SYLPROJECT
Sustainable Yak Leather

## VEGETABLE TANNING; PART 3. SCIENCE.[1]

Tanning hides and skins changes them into leather[2]; material which is resistant to spoilage and suitable for the manufacture of a large range of products (including footwear, garments and miscellaneous goods). A series of about 20 processes is required to change fresh raw material into something suitable for making shoes (for example); starting with preparation of the fresh hides and skins, and ending with '*finishing*' (e.g. colouring and/or coating). However, the critical and definitive process is the chemical combination between the collagen protein of hides and skins, and the vegetable (organic) or mineral (inorganic) tannin; that takes place in what is known as the tanyard.

***Example of leather-making processes; raw materials production to finishing.***

| Raw material | | | | | | Beamhouse | | | | Tanyard | | | | | | Finishing | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Flaying | Fleshing | Trimming | Preservation | Storage & transportation | Sorting & grading | Soaking | Fleshing | Liming | Splitting | Deliming | Bating | Pickling | **Tanning** | Fixation | Shaving | Fat liquoring | Dyeing | Drying | Staking |

Details of particular, commercial leather making processes, will vary according to:

- nature of the raw material,
- intended product,
- operating and marketing considerations,
- labelling and certification requirements, etc.

Some processes - e.g. preservation - may be omitted entirely; when tanneries are able to source their raw material locally (fresh each day). Others - e.g. splitting - may be undertaken at different stages; and some (e.g. sorting) are likely to be repeated more than once. Not all processes are undertaken contiguously; by the same operators, in the same location. For example, preserved hides and skins may be stored for many months and traded internationally (like '*partially processed'* pickled materials also). Accordingly, though most countries have livestock resources and produce hides and skins as a raw material, beamhouse, tanyard and finishing operations (and the subsequent manufacture of leather products) are increasingly – though not exclusively - concentrated within particular locations and sometimes particular countries. For example:

- vegetable tanned crust leather; Nigeria,
- utility shoe leather and footwear; China, and
- luxury, high fashion leathers, and leather products; Italy

Conversely, in traditional artisanal vegetable tanning - typically very small-scale – many of the constituent processes are closely connected time-wise, and tend to occur within the same small locality.

The chemical combination between collagen (in the dermis of hides and skins) and vegetable tannin during processing is not, on its own, sufficient to provide leather that is useful for the subsequent manufacture of products (such as footwear, garments and miscellaneous goods). The epidermis (including hair, wool or fur) that overlies the dermis must be removed, along with the hypodermis (underlying residual fat and flesh). Thereafter, non-collagenous, interfibrillary material - within the dermis - must also be removed to provide a more open (porous) structure. Only then is it possible for vegetable tannins to penetrate the full thickness of the dermis. Since only the dermis contains the leather-making collagen – and collagen only constitutes

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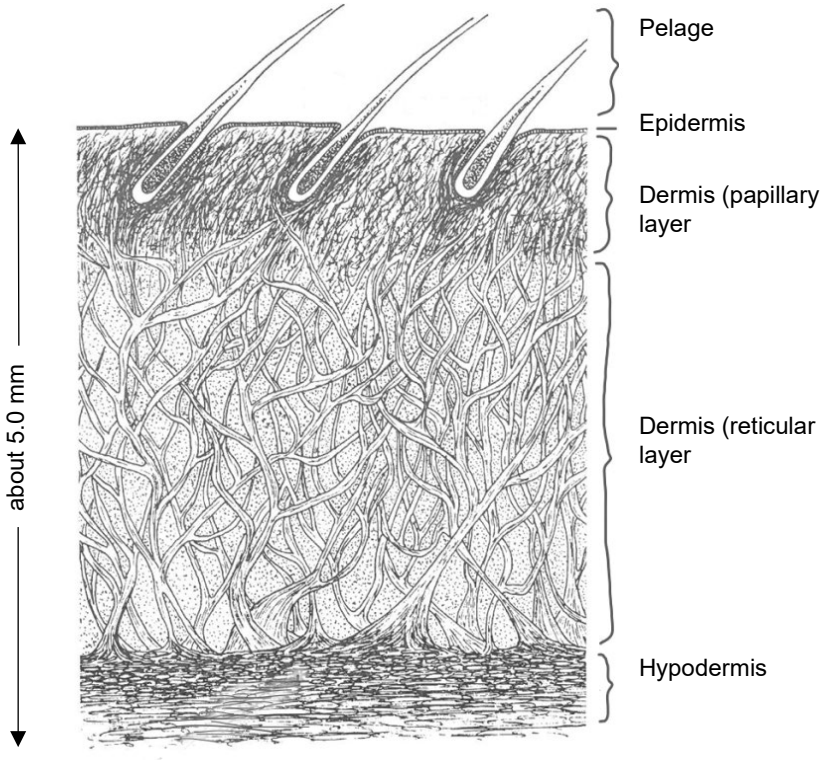
[1] '*Vegetable Tanning; Part 3. Science'* is the third of a series of brief articles describing some basic aspects of vegetable tanning; and was preceded by the *'Introduction'* and '*History*'. Follow-up articles will concentrate on the technology and current developments related to vegetable tanning. More detailed information on all topics (including theory and practice) will be provided during inputs to training planned for later in 2022.

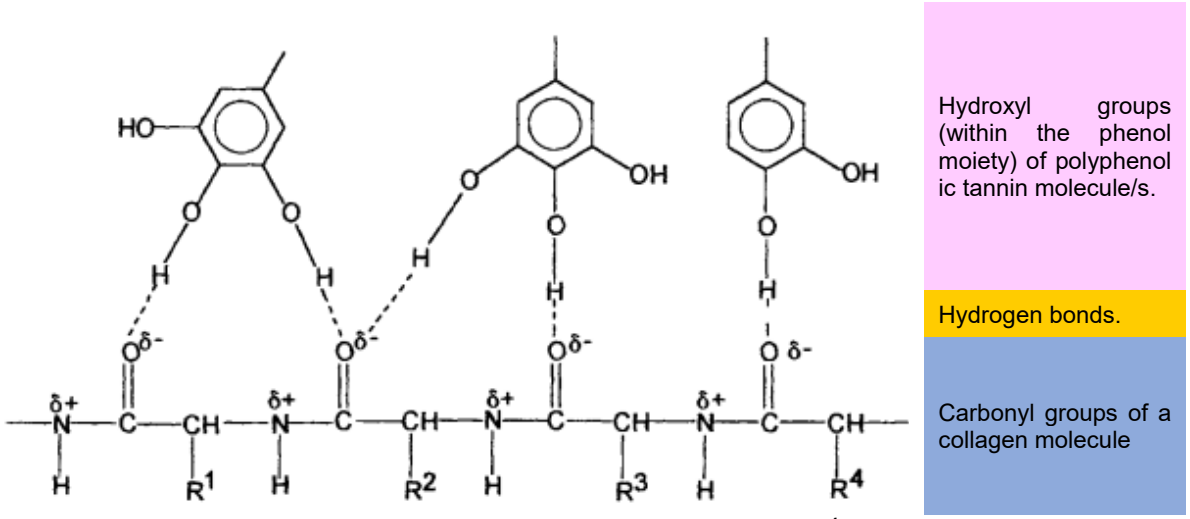
[2] '*Hide or skin with its original fibrous structure more or less intact, tanned to be imputrescible … '* . IS0 15115;2019.

about two thirds of the total protein of hides and skins – preliminary processes (prior to tanning) can yield a lot of materials that provide scope for recovery, recying and/or reuse. And even after tanning, not all the collagen ends up as leather, in finished products. As much as half of the collagen may remain unused; as splits, shavings, trimmings, etc. In some cases, the non-leather components of hides and skins might constitute high value products (co-products/by-products) in their own right; such as the fine wool of some sheep skins, and the underwool (cashmere) of certain goats. Others – less valuable but equally important – include the fleshings and trimmings used to make animal feed for example. To reduce the environmental impact of leather producing operations, it is important that all non-leather components (and tanned materials not used in finished products) should be recovered, recycled and/or reused.




***Transverse section of a hide (based on Godfrey)[3]***

Vegetable tanning is accomplished by a chemical combination – between hydroxy (-OH) groups of vegetable tannins, and carbonyl (C=O) groups of constituent amino acids within collagen molecules - in the form of hydrogen bonds. Though individually weaker than the covalent bonds that occur in mineral tanning (with chrome oxide) hydrogen bonds - acting in cooperation, in large numbers - are collectively strong enough to create leather.




***Hydrogen bonding in vegetable tanned leather (based on Covington 1997)[4]***

[3] https://manual.museum.wa.gov.au/conservation-and-care-collections-2017/leather
[4] https://flemish2016.files.wordpress.com/2018/10/modern-tanning-chemistry-ad-covington.pdf

Despite the apparent simplicity of the process, the chemistry of vegetable tanning is widely accepted as much more complicated than mineral tanning. In particular, the hydrogen bonding involved is difficult to accomplish properly, requiring attention to innumerable factors including:

- characteristics of the hide or skin being tanned,
- characteristics of the tannin being used,
- characteristics of the processing vessel (including level of agitation),
- relative size of the liquor (the '*float*'),
- presence of salts, acids, the pH, use of auxiliary chemicals, etc.,
- temperature, and
- time.

Given the dense nature of the network of collagen molecules (micro-fibrils, fibrils and fibres) in the dermis of hides and skins, and the relatively large size of vegetable tannins, it is not surprising that the process was - historically - very time consuming (taking up to a year to complete). Modern methods are considerably quicker, but if not managed properly, risk stalling the whole process, if excessive concentrations of tannins obstruct the surface layers causing '*case hardening'*.

Despite this article's attention to the vegetable tanning process in particular, all other component processes contribute to the characteristics of the final leather. For example, proper preservation of the raw material is essential to avoid putrefaction - and damage to the leather-making collagen protein of the dermis - which cannot be avoided (but may be subject to expensive '*correction*' later. Similarly, careful selection of oils and other finishing chemicals – compatible with the particular tannin used previously – is important to avoid spewing, staining, and fading. Accordingly, successful manufacture of vegetable tanned leather is dependent upon knowledge and inputs from a number of sciences, including:

- chemistry (analytical, organic chemistry and biochemistry, physical chemistry, etc.)
- physics (bio-physics, engineering, thermodynamics, etc.), and
- zoology (agriculture, biology, botany, etc.).

Thereafter, utilisation of leather – particularly to manufacture and marketing of leather products – requires knowledge of:

- statistics (to determine minimum sample size for analysis and testing during research, development and production, to determine the relevance/significance of results, etc.),
- psychology (to understand people's perceptions and preferences for particular types of leather, fashion trends, etc.), and
- business (finance, operations, marketing etc.).

In short, there is a lot to be known about the manufacture of leather (and leather products), and much of the science is documented in publications dating back more than 100 years. Today a large number of journals[5] are dedicated to the science (and technology) of tanning, including the *Journal of the American Leather Chemists Association* (JALCA) and the *Journal of the Society of leather Technologists and Chemists* (JSLTC).

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[5] https://iultcs.org/wp-content/uploads/2020/10/Leather_Journals.pdf