FINE HAIR ON AMERICAN BOVINE LEATHERS

Dr. Luis A. Zugno1a and Andreas Rhein2b

1 Buckman, 1256 North Mclean Blvd, Memphis, TN, 38108, USA
2 Tyson Foods, Inc., 800 Stevens Port Drive, Dakota Dunes, SD, 57049, USA, lazugno@buckman.com
andreas.rhein@tyson.com

Abstract

Fine hair is the biggest seasonal challenge for bovine leather production in the United States. The origin, timing and severity of the fine hair problem can be unpredictable and vary from year to year. Seasonal changes in the hair growth cycle are prompted by the lower temperature from fall to winter; the bovine hair increases in amount, length and thickness. This problem is very old and has increased in severity due to changes in the leather manufacturing process, cattle breeding conditions and breed diversity. The amount of fat and thickness of the hide also play important roles. The extent of the problem has not been documented and is not fully understood by the scientific community. The presence of fine hair (residual hair) on the wet blue and final leather is a cause of downgrading the leather. If the wet blue has fine hair, it cannot be removed in further processing in crust or finishing. Some leather types can tolerate more fine hair than others. In this paper we will conduct a scientific evaluation of the fine hair on American bovine hides, wet blue and finished leathers through cross sections and stains, and optical and electron microscope observations. We will include measurements of hair thickness and hair depth inside the hide. The work will compare sulfide and oxidative unhairing of winter hides, characterize and show the details of the fine hair through cross sections, and offer indicative measures to minimize the problem. Information from the largest wet blue manufacturer in the US with four tanneries will provide insight on the fine hair seasonality, types of breeds, and cattle displacement temperature ranges and will discuss adaptive changes needed in the "winter" to control the fine hair.

Keywords: bovine, wet blue, fine hair.

1 INTRODUCTION

The presence of fine hair on American hides is an old problem and has increased in the last decades due to changes in breed, feed, herd movement and climatic adaptations. The changes in the processing conditions in the tannery have also contributed to this problem. There is limited information on the topic, and the industry has accepted that fine hair is a seasonal problem and cannot be resolved; beamhouse leather producers and customers work to manage it the best way possible to minimize the problem. The limited processing time practiced in the US during soaking, and unhairing/liming of fresh hides aggravates the fine hair problem. In comparison, the salted or brine cured hides processed in the US or overseas have minimized this problem. For simplification purpose in the paper we will use the term wet blue to define both wet blue and wet white leathers. Jean J. Tancous (1) in her book Skin, Hide and Leather Defects says: "The fine hair problem cannot be completely blamed on poor beamhouse techniques as it may arise from a 'natural characteristic' of the animal, i.e., the shedding of the hair root which occurs at seasonal intervals. As a hair grows older, the root atrophies and shrinks; it then falls out. A new papillary hair invaginates below the receding old hair; and thus, the old hair is replaced by a deeply rooted, new fine hair. It is unfortunate for the tanner that new short hair has firmly anchored roots, as they resist easier
removal in the beamhouse and cause the fine hair difficulties."
Merril (2) describes that papillary hairs, being more deeply set and more firmly anchored, are more difficult to remove, giving rise to the vexatious 'fine hair' problem.

Thorstensen (3) describes the use of sodium borohydride as an aid to fine hair removal. On the hair-root studies Kuntzel and Stirtz (4) answer the question whether the more deeply anchored papillary hairs are more difficult to remove in the tannery practice than the less-rooted club hairs:

No difference in ease of removal of these two hair types is to be found either in enzymatic or sulfide unhairing. According to the authors, leaving behind the pigmented parts of papillary hair roots and the pigmented young hairs found beneath the club hairs may well cause trouble.

2 Hair Growth Cycle

Most of the studies on hair growth cycle were made on human hairs. There are some similarities and differences with the bovine hair cycle. This is very complex even within the bovine hair due to the changes that can happen with the animals due to age, climatic conditions, breeds and feed.
One of the earliest reviews of the biological and chemical properties of animal hair was done by Stoves (5) in 1947. Stoves described the process of hair development: "After a period of time, dependent on the type of fibre, the papilla of the mature hair ceases to proliferate and hair growth terminates. Changes then occur in the basal portion of the follicle which, together with natural movement of the skin, result in the hair becoming detached from the papilla. The hair root shrinks and a growth of the cells of the root sheath takes place between the root and the papilla. The upward pressure of these growing cells forces the old hair towards the skin. Through this matrix of proliferating epithelial cells, the new fiber ultimately grows by a process analogous to that already described. Opinions have differed as to whether or not the cells of the old papilla completely disappear and are replaced by a new structure."
Schleger (6) studied the relationship between cyclic changes in the hair follicle and sweat gland size in cattle and used the classification of hair follicles based on Chase, Rauch and Smith (7). In his paper he describes the eleven phases of the follicle cycle. Butcher (8) described the papillary system and replacement of hair in mammals.

In The Biology of Hair Follicles, Paus and Cotsarelis (9) describe with details the development and cycling of human hair follicles (Fig. 1).

Here is the glossary of terms used:
Anagen: growth stage of the hair-follicle cycle
Bulb: lowermost portion of the hair follicle, containing rapidly proliferating matrix cells that produce hair
Catagen: stage of the hair cycle characterized by regression and involution of the follicle
Club hair: fully keratinized, dead hair - the final product of a follicle in the telogen stage
Telogen: resting stage of the hair cycle; club hair is the final product and is eventually shed
Terminal hair: large, usually pigmented hair on the scalp and body.

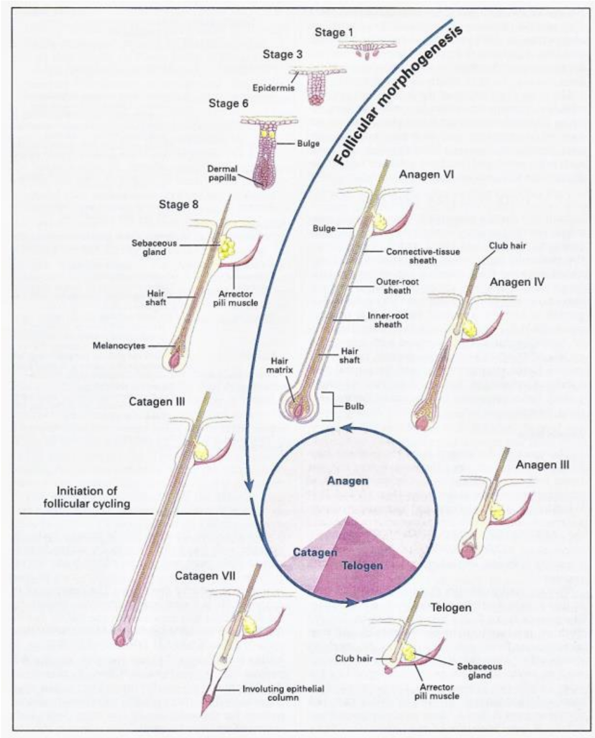

Fig. 1. *Development and cycling of hair follicles. Selected stages of the morphogenesis of hair follicles and the three stages of follicular cycling (anagen, catagen, and telogen) are shown. The Roman numerals indicate morphologic sub-stages of anagen and catagen. The pie chart shows the proportion of time the hair follicle spends in each stage (9). Published with permission from The New England Journal of Medicine.*

The human hair cycling is described by Paus and Cotsarelis (9): Each hair follicle perpetually goes through three stages: growth (anagen), involution (catagen) and rest (telogen). Numerous growth factors and growth factor receptors are critical for normal hair-follicle development and cycling, but no single growth factor appears to exert ultimate control over these processes. The onset of the anagen stage recapitulates hair-follicle development, since the formation of the new lower hair follicle begins with the proliferation of secondary germ cells in the bulge. During the catagen stage, hair follicles go through a highly controlled process of involution that largely reflects a burst of programmed cell deaths (apoptosis) in the majority of follicular keratinocytes. Toward the end of the catagen stage, the dermal papilla condenses and moves forward. During the telogen stage, the hair shaft matures into a club hair, which is eventually shed from the follicle, usually during combing or washing.

Stenn and Paus (10) made a complete review of The Controls of Hair Follicle Cycling fifty years after Chase (11). One of their conclusions is that we need to know more about the controls for inducing each of the phases of the cycle – anagen, catagen, telogen, and exogen – and the role of apoptosis in the cycle.

3 Seasonal Changes in Hair Growth

Most of the studies on seasonal changes and hair growth were made in the 1960s. Australia was a great contributor in this area; the studies made are still a reference today. Unfortunately, the detailed work done in many regions (and countries) do not have the extreme temperatures (hot and cold) or sun exposure that we have in the US areas of cattle growth.

Yeates (12) has shown that cattle go through a regular seasonal cycle of hair growth and shedding influenced by light. In his study, the daily photoperiod was altered to simulate the synchronous duration of daily lighting of the opposite (northern) hemisphere. The results show that the full range of coat changes may, irrespective of seasonal temperature, be reversed by artificially reversing the seasonal trend of daylight duration. This is presumptive evidence that the natural light environment is a major controlling factor in normal pattern of seasonal coat change with cattle of European origin. Dowling (13) had reason to believe that the process of shedding can also be influenced by other things such as the nature of food supply and the condition of the animal. The important thermal property for the prevention of heat loss from the body is the capacity of the winter hair covering to stabilize an insulating layer of air, whereas the summer coat must allow heat loss which is the site of the balance upon which regulation is usually affected under hot conditions. Bos indicus species of cattle and relatively heat tolerant breeds of Bos taurus species of cattle have more medulated hair fibers, denser, more compact coats and better developed skin glands than the less tolerant breeds of Bos taurus.

Schengler and Turner (14) used the coat score instead of the felting score to provide indication of the coat type. The superiority of the coat score probably lies in the fact that it takes account of features of coat structure which are lost in hair samples. It gives weight to the different coat characters, and to their expression over the whole body of the animal rather than in a very small sample area. The degree to which various coat characters are interrelated is notable. Length, diameter, medullation, curvature, and follicle angle are all quite different had measurements, and they all had correlated with skin temperature and gain.

Hayman and Nay (15) made observations on Bos taurus and Bos indicus. Two shedding periods were observed, spring and autumn. Approximately four months were required for the complete change from winter to summer coat, the change in appearance being dramatic. Less time was required for autumn shedding and there was a less dramatic change of the coat. That are two peak shedding periods, in spring and autumn, when almost the entire coat is changed. The pattern and rate of shedding in a temperate environment are similar on Bos taurus and Bos indicus and in crosses between them. Histological data showed that during shedding almost all mature hairs were lost from the skin follicles. All types of cattle had light summer coats and long, heavy winter coats. No difference in hair diameter was observed between summer and winter coats in Bos taurus, but in Bos indicus hair diameter was much greater in the summer coat.

They observed that approximately 6% of the follicles were found to be very much larger than the rest. They lay at a different angle to the surface, penetrated to a greater depth in the dermis, were of a greater diameter, and were associated with a multilobar sebaceous gland and a much larger sweat gland than the other follicles. Drawings are shown in Fig. 2. The new hair (A) is club hair, and mature hair (B) is the papillar (or terminal) hair.

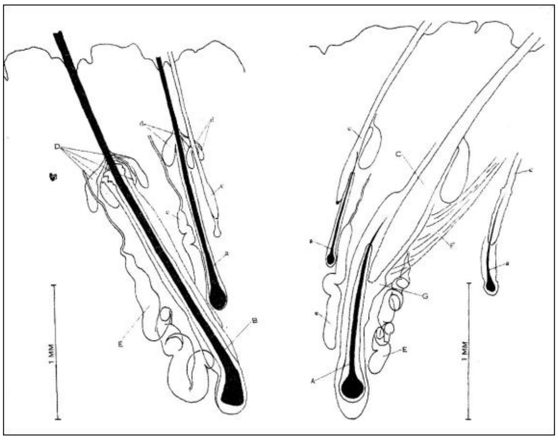

Fig. 2. Giant and average follicles in various stages of activity (drawn to scale). Capital letters, giant follicles; lowercase, average follicles. A, new hair; B, mature hair; C, shedding hair; D, multilobar sebaceous gland; d, bilobar sebaceous gland; E, large sweat gland; e, smaller sweat gland; F, large arrector pili muscle; G, ental swelling at attachment of large arrector pili muscle. (15)

Dowling (16) observed that the difference in heat tolerance of the same animal at different seasons can be attributed to corresponding changes in the hair coat. Animals in a long, woolly winter coat were not heat tolerant, whereas that same animals clipped were.

Dowling and Nay (17) have shown the complexity of studying the cycle of growth and shedding of hairs; the difficulty is to say whether an individual hair is growing, is resting, firmly held in the follicle, or is about to shed. Nor when the hair is shed can one say when the follicle will produce a successor. According to the authors there are two seasons of follicle activity and hair growth, one in spring and another in the autumn; except in these seasons most follicles are mature and hold a club hair whose growth is finished. Some follicle activity is going on in all seasons. They propose a probable sequence of events: “In spring, a short, thick, hard coat is grown, most of the winter hairs being shed from the growing follicle. In autumn, the short hairs are shed to make way for hairs growing in follicles which have again become active, and these now grow longer, thinner hairs. The changes in coat between winter and spring and between summer and autumn are due to a replacement of fibres at both times. The winter coat is a new coat, and not an elongation of the summer coat. The summer coat is mostly present as club hairs which cannot continue growth but will stay as they are until they are shed. Further, the winter coat is made of hairs with smaller diameter than those of the summer coat, and the summer coat has shorter hairs than the winter coat. Continued growth could account for hairs becoming longer, but not for hairs becoming shorter.”

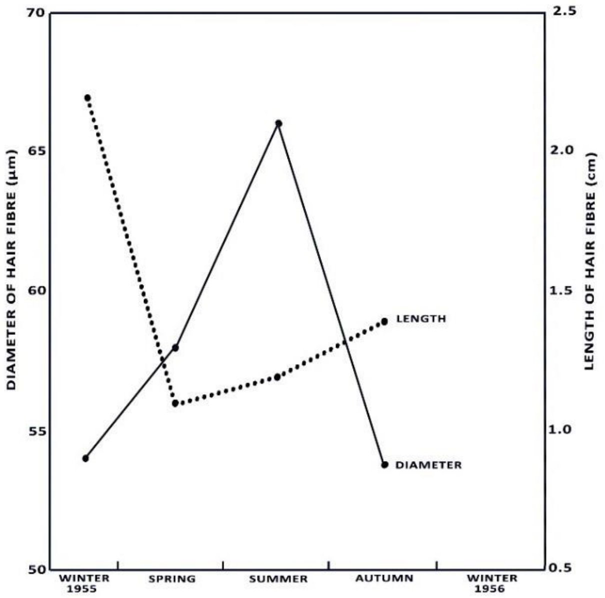

Fig. 3. The average diameter of the fibres of the coat compared with the average length. Each point represents the mean measurements of 10,000 hair fibres. (17)

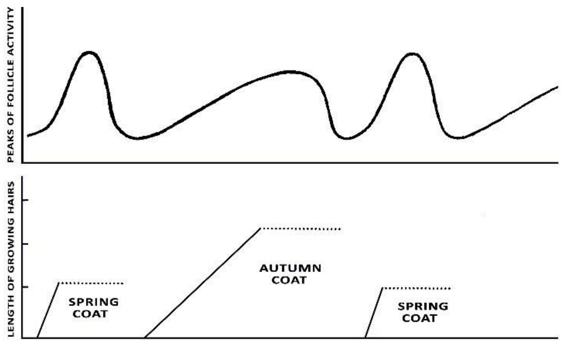

Fig. 4. Diagrammatic illustration of cyclic giant and average follicles in various stages in the follicle activity (above) and fibre length (below). (17)

Berman and Volcani (18) studied the annual cycle of coat growth and shedding rates in Holstein and Syrian x Holstein cattle in three different climatic regions of Israel. The results show that day length is not the only factor influencing the annual cycle of hair quantity and coat thickness but that the air temperatures are of influence too. In this experiment the hair diameter was influenced by variations in the day length.

Webster, Chlumecky and Young (19) raised heifers indoors in a room at 20°C or outdoors at -28°C with or without shelter. They found that the rate of hair growth (mg/cm2. 24h) was the same, but the heifers raised outdoors had twice the total hair cover (mg/cm2) of the heifers raised indoors because of the reduced shedding.
Schleger (6) studied the morphology of hair follicles in the 11 growth phases. He found that gland size was significantly influenced by follicle phase. Glands were largest in anagen VI and catagen c and were completely regressed in telogen. He concluded that there is an association between hair growth phase and sweat gland size and sweat gland activity. These three he found to vary together when comparisons are made with breeds or strains, between animals within breeds, between different body regions, and between seasons.

Nay and Hayman (20) found that Zebus have much larger and more numerous sweat glands than European animals. Within Zebus, sweat glands were slightly larger, and much more numerous, on the midside than on the dewlap. They are much closer to the skin surface in Zebu cattle than in European. Udo (21) evaluated the hair coat characteristics in Friesian heifers in the Netherlands in Kenya. He observed that heifers brought to Kenya had increased hair density initially, and then it decreased again to normal values. The seasonal changes in hair density in the Netherlands indicate that in spring and summer there are more empty follicles than in autumn and winter. This could be because several follicles producing non-medullated hairs in autumn shed their hair in spring and remain empty in the summer months. So, when there are fewer non-medullated hairs per unit area, there are probably more empty follicles per unit area. He also found large seasonal changes in melanin content: it was much higher in the winter than summer.
Most of the recent research on cattle adaptation, diet, and health is made with the objective of increased body weight and productivity. Here are some of the recent works. Psaros' (22) research has shown that cattle that are able to shed their winter hair coat in warmer summer months are more likely to tolerate heat stress and produce a heavier calf.
Gray et al. (23) evaluated the differences in hair coat shedding and effects on calf weaning weight and BCS (Body Condition Scoring) among Angus dams. They concluded that hair coat shedding is a heritable trait and could be altered by selection. Producers within the Southwestern or Southern United States who are concerned about heat stress may want to select cattle that shed their winter hair coat earlier in the season. Cows who shed their winter coat by June 1st will wean heavier calves on average. In another study Gray et al. (24) observed that cows that fail to shed in a timely manner tend to show more sign of heat stress when compared to slick-coated contemporaries.

Aiken et al. (25) conducted experiments to characterize and evaluate rough hair coats of cattle grazing endophyte (Neotyphodium coenophialum)-infected tall fescue (Lolium arundinaceum) during the summer, and the effect of this food source on body temperature. They observed that 80% of the hairs were emerged during long day lengths rather than short day lengths. They concluded that rough hair coats on cattle grazing endophyte-infected tall fescue composed predominantly of hair emerged during long day lengths in the late spring and summer. Growing to excessive hair lengths, these rough hair coats insulate elevated core body temperature to intensify hyperthermia triggered by ergot alkaloid-induced vasoconstriction.
Gilbert and Bailey (26) observed that Angus cattle tended to have shorter, less medullated coats, shorter, larger diameter undercoat hairs and guard hairs with less medullation than Herefords.
Williams (27) published the thesis "Hair Shedding Scores Relating to Maternal Traits and Productivity in Beef Cattle" with pictures illustrating the five Hair Shedding scores. Decker and Parish (28) made a publication on hair shedding scores as a tool for selecting heat tolerant cows.

4 Materials and Methods

Wet blue samples were collected from different suppliers in the United States. Crust and finished leathers were supplied from commercial samples from Asian tanneries using American wet blue. Black Angus hides were brine cured from Texas and north Texas.
Wet blue, crust and finished leather were analysed by SEM and optical microscope. For optical microscopy evaluations on the grain, cross sections were done using various standard laboratory stereoscopic light

microscopes. Electron microscopy evaluation and pictures (SEM) were done with Jeol JSM-6480LV, at 15 to 20kV.
Hair thickness measurements were made by mounting the hairs in five minute setting epoxy and sanding the epoxy perpendicular to the hairs. The measurements were made on the electron microscope Jeol JSM-6480LV. Other measurements were made directly on the cross sections or on the grain side using the electron microscope.

Cross sections of the salted hides were prepared using a radial microtome with cryostat and stained using Haematoxylin and Eosin as described by Tancous (1). The Haematoxylin solution Harris modified (cat. HHS16) and Eosin (cat. HT 110116) were purchased from Sigma-Aldrich, St. Louis, MO, 63103, USA. Cross sections of the wet blue, crust and finished leather were prepared using a radial microtome with cryostat and photographed by optical microscope.

For the unhairing evaluations we have separated the club (average 60 µm thickness and 20 mm long) and papillary hairs (average 150 µm thickness and 60 mm long) after removal from salted winter Black Angus hide pieces. The hairs were mounted on a piece of plexiglass 6 mm x 8 mm x 80 mm. Ten club and ten papillary hairs were glued with epoxy to the plexiglass, see Fig. 5. Unhairing solutions were made with sulfide, sulfide plus calcium hydroxide or peroxide in alkaline medium. Sodium dodecyl sulphate was added as a surfactant to reduce the superficial tension. Sodium dodecyl sulphate, sodium sulfide, sodium hydroxide 50%, hydrogen peroxide 35% and calcium hydroxide were purchased from Alfa Aesar, 2 Radcliff Rd, Tewksbury, MA, USA. The unhairing tests were run in a 1 L glass beaker with 800 mL solutions that were placed in a magnetic stirrer with a magnetic bar; the testing was conducted at 23°C for up to 10 hours with very frequent observations. The plexiglass with hairs was mounted parallel to the beaker wall so the hairs were submerged parallel to the liquid surface. The following solutions were used for test (Table 1):

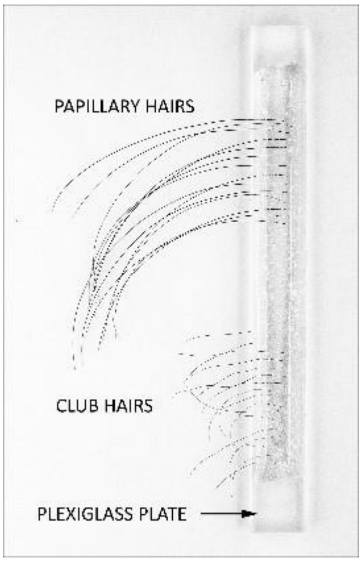

Fig. 5. *Plexiglass plate with the papillary and club hairs glued with epoxy.*

Table 1. Compositions of the solutions used for the unhairing tests.

	Sulfide (g)	Sulfide and calcium hydroxide (g)	Oxidative (g)
Sodium sulfide nonahydrate 98%	29.6	29.6	
Lime 95%		24	
Hydrogen peroxide 35%			100
Sodium hydroxide 50%			48
Water	770.4	746.4	652
Sodium dodecyl sulphate solution 10%	1 drop	1 drop	1 drop

5 Results and Discussion

Since our initial investigation of the fine hair (29) we have made an extensive literature review and obtained data from the tanneries. The fine hair problem is far more complex than initially expected. In this publication we will have some answers, but many more questions need to be answered. The diverse number of variables makes this problem very complex, and it probably cannot be solved fully.
The cross sections of black Angus salted hides in the wintertime show clearly the presence of club and papillary hairs. Fig. 6 shows the difference in diameter and length between the two types of hair; the papillary hairs are deeper inside the hide and much thicker than club hairs.

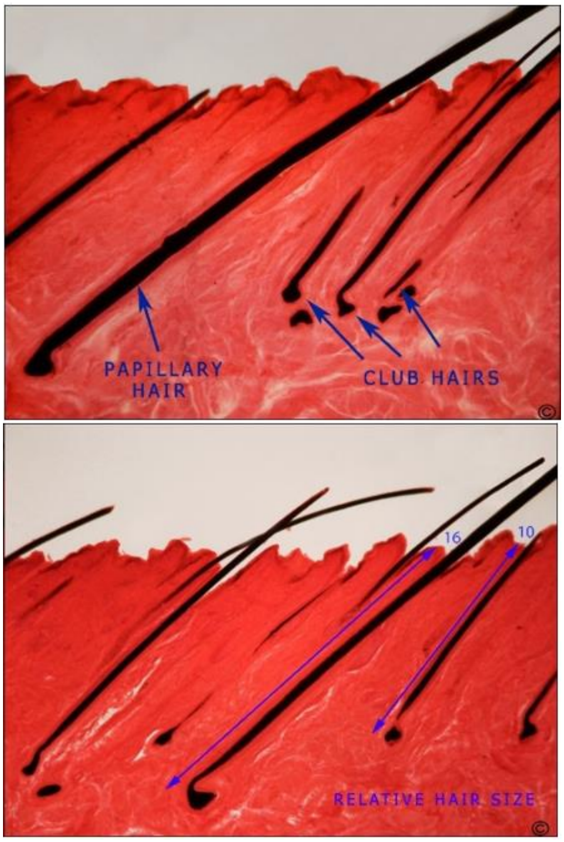

Fig. 6. Cross sections Haematoxylin-eosin stain. Left shows examples of papillary and club hairs. Right shows the relative size of the papillary and club hairs.

On the unhairing tests with sulfide, sulfide plus calcium hydroxide we have observed that club and papillary hairs are dissolved in almost the same ratio. With peroxide in alkaline medium we observed that both types of hairs start to bleach, and the club hairs are dissolved before the papillary hairs; this matches our previous observations made with hides. The test we designed had limited mechanical action in the hairs; this was made mostly with the purpose of observing the chemical effect on the dissolution of the hairs. On bovine hides processed in the tannery, the mechanical action will play a very important role in the removal of the hairs.

We have collected samples of wet blue with fine hair from different suppliers through the years, and all the samples have in common the defined and almost intact presence of the hair. The black hairs are predominant, but in some cases, we also have observed brown hairs. The white hairs either were not present or were not observed. It is sometimes suggested if we could just bleach the hairs with an oxidizer the problem would go away. The use of an oxidizer will bleach the hair and weaken the hair; this probably can work if the leathers are used full grain. In corrected grain leathers, the problem is only minimized and will magnify after buffing.

Oxidation is not a viable option for wet blue due the danger of Chromium VI formation. The wet blues were observed under optical and electron microscope (SEM). Hair diameter and length were measured. We found a wide distribution of hair diameter and hair length. The wide diameter (60 µm to 100 and 160 µm) range suggests that papillary and club hairs are still present on the leathers. The fine hairs, club hairs, are present in most cases, but papillary hairs were also observed. See Fig. 7.

***Fig. 7.** Left optical photograph of wet blue with fine hairs. Right cross section of the wet blue showing intact hairs.*

On full grain crust we could readily observe the fine hairs. Here in this commercial sample from Asia we have hairs from 60 to 155 microns. In this case we also have the presence of papillary and club hairs. The hairs have remained intact after retan and mechanical operations. See Fig. 8.

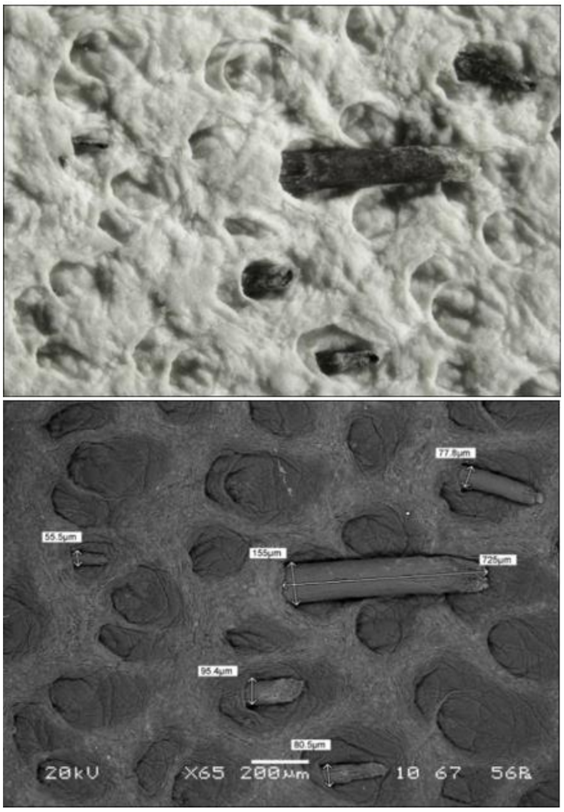

Fig. 8. *Left, optical photograph of crust leather with fine hair. Right, SEM image with hair measurements (65X)*

Our observations also have shown that hair remains intact, partially broken or removed on the surface of the nubuks. Many times, the hairs are only visible after coarse buffing to produce nubuk. Having fine hair on nubuk degrades the leather considerably. In Figure 9 below, we have an example of how a nubuk surface looks having fine hairs and a detail of a hair cut in half upon buffing; here the hair was intact after buffing and shows detail of the effect of the sanding paper on the hair.

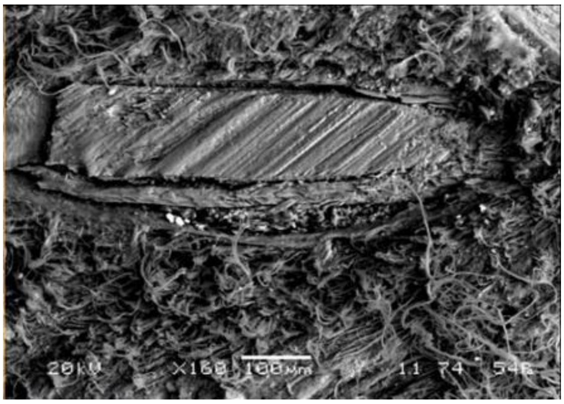

Fig. 9. *Left, optical photograph of nubuk leather with fine hair. Right, SEM picture of a nubuk, where the hair was cut on the middle during buffing. (160X)*

It remains a puzzle why we can have very few fine hairs on a few leathers in a drum. In many cases the hairs are very intact, as if they were immunized and cannot be removed. This happens with winter hairs.

In our opinion what is called “fine hairs” do not refer exclusively to the thin club hairs because both club and papillary hairs are responsible for the “fine hair” problem. Probably the problem could be better defined as “short winter hairs.”

6 Significance to the Tanning Industry

The US converts about 10 million hides per year to wet blue mostly for the export market. Most of the hides are processed fresh, coming straight from the abattoir, still hot and are cooled for proper fleshing before soaking. The hide weight after fleshing ranges from 25 to 50 kg. The beamhouse time is less than 24 hours, which includes loading the drum, soaking, unhairing, liming and unloading the drum. The typical drum loads are 16 tons with 300 to 500 hides/drum.

Every year the fine hair problem starts in the fall - in early to late November. The problem usually peaks from mid-December to mid-January. Most of the time it is completely gone by the end of March. The location of the hair on the wet blue is usually on the two front pockets (see Figure 10) and can be extended to the neck area if the problem is aggravated. In severe cases the hair is all over the hide including the butt area. It is unusual to have hair in the neck (or butt area) without having hair on the front pockets.

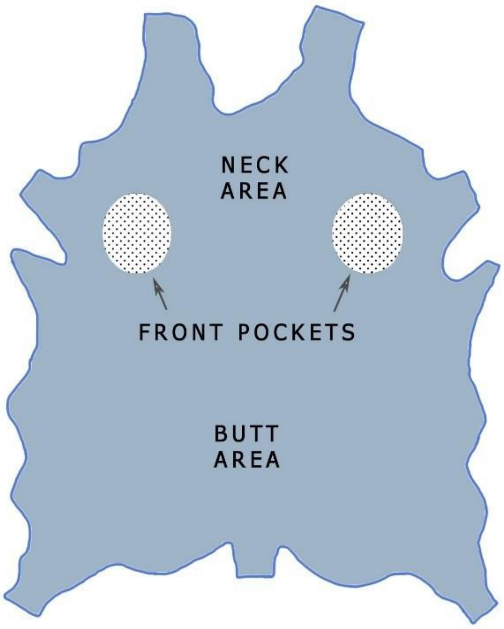

Fig. 10. *Drawing of a bovine wet blue leather showing the three most common areas of fine hair. The front pocket is the most common, followed by the neck and butt areas.*

The amount of hair in a drum is calculated as a percentage of wet blue with hair. A wet blue is considered to have hair if it is visible and bigger than a hand size after wringing; the inspection is one hundred percent on the wet blue. The size of the hair is usually not taken in account; in summer the hair is almost non-existent. During the fall and winter seasons the percentages can go from 0 to 20%. Wet blue with hair is separated and sold at a lower price. Unfortunately, not all the hair can be visible after wringing, and this can cause a very big problem to produce full grain, nubuks or corrected grain leathers.

Many times, the wet blue with fine hair is sold at a lower price and is downgraded. We estimate that downgrading reduces the wet blue selling price by 10 to 20%. Some types of leathers can accept some quantity of fine hairs like the automotive leathers that go to splitting and then have heavy mechanical action that can dislodge most of the fine hairs; the heavy finish with embossing also helps to make the residual fine hair not visible. Many automotive leathers are also snuffed.

The biggest problem for the tannery is to process the wet blue for example to a nubuk, and then find out after buffing that the leather has residual fine hair, like as shown in Figure 9. This leather must be downgraded and sold as reject, reducing the value about 60% and sometimes resulting a discount claim against the wet blue supplier.

The severity of fine hair changes from year to year. Some years are better than others, but this is related only to the amount of fine hair. Every year wet blue will be produced with fine hair, the question is only how much.

Here are some historical and practical observations:

- Lighter hides and heifers usually have more hair than jumbo hides. The age difference between heifers and animals that have jumbo hides is usually three months. This is probably due to the increased surface area and amount of hair. The heavier hides also have more mechanical action that can dislodge the hair. In a drum most of the time the hides have the same weight, but it is frequently the case that a percentage of hides can be either lighter or heavier than the average of the load.
- Hides from large confinement areas like Amarillo and Finney County have a more uniform size of animal and breed. These areas have an irregular profile for fine hair.
- Hides from small farms have more diversified size of animal and breeds, and this brings an increased amount of fine hair.
- There is no pattern to when in the season the fine hair will be visible; sometimes one location may have hair in December, none in January and February and suddenly the percentage of hair increases in March and April.
- During late spring, summer and beginning of fall no fine hair is observed.
- On the drum by drum basis it is possible that in one day a few drums will have about 2% of leather with fine hair, and then the next 10 days no hair is observed.
- Black Angus is one of the most common breeds in north Texas; in the Texas area, Oklahoma and New Mexico, the Zebu and Brahma are predominant. These breeds are tropical breeds and will not withstand the harsh winter. Most probably these breeds suffer most with the winter in these locations and therefore produce a heavier and more stable coat in the winter. These hides also have a more intense problem of fine hair.
- Salted or brine cured hides have less problem with fine hair. During salting or

brine curing the globular proteins are mostly removed. The hide permeability increases with the addition of salt. These hides require a longer soaking time and are properly soaked for further processing, much better than fresh hides that have a limited and improper soaking.

- Our observations do not clearly correlate the reduction of daylight hours to the increase of fine hair. In our opinion the temperature changes, breeds and nutrition play a more important role. What is surprising is that production can go many days without fine hair, and suddenly the problem appears for a few days and disappears again. Other times only a few drums have 5 to 10 hides with hair for a period, then the number of hides with hair can increase or simply not exist. Other times the fine hair appears at the end of October or late April, which are times that fine hair should not happen.
- In cattle raising in the United States, we have two important factors that severely affect hair cycling according to the literature: change of hours of sunlight and temperatures. In Figure 11 we have the US map with indication of cattle and calf population location. Also, we identified the average winter and summer temperatures for north and south which show the harsh winter in the north. The daylight hours at summer and winter solstice are also listed, In the north the difference can reach eight hours, and in the south, four hours.

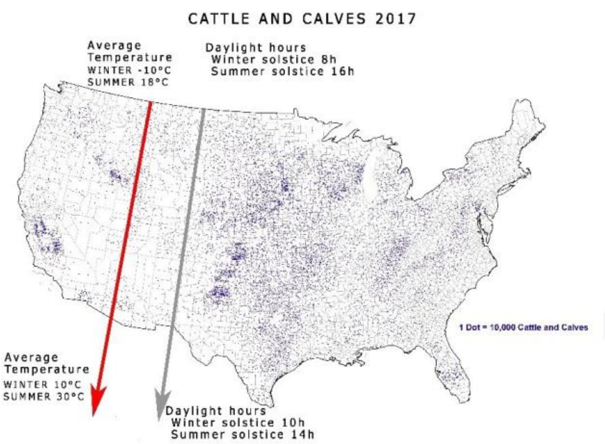

***Fig. 11**. Map of the US population of cattle and calves (30). We added information on average temperatures and daylight hours for the north and south. The numbers are estimated.*

Factors that can minimize the fine hair problem:

1) Green fleshing. During wintertime the hides accumulate manure that makes it very difficult to properly flesh the hide without damaging it. Improper fleshing leaves the hide with a large amount of subcutaneous tissue and fat, which makes it more difficult to soak properly the hides.
2) Soaking. There is a need to extend the soaking times to counterbalance the improper fleshing. This is seldom possible because the tanneries run a very tight 24-hour processing time from soaking to liming. Proper soaking auxiliaries that remove the globular proteins and improve the permeability of the subcutaneous tissue can be used, as well as powerful wetting agents. Enzymes can play a very important role here.
3) Drum loads. Proper mechanical action is needed during soaking, unhairing, liming and deliming. Overloading in drums does not allow proper mechanical action needed to remove the hair. Not always it is possible to reduce the drum loadings.
4) Swelling control. When excessive swelling happens, the hair gets trapped inside the hair follicle and no chemical can further attack the hair. This is clearly visible Figure 6 where the hair seems to be almost intact. This can also be caused by insufficient reductive potential, where pH and reducing chemicals are not properly balanced.
5) Lime fleshing and lime splitting.
6) Uniform loads. There is a proper formulation for different weights of hides that also includes drum weight, alkalinity, reducing agents and auxiliaries. A mixed load can have improper balance and result in an increase on the amount of fine hair. Processing fresh hides makes it almost impossible to weight-break the loads for proper formula use.
7) Seasonal formulations. Formulations need to be adjusted for winter. Most tanneries have a summer and a winter formula. The formulas need to be used at the correct time.
8) Proper formulations. If formulations are not properly balanced for winter, having a security reserve of reducing agents, any variation associated with a process such as process time, improper drainage, float volume, mechanical action, drum load and mixed loads can have improper balance that will increase the amount of fine hair.

7 Acknowledgments

The authors thank Ms. Maureen Fitzer, Research Analyst, for the comprehensive work on literature search; Dr. Elton Hurlow and Ms. Debbie French for the review; and Dr. Thomas McNeel for the support on the unhairing tests.

References

1. Tancous, J.J., Skin, Hide and Leather Defects, Leather Industries of America, Lee Corporation, Cincinnati, OH,45241, 1992
2. Merril, H.B., The Mechanism of Unhairing, Chemistry and Technology of Leather, Krieger Publishing, Malabar, FL, USA, 1978
3. Thorstensen, T. C., The use of sodium borohydride as an aid to Fine Hair removal, JALCA 62, 181-190, 1967
4. Kuntzel, A. and Stirtz, T., Hair Roots Studies, JALCA, 53, 445, 1958
5. Stoves, J. L., Some Biological and Chemical Properties of Animal Hair, J. Soc. Dyers Colourists, 63,3, 1947
6. Scheger, A. V., Relationship between cyclic changes in the hair follicle and sweat gland size in cattle. Aust. J. Biol. Sci., Vol. 19, No. 4, pp. 607-617, 1966
7. Chase, H.B., Rauch, H. and Smith, V.W., Physiol. Zool. 24, 1, 1951
8. Butcher, E. O., Development of the Papilary System and the Replacement of Hair in Mammals, Ann. N.Y. Acad. Sci., 53, Art 3, 508, 1951
9. Paus.R. and Cotsarelis, G., The biology of hair follicles, New Eng. Jour. Med., V 341, 7, 491-497, 1999
10. Stenn, K. S. and Paus, R., Controls of Hair Follicle Cycling, Physiological Reviews, V.81, 1, 449-494, 2001
11. Yeates, N.T.M., Photoperiodicity in Cattle, Aust. J. Agric. Res. 6, 891-902, 1955
12. Dowling, D. F., Seasonal Changes in Coat Characters in Cattle, Proc. Aust. Soc. Anim. Prod. 2:69-80, 1958
13. Scheger, A.V. and Turner, H. G. Analysis of coat characters of cattle, Aust. J. Agric. Res. Vol. 11, No. 5, pp. 875-885,1960
14. Hayman, R. H. and Nay, T., Observations onhairgrowthandshedding in cattle Aust. J. Agric. Res., Vol. 12, No. 3, pp. 513-527, 1961
15. Dowling, D.F., The significance of the coat in heat tolerance of cattle, Aust. J. Agric. Res., 10:5, pp. 744-748, 1959
16. Dowling, D.F. and Nay, T., Cyclic changes in the follicles and hair coat in cattle, Aust. J. Agric. Res. 11:1064, 1960
17. Berman, A. and Volcani, R., Seasonal and Regional Variations in Coat Characteristics of Dairy Cattle, Aust. J. Agric. Res., Vol. 12, No. 3, 528-538, 1961
18. Webster, A.J.F, Chlumecky, J. and Young, B. A., Effect of cold environments on the energy exchanges of young beef cattle, Can. J. Anim. Sci. 50:89, 1970
19. Nay, T. and Hayman, R. H., Sweat glands in Zebu (Bos indicus L.) and European (B. taurus L) cattle, Aust. J. Agric. Res., 7:5, 1956
20. Udo, H.M., Hair Coat Characteristics in Friesian Heifers in the Netherlands and Kenya, Wageningen, Netherlands,78-6, 1978
21. Psaros, K.M., Heritability of Hair Coat Shedding Scores in Angus Dams and the Relationship with Pre-Weaning Growth in their Calves, M. Sc. Thesis in Animal Science, North Caroline State University, Raleigh, NC, 2013
22. Gray, K. A.; Smith, T.; Maltecca, C.; Overton, P.; Parish, J. A.; Cassady, Differences in hair coat shedding, and effects on calf weaning weight and BCS among Angus dams. J. P. Livestock Science, Vol. 140, No. 1-3, pp. 68-71, 2011
23. Gray, K.A., Cassady, J.P., Maltecca, C, Overton, P., Parish, J. A., Smith, T., Hair Coat Shedding in Angus Cows, BIF Annual Research Symposium, Bozeman, MT, June 1-4, 2011

24. Aiken, G.E., Pas, J.L., Looper, M.L., Taber, S.F. and Schrick, F. N., Disrupted hair follicle activity in cattle grazing endophyte- infected tall fescue in the summer insulates core body temperatures, The Professional Animal Scientist, 27, 336-343, 2011
25. Gilbert, R.P. and Bailey, D.R., Hair coat characteristics and postweaning growth of Hereford and Angus cattle, J. Anim. Sci., 69(2):498-506, 1991
26. Williams, A., Hair Shedding Scores Relating to Maternal Traits and Productivity in Beef Cattle, Undergraduate Honours Thesis, Animal Science Department, University of Arkansas, AK, 2013
27. Decker, J. and Parish, J., Hair shedding scores: A tool to select heat tolerant cow, e-Beef.org, 2017
28. Zugno, L.A., Investigation of Fine Hairon American Cow Leathers Part I, 114th ALCAConvention, Itasca, IL, USA, June 19-22, 2018
29. US Department of Agriculture. National Agricultural Statistics Service Document 17-M208 https://www.nass.usda.gov/Publications/AgCensus/2017/Online_Resources/Ag_Atlas_Maps/17-M208.php