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**ADDIS ABABA INSTITUTE OF TECHNOLOGY (AAiT)
SCHOOL OF GRADUATE STUDIES
DEPARTMENT OF CHEMICAL ENGINEERING
LEATHER TECHNOLOGY STREAM**

APPROACH TOWARDS HIGH PERFORMANCE WATER VAPOUR PERMEABILITY UPPER LEATHER FROM GOAT SKIN

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University, Institute of Technology, in Partial Fulfilment of the
Requirements for the Degree of Masters of Science in Chemical
Engineering (leather technology)

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List of Abbreviations

WVP	water vapour permeability
WVA	water vapour absorption
CSA	Central Statistical Agency
Min.	Minimum
Max.	Maximum
N	Newton
L/O/N	Leave over night
PCS	Pieces
W/B	wet blue
WVTR	water vapour transmission rate
MVTR	moisture vapour transmission rate

Abstract

The mechanism of increasing WVP Goat upper leather, the processes have been developed. These process developed during the project were, increased percentage of bating enzyme during bating process, increased the duration time of liming process, avoided the qubracho powder and acrylic syntan during retanning process, decreasing of synthetic fat liquor and instead used semi synthetic fat liquor, increased the percentage of degreaser during degreasing process, after wet blue for 2hrs treated the leather with 1% of urea and acetic acid.

For each process, the physical properties such as WVP, tensile strength, percentage elongation at break, tear strength and grain crack were carried out. The result obtained from each process at crust and finished listed in chapter 4 in table form. The experiments carried out for both control and experiments for all experiments.

CHAPTER ONE

INTRODUCTION

1.1 Background

Ethiopia is one of the countries in the world who possess largest livestock population. According to CSA publication on livestock resources, Ethiopia has 53.4 million cattle, 25.5 million sheep and 22.7 million goats (CSA, 2011). This puts the country as one of the richly endowed countries in livestock resources. It is estimated that the country can collect 3.7 million cattle hides, 8.4 million sheep skin and 7.7 million goat skin. The hides, skin and leather is a critical strategic sector for the economic and industrial development of Ethiopia. It has an abundant and renewable resource base in Ethiopia's large population of cattle, sheep and goats [9].

The leather used for making of upper components of shoe is known as shoe upper leather. Most of the shoe upper leathers are chrome tanned leather. Combination tanning is carried out with a combination of chrome, vegetable, synthetic or other tanning agents to improve the fullness and firmness and some other desired properties of shoe upper. These desired properties are aesthetic appeal, tensile strength, water vapour permeability, tear strength, percentage of Elongation at break, grain crack and etc [2, 16].

one of the most important properties of shoe upper leather is water vapour permeability which contributes to body comfort by allowing perspiration to evaporate and be dissipated to the surrounding. Under normal conditions about 5 grams/ hour sweat is produced by a human when the atmospheric condition is between 30–35°C. Under industrial working condition, the sweat produced by a human foot is around 10 gram/hour. This sweat has to be sent out to the outside of the shoe for comfort wear. Leather footwear has the ability to absorb the sweat produced and transmit to the upper part of the leather through wicking process [4.17]. This process is known as Water vapour permeability or water vapour transmission. This is possible by the porosity characteristic of leather. Water vapour permeability is a measure of the passage of water vapour through a membrane. It is the rate of water vapour transmission per unit area per unit of vapour pressure differential under test conditions. It is

also known as water vapour transmission rate (WVTR) or moisture vapour transmission rate (MVTR).

Water vapour permeability is one of the most precious physical properties of leathers, which may greatly affects the breathability and the comfortable feelings of leather goods. There are plenty of capillaries among collagen fibres in leathers as well as lots of hydrophilic groups on the collagen chains. They may endow leathers with good water vapour permeability, compared with other synthetic clothing-materials [7]. Water vapour permeability is the ability of leather shoes allowing water vapour to transfer through from higher humid air to lower humid air. Water vapour permeability the volume of permeating water vapour in unit time and unit area, its unit is $\text{mg}/\text{cm}^2\text{h}$ [5]. Water vapour permeability upper leather more use full for hot areas.

The water vapour permeability of leather depends upon a number of factors including thickness of sample, grease content, and the relative humidity and temperature of the atmosphere [8, 6]. The remedy of these problem remove the grease during degreasing process, use special chemicals those not affects the water absorbent such as fat liquor and also choose the specials re tanning materials. The ability to transmit water vapour is one of the important properties of leather that makes it so desirable for use in the construction of shoes. To get this property one approach is used the right chemicals that improve water vapour permeability. In the recent year water vapour permeability leather has grown time to time in leather manufacturing industry. The production of these water vapour permeability leathers continues to increases radically and this trend is expected to continue.

Almost all kind of leather has a certain degree of natural water vapour permeability. But this is sufficient for normal purpose. However leather having improved water vapour permeability is sometimes required for special purpose. Leather sometimes gives unsatisfactory service because natural water vapour permeability is not sufficient. For these reason i concerned to improve water vapour permeability without affecting another properties those required for upper leather have very important [4].

Water vapour permeability upper leather can be produced by opening up the fibre at liming stage removing the grease and by chosen special re tanning and fat liquoring chemicals those

not fill much the fiber[6]. During choosing the chemicals I concerned also another property like tensile strength, Tear strength, percentage of elongation and etc. During choosing the chemicals if we are not consider other properties the products lack of these properties.

1.2 Objectives

❖ General objective

The general objective of the project was approach towards high performance water vapour permeability upper leather from Goat skin

❖ Specific objectives

1. Improved the water permeability of the goat upper leather at liming, degreasing, bating retanning and fat liquoring process stage.
2. Process modification to produced water vapour permeability goat upper leather
3. Study the physical properties of Goat upper leather at different process stage.
4. To aware the tanners to produce water vapour permeability upper leather

1.3 Statement of the problem

Water vapour permeability is the comfort property of leather. This is possible by the porosity characteristic of leather. The porosity of goat skin is compact that mean the fiber compact each other when compare to sheep skin and cow hide. Re tanning, finishing and fat liquoring processes in leather making reduces this water vapour permeability property to a greater extent. During the process, by selecting special chemical this problem was reduced without affecting the fullness softens and the aesthetic appeal.

Producing good water vapour permeability upper leather from goat skin gives plenty of benefits. Most of times tanners are produced goat suede upper from goat skins. During suede they pay extra expense for shaving and buffing. In addition to this expanse in our country we don't have experienced operators to produce good suede upper.

There is lack of awareness to produce high water vapour permeability upper leather from goat skin use it, to advertising to the people those live in hot areas. This thesis use as in put to solve this problem to Ethiopians tanners.

The types of shoes are used under different environmental conditions have different futures. The shoes those we used in hot area have a marked effect upon the moisture vapour transmission rate which incorporate a semi permeable film or membrane within their structure. This thesis study helps to understand the way how we improve water vapour permeability during leather process. During improve this property i consider other properties that means without affects those required for upper leather.

Under normal conditions about 5 grams/ hour sweat is produced by a human when the atmospheric condition is between 30–35°C. Now a day the people those live in this range temperature almost they wear open shoes. But if they have got leather shoes that can send out completely the sweat to the outside from their leg they prefer these types of shoes. Our country has a number of goat skins. Currently the temperature of the world increased day to day and in future the demand will be increase. So that our country produce such type of upper leather from goat skin and can get foreign currency in addition to sheep and cow upper.

1.4 Significance of the study

The significance of this thesis work generally:-

- ❖ It will increase the awareness of tanners to produce normal upper leather by shifting from suede with sufficient water vapour permeability.
- ❖ It can be used as a reference for leather industries.
- ❖ During suede production the tanners pay extra expense to buy buffing paper and this thesis will solve this expense.

CHAPTER TWO

LITERATURE REVIEW

2.1 Raw Material availability in Ethiopia

The supply of finished leather depends on the availability of the raw hides and skins in the country. Ethiopia is one of the countries in the world who possess largest livestock population. Ethiopia stands eighth for cattle, twelfth for sheep and eighth for goat livestock populations [FAO 2011]. 53.4 million cattle, 25.5 million sheep and 22.78 million goat livestock population are found in Ethiopia, which is the share of Ethiopia is 2.5% of the world livestock population [CSA 2011]. The raw skin and hide production and the off take ration are presented in the following table.

Animals	Population thousand heads	Raw skin & hide Production (Million pieces)	Off-Take Ratio (%)
Cattle	52,000	3.7	7.12
Sheep	27,096	8.7	32.11
Goats	22,094	8.1	36.66

Source: FAO World Statistical Compendium for Raw Hides and Skins, Leather and Leather Footwear 2011

Table 2.1 population distribution of cattle sheep and goat

2.2 Histological structure of a goat skin:

The normal size of the skin varies from 23*12 *inch* and 33*18 *inch*. Skins of sizes below the former and above the latter are called “kids” and “heavies” respectively. In many aspects the structure of a goat skins can be considered in between a cow calf and a sheep skin.

Epidermis of a goat skin:

- The epidermis of a goat skin covers approximately 1 to 2.6 % of the total thickness of the skin.
- The average number of hairs varies from 8000 to 18,000 hairs per square inch. Two types of hair are present (coarse and fine hairs).
- Like the calf the goat has straight hair follicles and hence straight hairs. The hair follicles are quite deeply rooted.
- The glands and fat cells are very much less in number in goat skins. The erectorpili muscle is well developed and long in goat skin.

Grain layer of a goat skin:

- The grain layer of the goat skin usually occupies approximately 24 to 54 % of the total thickness of the skin.
- In the grain layer the collagen fibre bundles are compactly woven. Because of lesser number of cellular components and fat glands the goat skin is comparatively compact than sheep skin.
- In the goat skins there is more elastin and it covers approximately 2/3 rd of the entire layer of the grain. The presence of larger amount of elastin tissue is perhaps one of the reasons why greater efforts are needed to open up the grain structure during pre-tanning process.
- In good quality goat skins corium and grain layer merges uniformly.

Corium layer of goat skin:

- The corium proper of the goat skin occupies approximately 45 to 75 % of the total thickness of the skin.
- The collagen fibres present in this layer are firmer and fuller than the corresponding ones in the sheep skins. It is nearly equal to that of a cow calf hide.
- In goat skins a very low angle of weave is present.
- Fat cells and fat droplets are rarely found in the corium proper of goat skin.
- A considerable amount of reticular tissue is present in goat skin.

Flesh layer of goat skin:

- It roughly covers 1 to 2 % of the total thickness of the skin.
- A considerable amount of elastin tissue is present in the layer.
- Natural fats and fat cells are present in this layer

2.3 Leather processing

The process to obtain finished leather from fresh hides or skins can be divided into four stages [14].

- ❖ Beam house operations,
- ❖ Tanning,
- ❖ Post-tanning
- ❖ Finishing

2.3.1 Trimming

Trimming is done to remove unwanted long Shank, horn, hooves, ears, tails etc and give a proper shape of goat skin [2, 13, and 14].

2.3.2. Sorting

The Raw hides and skins are procured by tanners from different regions & species and they are of different size and weight categories. However, after processing the final leather should comply with certain physical and chemical properties, standards and with the customer/buyer satisfaction. In view of this, several quality control measures are planned and followed during leather making. Raw material segregation before soaking is one of such steps to achieve the desired quality [13]. Sorting is carried out according to size, weight, thickness, grade etc and formed into batches to maintain the quality of leather.

2.3.3. Weighing

Weight of salted wet goat skin is taken in order to measure the chemical required for the subsequent operation.

2.3.4 Soaking

The cured skin is soaked in water to rehydrate the fiber structure with water, to remove the preservation salt, non structural proteins (non collagenous), dung, dirt and blood. The soaking chemicals include: Water, detergents, biocides and alkalis. Soaking enzymes can also be used to speed up the rehydration process [1, 18]

Temperature of float	25-28 ⁰ C
pH of float	7.5-9.0
⁰ Be	<1
RPM of Drum	1-3
Time	Depending on condition of stock

Table2.2 parameters those we control [18]

Completion of Soaking:

Completion of soaking is tested by folding the skins/hides flesh side out, and feeling for uniform softness and flexibility. No streak of hardness should be there. Over soaking should be avoided as it will lead to looseness, loss of substance, accentuation of vein marks, in extreme cases putrefactive damage (hair slip and grain off effect in the final leather [18]

2.3.5 Unhairing

Unhairing is a process of removing the hair from the skin. The traditional method of dissolving the hair is to dissolve it, called ‘hair burning’. Hair removal in alternative ways, ‘hair saving’, keeping the hair intact while removing it; each technology requires a different degree of process control [1]. Chemicals needed for this process are lime, sodium sulphide, water and if necessary unhairing enzymes [18].

2.3.6 Liming

The treatment of soaked skins with lime, sodium sulphide (sharpening agent), surface active agents etc in a drum, pit or paddle is liming. The purpose of liming is to remove hairs, epidermis, natural fats and greases interfibrillary proteins (cementing substance) to swell and split up the fiber bundles into fibers, to soften the collagen fiber lattice and make the final leather non patchy, soft and pliable[1].

2.3.7 Fleshing

The aim of fleshing is to clean the skin by removing the adhering fat and tissues on the underside of the skin to facilitate the penetration of chemicals applied in subsequent stages. This operation is carried out using fleshing machine [14]



Fig2. 1 before and after fleshing

2.3.8 Weighing:

The pelt goat skin weight is taken to calculate the amount of chemical required for the successive operation.

2.3.9 Deliming

Deliming is removing the alkalinity by washing the pelt in paddle or dram. The objective of deliming are: - removing the lime, lowering the pH in preparation for bating, and reversing the swelling. It can be carried out by using:- Weak Acids, Acidic Salts, Carbon dioxide , Ammonium salts (In industry it is common to use either ammonium sulphate or ammonium chloride)[1].



Fig.2.2 during checking of completion of de liming with phenolphthalein

2.3.10 Bating

The treatment of delimed pelt with enzymatic bate powder to remove non leather making substance and to make the grain surface clean, smooth and fine and give the finished leather soft pliable stretchy feel. The efficiency of bating depend on temperature, strength & pH of bate liquor and duration of the process. The Bating purpose is to remove the hair roots, break down of the non-structural proteins and to get clean pelt. Mostly the chemicals used bating enzymes[1,2,13,18]. The completion of bating should be checked during process. Before bating the air bubbles not come out.



Fig. 2.3 checking of air bubbles before bating



Fig. 2.4 checking of completion of bating

2.3.11 Pickling

The pickling process is primarily conducted to adjust the collagen to the conditions required by the chrome tanning reaction [1]. Objects of Pickling is To bring the delimed and bated pelts to a required degree of acidity before chrome tannage, even vegetable tannage, To

reduced the PH ,To modify the fibre structure, To reduce the astringency of chrome tanning agents To preserve the skin and to achieve the special effect.(SHARP HUASE). The traditional recipe for pickling based on limed pelt weight is 100% Float, 10% salt, 1% Sulfuric acid [1].

The pH needed before commencing chrome tanning process is 2.8 to 3.0. To achieve this pH acidic treatment of pelt is necessary. However, when the pH of the pelt goes below 4.3 acid swelling is happened. Hence, to suppress the swelling salt is added before acidic treatment.

2.3.12 Tanning

Raw hide/skin is a biological material and hence susceptible for putrefaction. Though there are many processes involved before tanning except pickling most of them not give stability to the leather protein. Tanning is the conversion of a putrescible organic material into a stable material that resists putrefaction by spoilage bacteria. Chemically treated the pelt with the tanning agent (basic chromium sulphate) and altered in chemical composition from an irreversible stabilization and as to become more resistant hydrothermal shrinkage and micro organisms. After completing chrome tanning, fixing is done by adding basifying agent for e.g. sodium formate /bicarbonate. Objects of Tanning To convert the putrescible hides and skins into non-putrescible leather, to raise the shrinkage temperature and to increase the resistance to hot water of the leather, to reduce the ability to swell when wet back, to increase the strength properties of leather[1.18] There are several types of tanning methods available, chrome tanning is very popular and globally about 90% of the products are based on chrome tanning. This is due to the fact that Basic Chromium Sulphate (BCS) is a versatile tanning agent and almost all kinds of leathers can be produced out of it.

During tanning the penetration of chrome was checked.



Fig.2.5 checking of chrome penetration

2.3.13 Ageing

The tanned leather is kept for few days (minimum 48hrs) in piling to get fixed the chrome (tanning agent with collagen by olation, oxalation and polymerization [1].

2.3.14 Samming

The amount of moisture present in chrome tanned leathers does not bring them into the condition for splitting and shaving. Considerable amount of moisture should be removed from the tanned hides and skins before they are split and or shaved. This removal of moisture to some extent is done by samming machine, which consists of two felt rollers which can squeeze out the water. The pressure exerted should not be high so that there are no compressed areas which may result in loose grain. If too much water is to be removed, it is advisable to sam twice with light pressure than once with heavy pressure. The moisture content is reduced to 45-50% in samming process. Some do the removal of moisture by hooking up the hides or sides or skins or spreading them on the floor. These are not advisable as certain portions particularly the flanks and edges dry up more quickly whereas the other portions remain wet[13,18]

2.3.15 Shaving:

The skin after samming, are further shaved to the required thickness in the shaving machine. In shaving operation also, care should be taken to see that undue shaving is not done in looser portions like bellies, flanks etc. Chatter marks should be avoided as this show up even in finished leather. The operators should be checked the uniformity of thickness in shaved leather, using thickness gauges. The main objective of shaving is to obtain the required thickness and uniform final leather [13, 14].

2.3. 16 Weighing

Taking shaved weight for to calculate the quantity of the chemical required in the subsequent operation.

2.3.17 Post tannin

Post tannin operation

The following are post tannin operation in leather processing.

- ❖ Acid wash
- ❖ Rechroming
- ❖ Neutralization
- ❖ Retanning

- ❖ Fat liquoring
- ❖ Dyeing
- ❖ Fixing

2.3.17.1 Acid wash

Acid wash is the first process performed in the drum after adjustment of the thickness of the wet blue leathers by shaving. This is performed to wash away any unfixed/loosely held chrome and also adjust the pH for rechroming. The chemicals used include an acid, mostly acetic acid and a fat and chrome dispersing agent (an amphoteric agent most of the times). Sometimes, oxalic acid is also used to scavenge hexavalent chromium if any in the leather or in the case of white or pastel colored leathers [18, 19]

2.3.17.2 Rechroming

The purpose of re-chroming for chrome tanned leathers is to get more uniform chromium content to get uniform layer-wise distribution of chrome in thicker part leathers. Another reason for re-chroming is to get fresh cationic charge in the aged wet blue leathers to improve affinity for dyes and fat-liquors. It is necessary to basify the chrome in re-chroming to a pH of about 4.0 to increase the fixation and allow the re-chromed leathers to age overnight before the leathers are taken for further processing. This is to ensure completion of olation process. If the re-chromed leathers are taken for neutralization process without aging, there is a possibility of stripping out chrome in the bath and the more serious issue with respect to production of free mineral acid in the leather due to continuing olation process resulting in poor strength properties of the leathers [1, 13]

2.3.17.3 Neutralization

After tannage chrome leathers (also other minerals salt tanned leathers) separate acid as a result of olation during intermediate storage before further processing. It is absolutely necessary to remove this free acid as it disturbs the subsequent process. Colour stain and over loading of the grain are caused by dyes and tanning agents existing on the surface, and smudging and fat stains results from precipitation of the fat emulsion. Further consequences are defects in the leather or in the end products [3].

Objects of neutralization:

- To remove the neutral salts and un combined chromium salts from the leather.
- Neutralization of free acid in the leather formed by the hydrolysis of the chrome complex. During neutralization process we have checking of the pH of the leather with

PH papers and Indicators such as Bromo Cresol Green (3.8-5.4) and Bromo Cresol Purple (5.2-6.8). If post tanning operations are performed without neutralization, the following things will occur.

- The dyes will get fixed only to the surface without penetration and the patchy and unlevel surface dyeing will result in
- The fatliquors will not be able to penetrate well due to premature breaking of oil in water emulsion resulting in surface greasiness and hard and bony leather without the internal softness
- The penetration of retanning material will not be good and there will be more loading of the grain resulting in empty leather with coarse grain and in worst cases the grain might crack due to excessive surface loading[13,18]

Extent of neutralization depends on the softness of final leather. The nature of raw material should also be taken into account for neutralization.

Corrected grain upper leather	pH -4.8-5.0
Softy upper	pH 5.0-5.2
Suede leathers	pH 5.2-5.5
Nappa garment leather	pH 5.5-6.0
Glove leather	pH 6.0-6.5

Table 2.3 the extent of neutralization required for different types of leathers

2.3.17.4 Retanning

Re tanning is a subsequent treatment with the most different tanning agents following the main tanning process in order to give the leather special optimum properties for use [3]. The processes that are performed after tanning but prior to finishing such as neutralization, dyeing, retanning and fatliquoring are called post tanning or wet finishing operations.

Objects of Re-Tanning:

- to improve the fullness and uniformity of substance
- to fill the looser areas in order to get uniform substance and fibre compaction in all parts of the skin
- to impart body and round feel
- to avoid grain looseness, improve 'break' and grain tightness

- to improve overall cutting value [18].

2.3.17.5 Dyeing

The purpose of dyeing leather is to improve its appearance and to increase the value of the finished leather. The dyeing of leather into various appealing colors plays an important part in meeting fashion requirements. The main objective in dyeing is to produce level colours over the whole surface of each hide or skin and to match the colour of pieces of leather in a pack of Leather with one another exactly [13, 18]

2.3.17.6 Fat liquoring

The process of uniform is coating of individual fibers with a fat layer by treating with emulsion of fats and oils. The treatment further influence the physical properties of the leather, such as soft and suppleness, extensibility, tensile strength, water proofness, permeability to air and water vapour etc.

2.3.18 setting out

Setting is mostly performed at the end of wet processing before drying. It is used to obtain smooth surface and grain area [3, 17].

2.3.19 Drying

The moisture content of the skin is reduced to be able to carry out the finishing operations. Drying can be achieved through different systems:

Drying chamber: is the oldest and most economical system and consists in natural air drying. The air can go in and out completely or be recirculated in a controlled way [14].

Drying tunnel: consist of a tunnel through which the leathers pass slowly, hanging from a conveyor, while the hot air circulates perpendicularly to the leathers' path.

Paste drying: consists in sticking the leather's grain side onto a glass plate. The glass plates covered with leather circulate slowly and vertically inside a drying tunnel [14].

Vacuum drying: the leather is spread out on a heated horizontal plate, the machine's airtight hood is placed over the leather and a strong vacuum is applied to quickly remove moisture from the leather [13, 14].



Figure 2.6. Vacuum drying [20]

2.3.20 Finishing

The final stage of leather production is reached with finishing process. These treatments have the purpose of making the leather usable and suitable for the manufacturing of the end products[3,18] Finishing is the last operations done in leather processing to improve the appearance, aesthetic and sale values of leathers and protecting the leather surface from damage during usage against rubbing, water, soiling and abrasion. The demand of the market adjusted in finishing.

The object of finishing is to give a treatment of coatings to the grain surface to protect it against dirt, staining, wetting, mechanical stresses like rubbing, scuffing, flexing etc., levelling or evening out the colour of the grain surface, hiding grain blemishes and upgrading its quality, improving the aesthetic appeal and the sales value of the product. By the finishing process, the grain surface of the leather is coated with various substances and is then submitted to different mechanical operations, depending upon the purpose intended whereby the appearance of leather can be highly influenced to make it more useful, attractive and appealing to users. Finishing may be employed to impart colours, a uniform shade, special patterns, a smooth or grained or printed/embossed surface, lustre (Matt or glossy) as well as opaque (covered) or transparent (aniline/semi-aniline) appearance to the leather surface. Finishing operation is the most vital part of the processing of leather as the final product is judged by its appearance, evenness of colour and surface, feel, handle, break, gloss etc.

Hence it is usually the finishers who have to face the complaints or blames, if anything goes wrong. They are also expected to correct whatever faults that have occurred during the earlier operations [13, 14, 18].

The main chemicals are:-

- Colorants
- Film forming materials
- Feel, flexibility and surface modifiers
- Flow modifier

Structures of finishing

A normal finish essentially consists of 3 coats.

- Bottom coat

The bottom coat may be either sealing or impregnation coat and clearing coat. The object of sealing or impregnating coat is to seal the grain to control the penetration of the season coat. The season coat should give a levelled and uniform filmed color coating and not overload the grain. Sealing should uphold firmly on the leather surface. Impregnation coat is applied for soft grain tightening and filling effects. The objective of the clearing coat is to make the grain devoid of any oils or fats and to improve the absorbance of the season coat by the leather.

- Pigment coat (Season Coat)

The season coat is to impart a desired color to the leather and level out the surface defects. The effects like glossy or matt, soft or hard feel can be brought about by proper choice of auxiliaries added to the season coat. This coat can be done either by pad or hand spray or Auto spray. By spraying on we can achieve levelness in film formation.

- Top coat

Top coat serves the purpose of protecting the season coat. It gives properties like appearance, handle, fastness to wet and dry rub resist to hot plating [13, 18].

2.4 Measures of performance requirement of upper leather

The quality of the products is defined as its degree of fitness to meet the needs and desires of the customer. The quality of products can be measured in terms of product performance requirements after the product has been delivered to the customer. In the case of leather products, the performance requirement can be measured in terms of the use property and the aesthetic values that the product should possess. In footwear technology, there are various

tests that measure the product performance to confirm that whether the product will exhibit the predetermined requirement while put on use [16].

2.4.1 Mechanical Performance Requirement

2.4.1.1 The Tensile Strength

Tensile strength is strength of leather in terms of force per unit area of cross section while applying force in linear direction. The Tensile Strength is maximum tensile stress recorded in extending a test piece to breaking point. Tensile strength is good realm to check whether the leather upper has sufficient structural resistance [16].

S.N	Property	Units	Upper	Lining	Furniture	Goods
1	Tensile strength	N/mm ²	15.0	15.0	10.0	10.0
2.	Elongation at break	%	40-80	40-80	40-80	40-80

Table 2.2 Guide lines for tensile strength and percentage elongation at break

2.4.1.2 The Percentage Elongation

Percentage elongation is the tensile strain of the upper leather of the shoe in the test length at breaking stage. The elongation at break shall provide a medium value, so that the leather has enough elasticity to adapt to the user's feet and to the movements derived from the use of foot wear. The elongation should not be too excessive to avoid the ease of footwear deformation. [16, 17]

2.4.1.3 The Tear Strength

The Tear Strength is the median force required to propagate a cut in a specified test specimen. The leather upper should possess high flexibility to prevent the appearance of cracks and tears in the ball area of the footwear upper [16]. Tear strength is one of the most important of properties for upper leather. The minimum requirements for upper leather are 40N [3, 17]

2.4.1.4 The Ball Burst

The Ball Burst is used to define the capability of the finished upper leather to withstand for the ball shaped steel material to burst as instantaneously increasing enforcement. The grain layer shall have a high elasticity, which allows it to withstand the elongation stresses to which it is subjected during footwear lasting, especially on the hot area [16, 17].

2.4.2 Physical Performance Requirement

2.4.2.1 The Water Vapour Permeability

The water vapour permeability of leather is inherently high. However, the use of fats and greases to improve water resistance of shoe leather may lower water vapour transmission to the point below the critical level, which has not been determined, at which the foot may be comfortable under a particular set of temperature and humidity conditions which the wearer of the shoes may encounter. It would be desirable to maintain water vapour transmission at a high level while simultaneously liquid water transmission is maintained at a low level.

It is to assess the upper leather's breathability, mainly in leather coated with very thick films. Persuading this breathability prevents the heat generated and accumulation, and consequently avoids the sweating of the foot [3, 5]

Mechanism of transmission of water vapour

The Mechanism of transmission of water vapour through fibrous organic materials consists of gaseous diffusion through pores or through conduction. By conduction is meant migration by means of solution, diffusion or capillary action from a region of high to low concentration, over hydrophilic surface [15]. Water diffusion occurs mainly in free space within leather.

Factors affecting water vapour permeability

- Leather Thickness: leather thickness and water vapour permeability have indirect proportional. When the leather thickness increases the water vapour permeability decreases
- Grease content water vapour permeability is greatly reduced by the presence of natural glyceride grease. The grain layer is the first stratum to become saturated with grease and consequently is highly influential stratum with respect to permeability[15]

2.5 Leather for shoe upper construction

Upper leather all leather which are use in the shoe production mainly for shoe upper construction. They have the largest share in the total leather production i.e.>50%,where by upper leather made from cattle hide accounts for the major parts following calf and goat skin and in descending order sheepskin, pig skin, horse hide and to small extent buffalo hide, kangaroo skin and reptiles or fish skin[3].

No.	Test	Requirements
1	Flexing endurance in the cold (-20 c ⁰)	50000dry, 10000 wet min. 30000 flexing
2	Adhesion of finish	3.0N , 2.0 N rub
3	Rub fastness	Min. 50 rub cycles
4	Fastness to hot plating	Min. 80 c ⁰
5	Split tear force	<ul style="list-style-type: none"> • Min.18 N (with lining) • min. 25 N (without lining)
6	Tensile strength	Min. 150 N
7	Elongation at break	Not less than 40%
8	Light fastness	Not less than rating 3(blue scale)
9	Fastness to migration	Max. Rating 3 (blue scale)
10	Water vapour permeability(WVP)	1.0mg/h.cm ²
11	Water vapour absorption(WVA)	10mg/cm ² (after 8 hrs)
12	Water proofing	<ul style="list-style-type: none"> • Penetrate water min.60min • Absorption of water max 35%
13	Water spotting test	Drying without staining

Table 2.3 the most important quality required of shoe upper leather

2.6 Leather for shoe inside construction

This group includes lining leather. The main function of lining leather is to compensate the absorption and release of wet transpiration of the foot during use. The tanning methods are vegetable tanning, a combination of chrome and vegetable tanning and pure chrome tanning. The lining leather should meet the criteria for good softness, pleasing handle, high fastness to perspiration, WVP, and absorption capacity and should contains only small amount of substance that are removable by washing[3]

2.7 Hygienic Properties for Leather Shoes

Hygiene properties of leather shoes, which has great influence on health and comfort, mainly contains air Permeability, water vapour permeability, hygroscopicity, heat preservation and antimicrobial ability. Natural leather has excellent hygiene properties for its collagen fibers, each hygiene property is not isolated and there are complex relationships between them. (Grey system theory). A pair of shoes with good hygiene properties is important to the health of feet and the whole body. With growing concern on health, better hygiene properties of shoes are expected. At present, air permeability and water vapour permeability are the items that must be tested to measure leather's hygiene properties, and some industry standards or national standards have been established. But there is no uniform standard in leather properties of moisture absorption, heat preservation and antimicrobial ability and the hygiene properties of shoe material are used to measure those of entire shoe directly [20].

Air permeability

The ability of shoes that air can go through their upper or sole is called air permeability. Since there are many gaps between the collagen fibers and fiber itself, natural leather has excellent air permeability performance. Air permeability in general is measured by air volume through leather of unit area in unit time, its unit is $\text{ml}\cdot\text{h}^{-1}\cdot\text{cm}^{-2}$, and the main test instrument is H·C Fedorov detector of leather air permeability [20]

CHAPTER THREE

MATERIAL AND METHODOLOGY

3.1 Materials

3.1.1 Raw materials

The raw materials that I used for this project were wet goat salted goat skin

3.1.2 Chemicals and equipments

3.1.2.1 Chemicals:- chemicals used in this project were leather processing chemicals which were mentioned in page 30 and 32

3.1.2.2 Equipments: Equipments, which were used for experimental work, are drum (sample drum), skin fleshing machine, skin setting machine, skin shaving machine, staking machine, hand spray, plating, weighting machine, cutter, PH Paper. For physical test, testing machine such as tensile strength testing machine (dynamometer), lastometer test for grain cracking were required.

3.2 Processing method

The processing steps in the production of upper leather that required mentioned in detail in the literature part. On following process modification have taken to get the required product.

3.2.1 Liming

The purpose of liming is to remove hairs, epidermis, natural fats and greases interfibrillary proteins (cementing substance) to swell and split up the fibre bundles into fibres, to soften the collagen fiber lattice and make the final leather non patchy, soft and pliable(BM). In this operation pH maintain at 12.5 to 13. During this process the water vapour permeability of the leather were improved by increased two times the process duration. When the duration of process long the fibre of the skin open more. If the fiber of the skin is open more the water vapour transmits was increased.

3.2.2 Bating

The treatment of delimed pelt with enzymatic bate powder to remove non leather making substance and to make the grain surface clean, smooth and fine and give the finished leather soft pliable stretchy feel. The efficiency of bating depend on

temperature, strength & pH of bate liquor and duration of the process. The Bating purpose is to remove the hair roots, break down of the non-structural proteins and to get clean pelt. Mostly the chemicals used bating enzymes. By taking the de-limed goat skin by varying the concentration of bating enzyme water vapour permeability was improved and other properties were not affected. Conventionally the percentage of bating enzyme is mostly 0.8-1% based on pelt weight. But By increasing this percentage varying from 1.2-1.5% based on the weight pelt skin. The physical tests were performed at crust and finished stage.

3.2.3 Degreasing

Degreasing of skin prior to tanning process is an important unit operation. Degreasing of skin is process remove the natural fat present in the skin. If this fat is not removed, it affects the leather water vapour transmit rate .Presence of large amounts of natural fat at the interior of skin matrix makes degreasing process a challenging one. After pickling by re fleshing and increasing the percentage of degreasing agent the water vapour permeability of the upper leather was improved. The rest process is as convectional. Physical properties such as tear strength, tensile strength, grain crack and break at elongation were not affected. The tests were performed at crust and finished stage.

3.2.4 Retanning

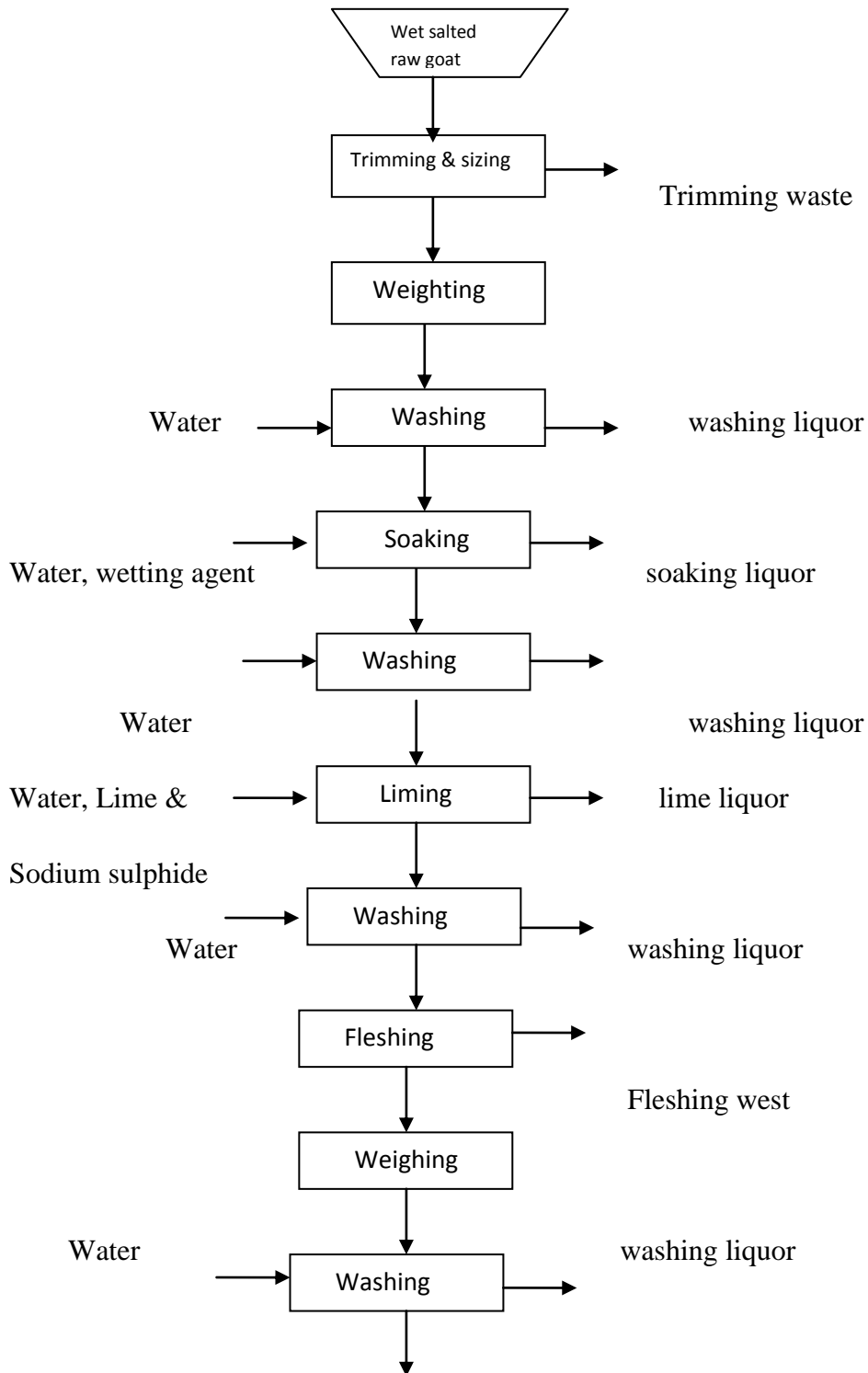
It is well known that chrome tanning produces empty types of leathers and vegetable tanned leathers produce fuller leathers. Hence in the case of chrome tanned leathers, more efforts are necessary to bring about uniformity in fullness and fibre structure. Retanning is the process performed to achieve this objective. Sometimes, retanning of chrome tanned leathers or vegetable tanned leathers are carried out to impart special characteristics such as improved dyeing characteristics or improving the affinity for fatliquors by altering the charge characteristics or bleaching or bringing about whiteness etc. Selective filling is required to get overall uniformity in fullness and fibre structure, there are different classes of retanning materials need to be used in combination get the desired results in retanning. During retaining the fiber will be compact and reduce water vapour permeability. But by selecting special retanning agents this problem was reduced. During the process by selecting special retanning agents (by avoiding acrylic resin and reduced quabacho) the water vapor permeability of upper leather of upper leather was improved.

3.2.5 Fat liquoring: -

Fat liquoring is performed to impart softness, flexibility, feel, drape, run etc. The strength properties are also improved by fat liquoring. Fat liquoring is to coat the individual fibres or fibre bundles (depending on the extent of fibre opening achieved in beam house operations for different types of leathers) with a thin layer of oil so that the internal friction is reduced and the fibres slide over one another to give the required softness and flexibility. During fat liquoring the compactness of fiber increased. But by using special fat liquor (semi synthetic fat liquor) those not much fill the fiber and not affecting the softness and other properties and improve water vapour permeability of upper leather. During the process by

3.3 Flow diagram of leather processing of goat skin for shoe upper leather

3.3.1 Flow diagram from raw to wet blue



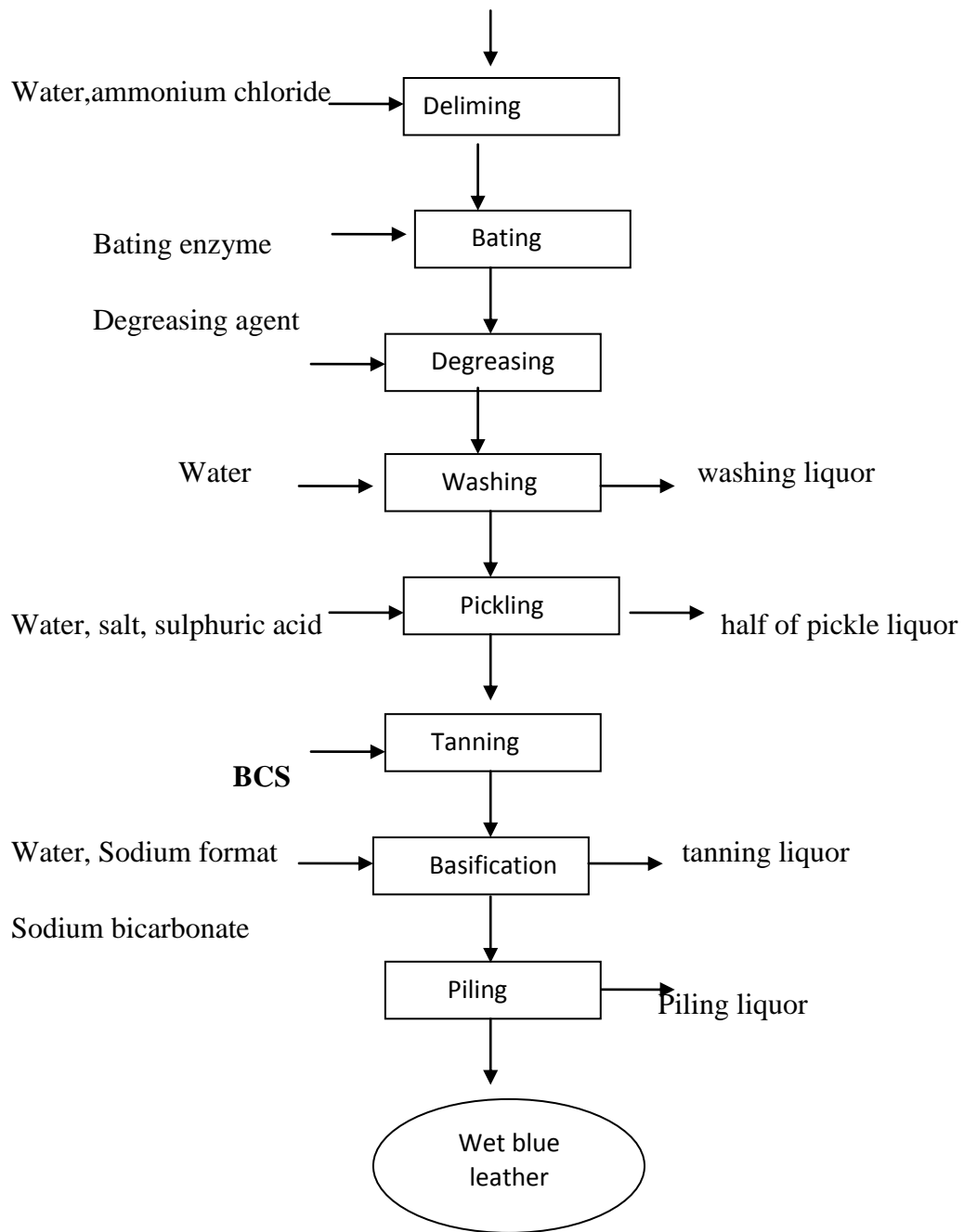
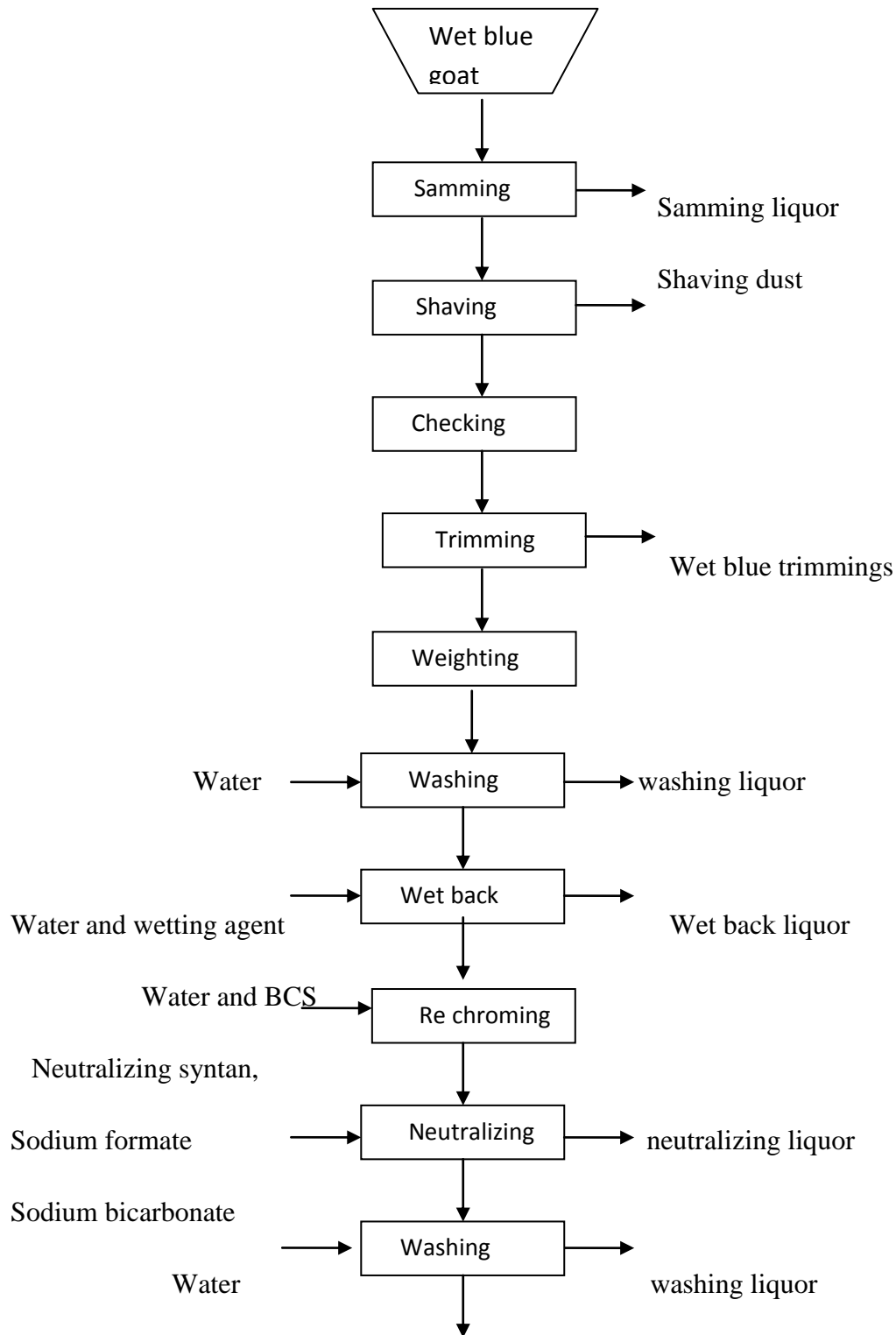


Fig3.1 Flow diagram from raw to wet blue

3.3.2 Flow diagram from post tanning to crust



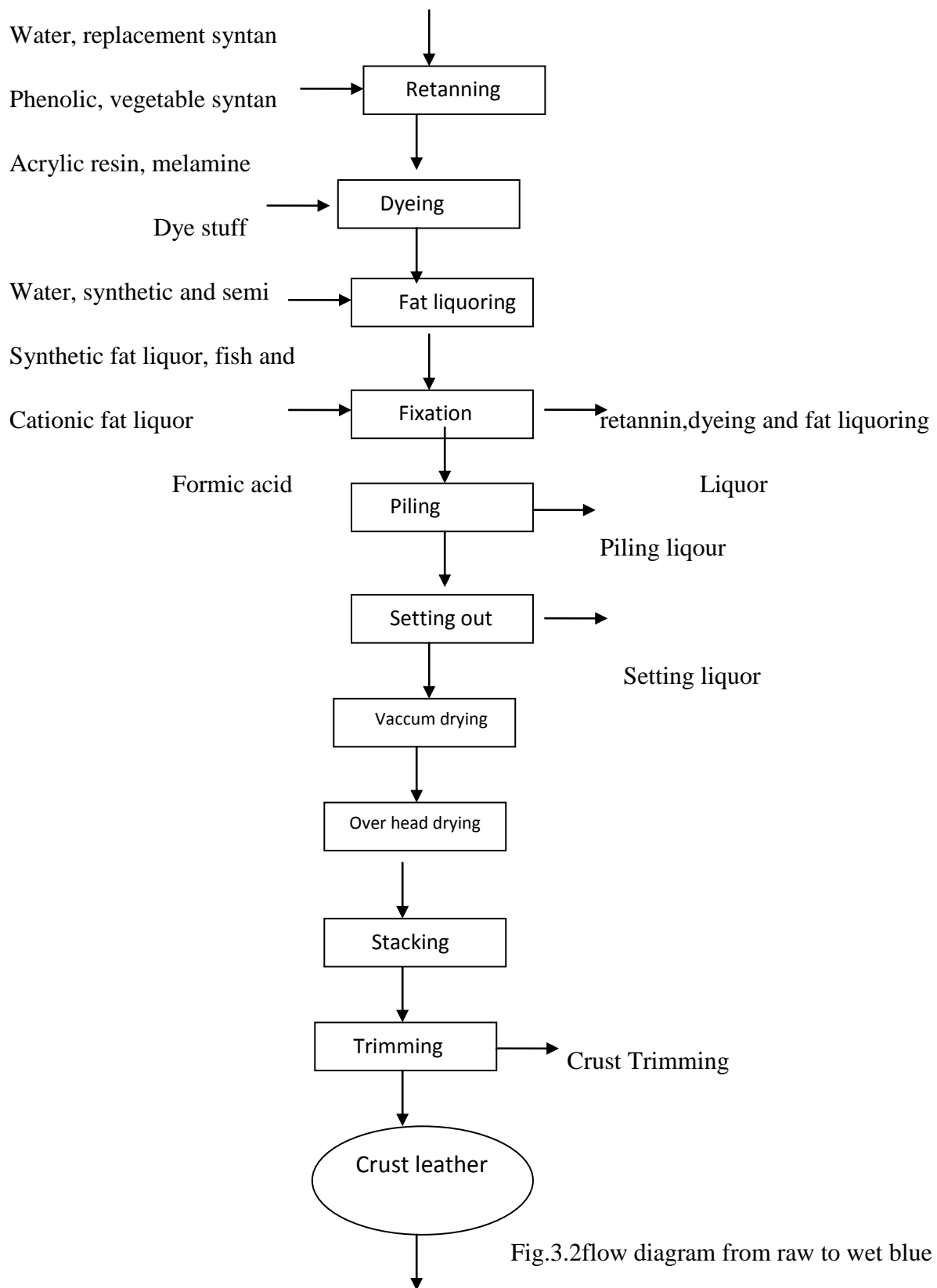


Fig.3.2flow diagram from raw to wet blue

Finishing

3.4 Process sheet

3.4.1 Process sheet from raw to wet blue

Raw material wet salted goat skin

Soaking

% based on raw weigh

Water	400%	4hrs
-------	------	------

Then washed it properly and piled it.

Unhairing

Prepared Lime paste as follows

Water	20%
-------	-----

Lime	10%
------	-----

Sodium sulphide	3% mixed properly.
-----------------	--------------------

Then applied the lime paste on the flesh side and piled flesh to flesh and L/O/N

Next day, removed the hair by scudding knife. After removed the hair put the skin in lime liquor which were,

Liming

Water	100%
-------	------

Lime powder	1%	ran 5' for every 1hr for 2 days. Then the pelts were fleshed and scudded.
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De liming to tanning

Raw material goat limed pelt

% based on pelt weight

Process	Chemicals	Temp.	%	Time	Remark
Washing	Water	30c ^o	200	10'	Drain
De liming	Water	30c ^o	100	60'	Checked completion of de liming with phenoptalein indicators
	ammonium chloride		4		
Bating	Bating enzyme (micro bate CNB)	35c ^o	1	45'	Checked completion of bating
Degreasing	Degreaser		0.6	90'	
	Wetting agent		0.2		
Washing	Add water	30c ^o	300	10'	Drain
	Add water	30c ^o	300	10'	Drain
Pickling	Add water	30c ^o	80	10'	
	Salt		10		
	Add sulphuric acid		1		
Tanning	BCS		4	45'	penetration was Checked
	Sodium formate		0.5		
	BCS		4	45'	
	Sodium formate		0.5		
Basificatio n	Add water	30c ^o	50	30'	
	Sodium formate		0'5		
	Sodium bicarbonate		1.5		

Table 3.1 process sheet from raw to wet blue

The bath was drained. The pcs were piled over night. Next day the pcs sammmed and shaved to 0.8mm thickness.

3.4.2 Process sheet from wet blue to crust

Raw material: - w/b shaved goat leather

% based on shaved weight

Process	Chemicals	Temp.	%	Time	Remark
Washing	water	30c ^o	200	10'	Drained
wet backing	water	30c ^o	150	40'	Drained and washed
	Wetting agent		0.2		
Re chroming	Water	30c ^o	50	45'	
	Bcs		4		
Basification	Water	30c ^o	50	30'	
	Sodium formate		0.5		
	Sodium bicarbonate		1.2	20'+20'+30'	The PH of the liquor was found to be 4.0-4.2 then L/O/N
Neutralization	Water	30c ^o	100	30'	
	Neutralizing syntan		1		
	Sodium formate		0.5		
	Sodium bicarbonate		1	20+20+30'	The PH of the liquor was found to be 4.8/5.0 , drained and washed
Post tanning	Water	45c ^o	100		
	Acrylic syntan (Relugan RE)		2	20'	
	Melamine (FB 6)		3		
	Melamine (MR 700)		3		
	Replacement phenolic (PF8)		3		
	Mimosa		5		

	power(GS)				
	Black dye		4	45°	Penetration was checked
Fat liquoring	Synthetic fat liquor (sx20)		2	45°	All the fat liquor diluted with 1:10 hot water
	Synthetic fat liquor (sx25)		2		
	Semi Synthetic fat liquor (LP16)		3		
	Lanoline(GL)		3		
Fixation	Formic acid		2	10°+10+30°	fixation was checked

Table 3.2 process sheet wet blue to crust

Drained, washed with 200% water twice and piled O/N. Next day set, hooked, staked, and trimmed. Then physical test for WVP, tensile strength, % elongation, tear strength and grain crack was carried out at crust stage.

Finishing

Protein binder	50 parts	
Penetrator	20parts	
Dye solution	100parts	
Pigments	30parts	
Water	800parts	2Xspray, dried
Water	600 parts	
Liquor	400parts	2Xspray, dried

Experiment 1 sample for bating

The percentage of bating enzyme (Bating enzyme (micro bate CNB)) 1.5%. The rest process the same as mentioned in table 3.2 and 3.1 for all experiments

Experiment 2 sample for liming,

Lime powder 1.5% ran 5' for every 1hr for 3 days

Experiment 3 sample for post tanning

Post tanning	Water	45c ^o	100		Penetration was checked
	Melamine (retinal MD80)		3		
	Melamine (genetal D2)		3		
	Melamine (retinal DC)		4		
	Replacement phenolic (retinal LSF 200)		3		
	Mimosa power(GS)		3		
	Black dye		4	45'	

Table 3.3 process sheet for experiment three

Experiment 4 sample for fat liquoring

Fat liquoring	Semi Synthetic fat liquor (fosfol 54)		4	45'	All the fat liquor diluted with 1:10 hot water
	Semi Synthetic fat liquor		3		
	Fish oil		1		
	Lanoline		2		

Table 3.4 process sheet experiment four

Experiment 5 sample for degreasing

After beating degreasing was carried out. The rest process as the same which was mentioned in table

Process	Chemicals	%	Time	Remark
Degreasing	Degreaser	0.6	90'	Washed two times
	Wetting agent	0.2		

Table 3.5 process sheet for experiment five

Experiment 6 sample for urea treatment

After tannin, with dry drum treated with 1% urea for 2 hrs with drum speed @ 10rpm

Experiment 7 sample for acetic treatment

With dry drum treated with 2% acetic acid for 2 hrs with drum speed @ 10rpm

3. 5 Methods of physical test

Goat upper leathers are natural materials made from goat skins and it is not topographically uniform, so that it varies in thickness and structure at different Parts of the leather.

The quality of leather is better assessed by sampling and testing from two or three different goat skins, rather than from random places taken from the same skin.

Leather cut samples will be cut from the official sampling position (ISO 2418). Conditioning of leather sample or leather cut test specimen is very important step in physical testing of leather. Before leather is tested in the laboratory, it is conditioned for 48 hrs under standard condition at 20c and 65% relative humidity.(ISO 2419)

3.5.1 Determination of Water vapour permeability.

Procedure

From the conditioned goat skin three test specimens were cut from back bone using acircular cutting knife with 34 mm diameter. Filled bottles of half its capacity with freshly dried desiccant silicagel (dried in an oven at $125 \pm 5^{\circ}\text{C}$ for 16hrs and cooled for 8 hrs in a closed bottle). The circular cut test specimen was inserted into the open end of the top screw type bottle cover facing the grain side inward. Screw this test piece holder on the mouth of the bottle. Fixed test jar in the holder of water vapour permeability testing machine. Prepared foar jars and secured into the testing machine. Started the experiment was run for 16 hours. This operation is done for making the continuous permeation and absorption process between the leather and desiccant. After 16hrs, replaced these three leather samples into three fresh

jars were filled with dry desiccant silica gel and weighted individually. These bottles was fixed into the holders of the test machine and was ran the machine for 8 hrs. The bottle was removed and weighted for increase in weight.

Calculation

Water vapour permeability, $\text{mg}/\text{cm}^2, \text{hour} = \frac{7639 \times m}{D^2 \times t}$



Fig 3.3 water vapour permeability measurement machine [17]

3.5.2 Determination of Tensile strength and elongation at break

Procedure

Dumbbell shaped taste pieces were cut both at parallel and perpendicular direction to the back bone of leather from proper location of leather.(ISO 2418). The test specimen was conditioned in the condition chamber at required temperature and humidity. (ISO 2419), measured the width of each test specimens to nearest 0.1 mm at 3 places on grain side and calculated the cross section area. The jaws of the tensile taster were set for 50mm length. Clamped the test specimen in the jaws and ran the machine until the test specimen breaks. Then recorded the highest load reached while the sample is subjected to breaking. The distance between the jaws was recorded when rapture of the test specimen occurred.

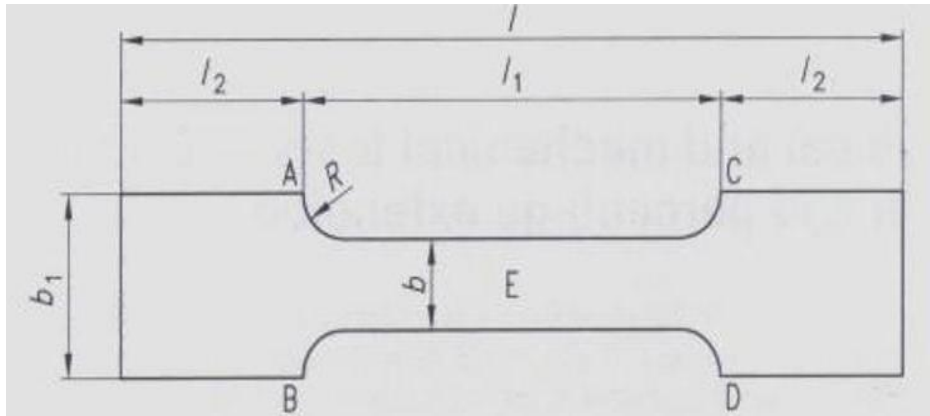


Fig3.4 shape of specimen for tensile strength

Calculation

Tensile strength, $N/mm^2 = \frac{\text{Breaking load (N)}}{\text{Area of cross section (mm}^2\text{)}}$

Area of cross section (mm^2)

% Elongation at break = $\frac{(b-a)}{a} \times 100$

a

Where Area of cross section = Width (mm) x Thickness (mm)

a = Initial distance between the jaws in mm

b = final distance between the jaws in mm

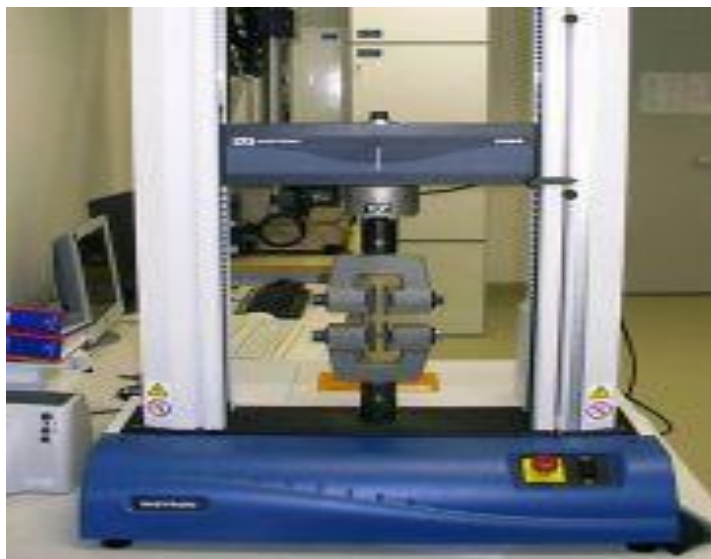


Fig 3.5 Tensile strength testing Machine (Dynamometer) [13]

3.5.3 Determination of tear strength

Procedure

Six test specimens (three from each principal direction) were cut using a cutting knife 70mm x 40 mm size with a central cut parallel to the longer edge to 50 mm length to form two legs. The specimens were conditioned for 48 hours and then measured the thickness at three places. One end of the leg of the test piece was inserted into the movable jaw of the tensile tester and the other leg into the fixed jaw of tensile tester in such a way that the legs are parallel to the direction of traverse. The tensile tester was run at the rate of 100 ± 10 mm/minute until the Test piece is torn apart. Was noted the mean force from the force verses distension curve.

It is determined as follows

Maximum tear force (N)

$$\text{Tear strength} = \frac{\text{Maximum tear force (N)}}{\text{Thickness (mm)}}$$

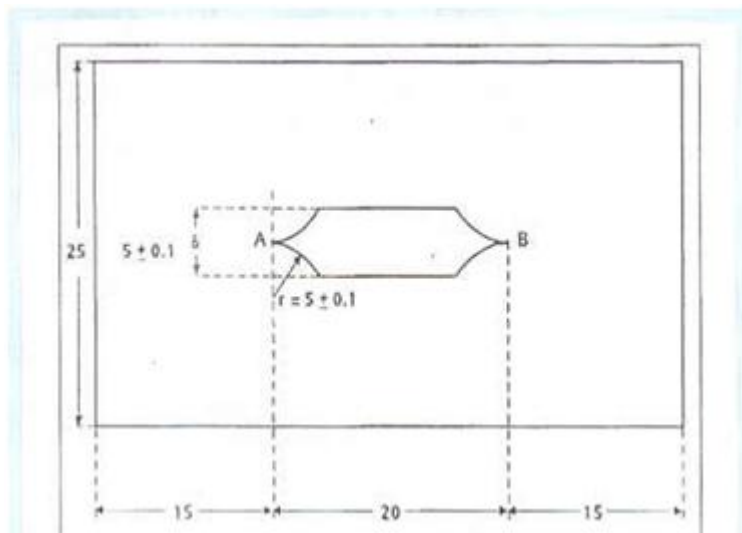


Fig.3.6 Shape of Tear strength sample

3.5.4 Determination of Grain crack

Procedure

Three test specimens 44.5 mm diameter was cut using a circular cutting knife. The test specimens were conditioned for 48 hours at $20^{\circ}\text{C} \pm 2^{\circ}\text{C}$ and $65 \pm 2\%$ RH for 48 hours. One test specimen was clamped between the circular rings facing grain side upwards in the machine. The machine was started by forcing the plunger at the rate of $0.2 \pm 0.05\text{mm/s}$. observed the surface of the specimen continuously at the centre for initial crack on the grain. The maximum distance and force was recorded at this point. The test was repeated for the remaining two test specimen. The mean values of the test results were calculated for: Grain crack load in Kgs or N and Distension at grain crack, mm

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 physical properties of goat upper leather

The physical properties of goat upper leather carried out for both control and experiments at crust and finished stage. The determined results were indicated in the following table for each experiment.

Experiment one (bating experiment)

The test were tasted and the test result were given in table 4.1

Thickness 0.9mm

	Min. requirements	At crust stage		At finished stage	
		Control	Experiment	Control	Experiment
WVP(mg/cm ² /hr)	0.8	10.79	11.82	7.53	9.72
Tensile strength(N/mm ²)	15	13.3	15.77	15.89	18.50
% elongation at break	40-80	64.4	65.78	68.29	70.23
Tear strength (N)	40	41.07	44.8	42.61	46.82
Load at grain crack (N)	200	220.23	213.7	219.34	210.15
Destination at grain crack (mm)	7.0	7.01	7.23	7.0	7.15

Table 4.1 the results which obtained from experiment one

The deference between control and experiment at crust stage was 1.03. When we have seen the figure is small. But this value is significant because the standard 0.8. Water vapour permeability value was reduced after finished the leather. The deference of WVP between control and experiment after finished the leather 2.19. From the result table except control at crust stage all properties fulfil the standard requirements.

Experiment two (liming experiment).

At liming stage the duration of the process was increased. Not only the time, the percentage of lime powder also increased from 1% to 1.5%. After processed the leather the physical taste were carried out and the results which obtained listed in table 4.2. The average of the sample thickness was 0.9mm.

	Min. requirements	At crust stage		At finished stage	
		Control	Experiment	Control	Experiment
WVP(mg/cm ² /hr)	0.8	11.79	11.82	8.53	10.01
Tensile strength (N/mm ²)	15	15.93	14.20	17.89	16.50
% elongation at break	40-80	63.11	61.33	68.29	66.12
Tear strength (N)	40	44.5	41.2	46.82	42.61
Load at grain crack (N)	200	213.76	211.45	211.3	208.12
Destination at grain crack (mm)	7.0	7.06	7.01	7.0	6.95

Table 4.2 the results which obtained from experiment two

From the result of table, the WVP at crust stage the deference between control and experiment not significant. After finished and carried out the WVP the values were 8.53 and 10.01 for control and finished respectively. The deference of these two values becomes 1.48 and it was significant. From the result of the table we observe that all physical properties fulfil the standard and it is acceptable. The values of tensile strength, percentage elongation at break, tear strength, load at grain crack and destination at grain crack of control more.

Experiment three (post tanning experiment)

After processed the leather, after and before finished the leather physical test were carried out and the following result obtained. During carried out test, the average thickness of the leather for both experiments and control were 1.2 mm.

	Min. requirements	At crust stage		At finished stage	
		Control	Experiment	Control	Experiment
WVP(mg/cm ² /hr)	0.8	9.02	11.02	6.23	8.05
Tensile strength (N/mm ²)	15	17.89	18.42	19.50	19.89
% elongation at break	40-80	60.30	71.57	63.08	73.58
Tear strength (N)	40	45.95	48.30	47.23	49.45
Load at grain crack (N)	200	302	418.5	299.5	417.7
Destination at grain crack (mm)	7.0	10.6	13.8	10.02	12.7

Table 4.3 the results which obtained from experiment three

From result table, the experiments both at finished and crust stage has shown good performance in percentage elongation but slight difference in tensile strength. This high performance in percentage elongation showed that the leather has enough elasticity.

Comparing the minimum requirement with the test result, the test result showed that this experiment achieved the minimum requirement in all aspects.

Experiment four (fat liquoring experiment).

After processed the leather, at crust and finished stage for control and experiments, according to the standard test methods, WVP, tensile strength, percentage elongation at break, tear strength, load at grain crack and destination at grain break carried out and the results mentioned in table 4.4. The average thickness of the test samples for both was 1.18 mm

	Min. requirements	At crust stage		At finished stage	
		Control	Experiment	Control	Experiment
WVP(mg/cm ² /hr)	0.8	9.02	10.87	6.23	7.89
Tensile strength (N/mm ²)	15	17.89	16.32	19.50	17.07
% elongation at break	40-80	60.30	64.17	63.08	66.02
Tear strength (N)	40	45.95	38.87	47.23	39.41
Load at grain crack (N)	200	302	301	299.5	299.0
Destination at grain crack (mm)	7.0	10.6	13.4	10.02	12.98

Table 4.4 the results which obtained from experiment four

From the result table, the WVP at crust stage the difference between control and experiment 1.85. After finished and the deference of WVP between control and experiment were 1.66 and the values significance. From the table the minimum requirement for the tear strength is greater than 40. Comparing this minimum requirement with the test result announced that the experiments did not achieve the specified minimum performance requirement in both stages.

Experiment five (degreasing experiment)

During the experiment process, at degreasing stage the percentage of degreaser was increased from 0.3 to 0.6. The average thickness of the samples was 0.9mm. The results obtained listed in table 4.5.

	Min. requirements	At crust stage		At finished stage	
		Control	Experiment	Control	Experiment
WVP(mg/cm ² /hr)	0.8	11.97	12.05	7.51	8.96
Tensile strength (N/mm ²)	15	17.31	15.81	21.05	18.88
% elongation at break	40-80	72.12	73.27	78.84	81.11
Tear strength (N)	40	43.4	39.96	44.48	41.33
Load at grain crack (N)	200	210	208	207	206.5
Destination at grain crack (mm)	7.0	7.67	7.12	7.79	7.01

Table 4.5 the results which obtained from experiment five

From the above result table the tear load of the experiments was below the minimum requirements. But after finished the leather it was fulfil the minimum requirements. The WVP of the experiments and control at crust stage not much significant, but after finished it showed significant.

Experiment six (urea treatment experiment)

After wet blue the goat leather treated with urea 1% based on pelt weight for 2 hours with dry float. After treated it piled ageing and the rest process the same as conventional. After prepared the crust ad after finished, for both control and experiments the physical test was carried out and the results obtained mentioned in table 4.6.

From table the WVP is more significant after finished the experiment and control. The difference of WVP of the experiment and control after finished the leather was 2. In the cases of WVP it showed better result. The minimum requirement for load at grain crack (N) is 200N. From the result table the load at grain crack of the experiment was below the standard, so that it not fulfils the requirements. The minimum average tear load of leather upper should be greater than 40 N. comparing this standard requirement with the test result illustrated that this experiment not achieved the minimum requirement for tear strength.

	Min. requirements	At crust stage		At finished stage	
		Control	Experiment	Control	Experiment
WVP(mg/cm ² /hr)	0.8	10.61	10.93	7.3	9.3
Tensile strength (N/mm ²)	15	13.23	16.55	15.26	18.51
% elongation at break	40-80	78.80	68.72	86.22	76.11
Tear strength (N)	40	42	38.2	40	36.68
Load at grain crack (N)	200	203	197.35	199.4	195.32
Destination at grain crack (mm)	7.0	7.50	7.02	8.04	7.46

Table 4.6 the results which obtained from experiment six

Experiment seven (acetic acid treatment)

After wet blue the goat leather treated with 1% acetic acid based on pelt weight for 2 hours with dry float. After treated it piled for ageing and the rest process was the same as conventional. After prepared the crust ad after finished, for both control and experiments the physical test was carried out and the results obtained mentioned in table 4.7.

From table the WVP is more significant after finished the experiment and control. The difference of WVP of the experiment and control after finished the same as experiment 6. In the cases of WVP it showed better result. The minimum requirement for load at grain crack and tear strength 200N and 40N respectively. Comparing this standard requirement with the test result illustrated that this experiment not achieved the minimum requirement for tear strength and load at grain crack.

The average of thickness of the sample for both control and experiments is 0.9mm.

	Min. requirements	At crust stage		At finished stage	
		Control	Experiment	Control	Experiment
WVP(mg/cm ² /hr)	0.8	10.61	10.93	7.3	9.3
Tensile strength (N/mm ²)	15	13.23	16.57	15.26	18.49
% elongation at break	40-80	85.67	77.54	96.22	79.44
Tear strength (N)	40	39.5	35.43	38.72	31.73
Load at grain crack (N)	200	199.3	196.7	197.23	194.67
Destination at grain crack (mm)	7.0	7.72	7.72	8.05	8.05

Table 4.7 the results which obtained from experiment seven

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

Water vapour permeability values of control and experiments at crust and finished stage for each experiment are shown in table 4.1-4.7. From the experiment increasing percentage of degreaser showed better WVP at crust stage from the rest experiment. But at finished stage long liming showed better WVP. Differences between at crust and finished stage were significant and WVP values decreased for all experiment. The WVP value for experiment three and four was lower from the rest experiment. The reason when the thickness of the sample increased the WVP reduced.

The tensile strength values for all experiments showed increased at finished stage. But among them at crust stage the value for long liming was below the standard. At both crust and finished stage the tensile strength highest for experiment three, this may be due to thickness of the sample.

The percentage of elongation showed increment at after finished the leather. The leather which treated with acetic acid showed the highest values both at finished and crust stage. From the result table we conclude that for all experiments the percentage of elongation at burst all experiments showed the values of percentage elongation at burst above the standard(all>40).

From the results of the experiments it was understood that the tear strength, experiment three showed better. At crust stage experiments 1, 2, 3 were above the standard where the other experiments were below the standard. At crust stage the tear strength for experiments 6 and 7 showed decreased while the rest increased. But at finished stage except experiments 6 and 7 all were acceptable.

The load at grain crack experiment three showed highest. From the experiments result table tear strength values were decreased after finished the leather. At crust stage almost all approach to the standard, but at finished stage experiments 6 and 7 below the standard.

The results found indicated that the values of Destination at grain crack for all experiments were above the standard. But after finished the leather the values of it decreased.

It could be concluded that, as per the results of the experiments, in the cases of tear strength and load at grain crack experiments 6 and 7 were not acceptable. The rest experiments in all cases were fulfil the standards and acceptable.

5.2 Recommendations

Due to the low attention given to the research to development of water vapour permeability upper leather from goat skin, there is no sufficient developed and released. Most of the research based on how water vapour permeability measured rather than developed. The awareness should be introduced to researcher and leather sectors.

Water vapour permeability is one of the comfort properties and specialty very important for shoe upper, so that emphasis should be given to tanners and encouraged them to develop better water vapour permeability upper leather from goat skin.

More Studies should be done to develop water vapour permeability from goat skin.

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