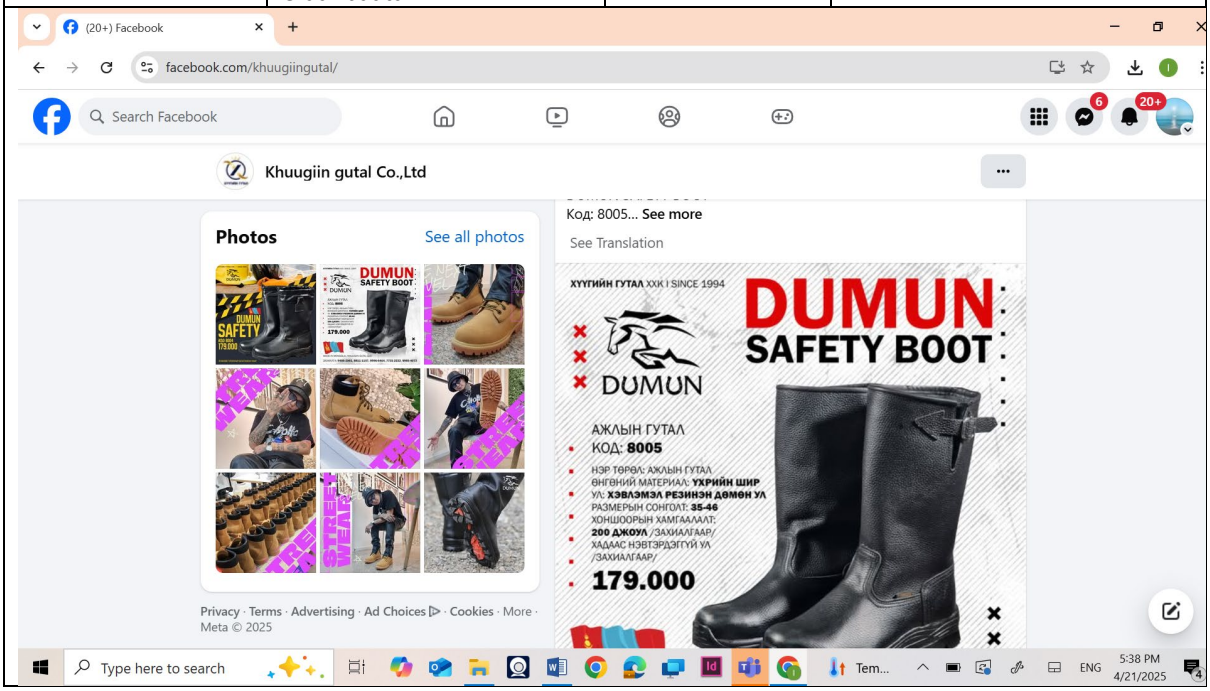


Khosgoyol	Second Floor New Garden Center	Footwear	https://www.facebook.com/khosgoyo/

	Opposite Khun-Uul Mall Yarmag Ulaanbaatar		976 8850 8859

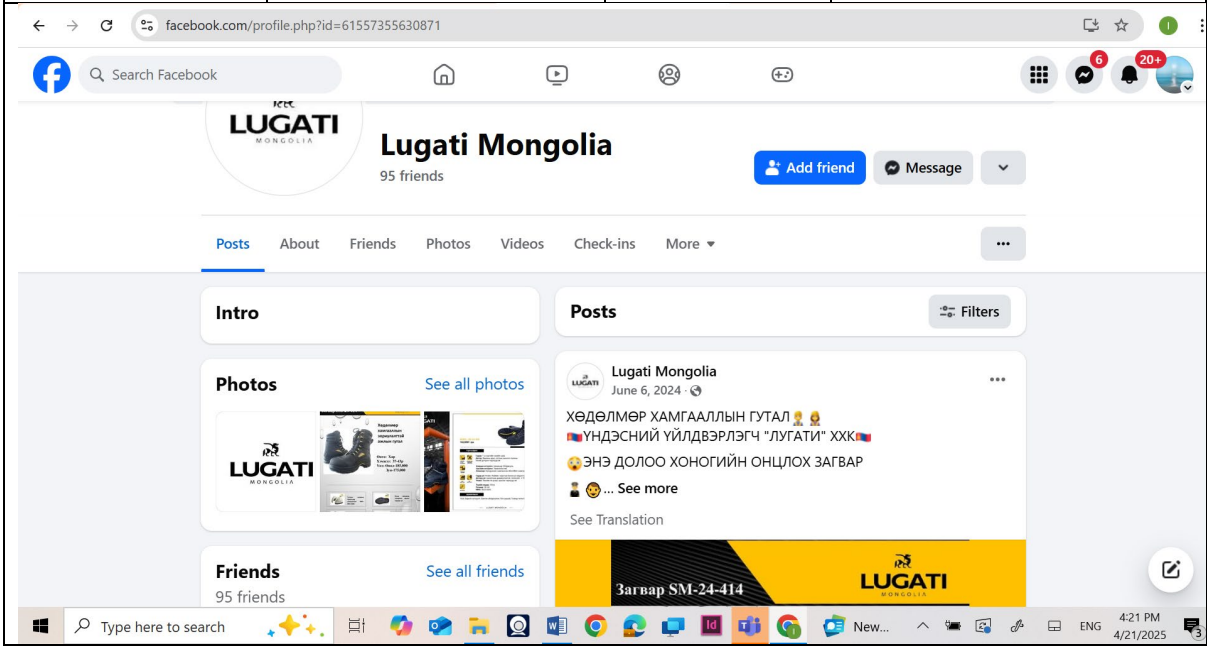


Khuugiin Gutal	7-130 16th Khoroo Sukhbaatar District Ulaanbaatar		https://www.facebook.com/khuugiingutal/ 976 7731 2222



Lugati	6th floor Buligar Factory Building 2nd Khoroo Khan-Uul District	Leather shoe manufacturer. Retail and wholesale	976 72272552 lugatibrand@gmail.com

	Ulaanbaatar		



Хүүгийн гутал ХХК			

Appendix 5. Examples of JSLTC Publications. [30]

SLTC JOURNAL ABSTRACTS
VOLUME 92
06 2008

INDUSTRIAL ECOLOGY AS A PLANNING APPROACH FOR A SUSTAINABLE TANNING INDUSTRIAL ESTATE

RITA PUIG,[1] MONTSE ARGELICH,[1] MIQUEL SOLÉ,[1] SONIA BAUTISTA,[1] JORDI RIBA,[1] PERE FULLANA,[2] CRISTINA GAZULLA,[2] DOLORS CALVET,[3] ANDREA RAGGI,[4] and BRUNO NOTARNICOLA[5]

[1] Escola Universitària d'Igualada (EUETII-Escola d'Adoberia), Universitat Politècnica de Catalunya, Plaça del rei, 15, 08700 Igualada, Spain
[2] Escola Superior de Comerç Internacional, Universitat Pompeu Fabra, Passeig Pujades 1, 08003 Barcelona, Spain
[3] Escola Tècnica Superior d'Enginyeria Industrial de Barcelona, UPC. Av. Diagonal, 647, 6a, 08028 Barcelona, Spain
[4] Dipartimento delle Scienze Aziendali, Statistiche, Tecnologiche ed Ambientali, Università 'G. d'Annunzio,' Viale Pindaro, 42 - 65127, Pescara (PE), Italy
[5] Dipartimento di Scienze Geografiche e Merceologiche, University of Bari, Via Camillo Rosalba, 53 - 70124, Bari (BA), Italy

This paper analyses the relocation, following Industrial Ecology principles, of tanneries from Igualada, Spain to a new sustainable industrial estate.

The tanning industry in Igualada has been located in the same river basin for more than 100 years. During the last decade, the city has been growing very fast and it is now beginning to force the industry to move to the outskirts. Environmental, social and economic aspects were analysed to assess the feasibility of the proposed move.

Results clearly show that relocating the tanneries to a new industrial estate is absolutely necessary for these companies to achieve sustainability. This move is economically feasible, it will have important environmental benefits (compared to the present situation) and is agreed upon by all involved. However, a very important challenge was detected: there is no agreement on where to locate the new industrial estate. The current proposal made by Catalan authorities lacks the unanimous agreement of all involved. To solve this problem meetings among interested parties will soon take place. Otherwise, the future of this important cluster in Igualada is uncertain.

This work helped the tanneries of the industrial cluster in Igualada, and could also help other similar clusters, *e.g.* to analyse the sustainability of a proposed move and to plan new sustainable industrial areas.

SLTC JOURNAL ABSTRACTS
VOLUME 65
03 1981

CONSERVATION OF CATTLE HIDES BY FREEZING

B. M. HAINES

An alternative to the conservation of cattle hides by salting is the use of deep freezing techniques. This paper reports on the development of a new process for hide conservation in which laboratory scale work has been extended to pallet loads of hides. Factors relating to optimum storage conditions and thawing procedure have been considered and the quality and yield of leather produced from frozen hides have been compared with that from salted stock. The leather produced was comparable but softer than that from salted hides.

[30] https://www.sltc.org/sltc-abstracts/search.asp?zoom_sor