EFFECTS OF TANNING AGENTS, AGE AND STRAIN ON QUALITY PROPERTIES OF RED SOKOTO GOAT LEATHER

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2016

DECLARATION

I hereby declare that this work is the product of my research efforts undertaken under the supervision of Professor B.F Muhammad and hasnot been presented anywhere for the award of a degree or certificate. All sources have been duly acknowledged.

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SANI LABARAN

SPS/12/MAS/00019

CERTIFICATION

“This is to certify that the research work for this dissertation and the subsequent write-up (Sani Labaran SPS/12/MAS/00019) were carried out under my supervision.

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APPROVAL PAGE

This is to certify that the research work reported here titled "Effects of Tanning Agents, Age and Strain on Quality properties of Red Sokoto Goat Leather" has been examined and approved for the award of the Degree of MASTER OF SCIENCE IN ANIMAL SCIENCE of Bayero University Kano Nigeria.

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DEDICATION

This dissertation is dedicated to my father (Late, Alhaji Labaran Adamu) May your soul rest in perfect peace (Ameen).

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ABSTRACT

The study was carried out to investigate the effects of tanning agents, age and strain on quality properties of Red Sokoto goat leather. The experiment was laid in a 2x2x3 factorial arrangement that involved 2 tanning agents (chromium sulphate and *Acacia nilotica*), 2 age groups (young 1-1½year and matured 2-3years) and 3 strains of Red Sokoto Goat (Red Sokoto, Kano brown and Borno white) in three replications. A total of 36 pieces of fresh goat skin from the three strains were weighed individually, preserved and processed into crust leather for Physio-chemical analysis. In the effects of tanning agent on physical properties of the leather, the result showed significant ($P<0.05$) differences in tensile strength, percentage elongation, grain test by ball burst, water vapour permeability, shrinkage temperature and water absorption. However, no significant difference ($P>0.05$) were observed with respect to leather thickness was recorded, on the effect of tanning agent on chemical properties of leather, the result also revealed that *Acacia* tanned leather recorded higher volatile matter (12.13%) and water soluble organic matter (26.17%) while the highest water soluble inorganic matter value (11.17%) was obtained in leather tanned with chrome. The results on effect of age on quality properties of the leather revealed that matured goat leather (2-3 years) produced the optimum quality leather. The results on effect of strain on quality properties of goat leather revealed that no significant ($P>0.05$) differences were observed with respect to all chemical properties of leather hence, Red Sokoto, Kano brown and Borno white goat leather were statistically similar ($P>0.05$) in all chemical constituents. The cost and return analysis showed that fresh skin contributed 35.85% of the total processing cost and tanning accounted for 46.22%. The results further revealed that the net return on investment was ₦950 per square meter of leather and the rate of return ratio showed that for each naira invested in processing Red sokoto Goat leather, a profit of ₦0.78 was obtained. It was concluded that matured Kano Brown Goat leather tanned with *Acacia nilotica* produced optimum quality leather. It was recommended to use matured Kano Brown goat skin for good quality leather production.

CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND INFORMATION

Globally, in modern civilization, the leather industry has made enormousimpact on every sphere of man's life – economically, industrially, socially,religiously, and politically. From the Stone Age to the beginning of the Egyptiancivilization through the Romans' domination till today, man has regarded skins and leather as dependable materials for meeting his basic needs such as making footwear,tents, shields, and sheaths, containers for liquids, boats and even armor (Landmann, 2003; Atiase, 2004; Kite and Thomson, 2006).Ever since, leatherwork has characteristically been regarded as a major contributing factor in the economic development and industrial transformation ofseveralcountries including the United Kingdom, Italy, Germany, United States of America, and France (De Haas 1925; Landmann, 2003; UK Leather, 2004; Kite and Thomson, 2006).

Currently, China, India, Pakistan, Turkey, Kenya, South Africa, Brazil, and Argentina are counted among the global industrial giants in the field of leather production which are beefing up their economic development and stability with enormous revenues generated from exportation of various forms of cured raw hides, skins, finished leather and leather artifacts (De Haas, 1925; FAO, 1986; Leather International, 2007; World Leather, 2008/2009; World footwear, 2008). Records on leather's economic utility showed clearly that apart from using leather for domestic purposes such as clothing, sofas and containers, the automobile, aviation, railway (trains, trams, undergrounds) and marine industries rely on leather to express luxury and comfort through upholstery and interior decoration (Leather International, 2006; World Leather, 2008/2009; This is a venture that has made the material an indispensable factor of dependability for building capacity towards revenue generation to support economic development.

Leather production was stated by the peasant traditional tanning industries which later became mechanized. The world cherished Morocco leather that was quoted in history books are being produced from Red Sokoto and Kano Brown goats found in northern Nigeria (Danbatta 1996 and Aminu, *et al.*, 2010).

Hides and skins are the basic raw materials for leather production and Nigeria is known to possess a significant stock of animals from which these basic raw materials are derived. The most important are cattle, goats and sheep (Ihuoma, 1993). Hides are obtained from large matured animal; while skins from small animals (Aganga, 1984).

The livestock population in Nigeria was estimated to be 15, 406, 153 cattle, 28,020,130 sheep, and 44,156,487 goats (Fe!sner and Schmel, 2002), given this situation therefore, it is natural for Nigeria to be a participant in the world trade on hides, skins, leather and leather products. The main centers of hides and skins production are the northern states of Kano, Sokoto, Katsina, Jigawa, Borno, Kaduna, Adamawa, Yobe and Bauchi,(Abbot *et al.*,1979). The net comparative advantage enjoyed by these states in livestock production confers on them the corresponding advantage of enormous hides and skin production. The ecology of the northern states of Nigeria is very conducive for large scale animal husbandry (Ihuoma and Okonkwo, 2001).

The leather industry depends on the availability of raw materials, which in turn is regulated by the animal population, the off-take ratio and the weight per hide and skin recovered. Between 1994 and 1996, 75% of the world bovine herd was located in developing countries which produce 56% hides on a numerical basis and 43% of the world hides output by weight. In the case of sheep and goatskins, the output from developing countries accounted in both cases for similar proportion to their global stock in numerical terms, 59% in sheepskins and 95% in goatskins, Anonymous, (2012).

In the period 1994-96 the global bovine population of some 1, 477million head yielded approximately 5.5million tons of raw hides on a wet salted basis. Total production of heavy leather was 460,000 tones and that of light leather 10,138million square feet. Approximately 65% of the light leather was used in 1996 for the manufacture of 4,539 million pairs of shoes with leather uppers. The remaining 35% was used for the manufacture of garments furniture and travel goods including handbags (FAO, 1998).

Raw hides and skins that were available to Nigerian leather industries were said to be of the order of 1.3 million cattle hides, 11 million goatskins and 2.3 million sheep annually (Aganga, 1984). Raw hides and skins purchased and traded at licensed merchants in Kano State in the year 2001 were in the order of 15,677 cattle hides, 1,399,778 sheepskins and 1,211,154 goatskins (Felsner and Schmel, 2002).

The leather industry utilizes a by-product of slaughter houses (meat industry) and transforms the raw materials into various types of leather and manufactured end products. The leather production-consumption chain has three (3) processing stages, each requiring different combinations of material inputs, labour and capital.

The first stage is the recovery of raw materials that has direct links with animal production activities, hides and skins are recovered from animals from slaughter houses. Leather tanning and finishing is the second stage that involves relatively capital-intensive operations while the third stage, which is the production of leather products is more labour intensive activity, Anonymous (2012).

Hides and skins are by-products of meat industry, this implies that farmers do not kill their animals for the primary purpose of producing hides and skins, but are technically said to be in joint supply they are estimated to be 5-10% of the value of meat (Ihuoma and Okonkwo, 2001).

Leather is processed in Nigeria into; wet blue, crust and finished leather. Generally about 60% of Nigerian skins are processed into wet blue and crust which are exported to be processed further by foreign company. Similarly about 10-15% is tanned and finished for utilization in the domestic economy. About 80-95% of the finished leather meant for utilization in the domestic sector goes into foot wear production while the rest is used in the production of leather goods such as hand bags, boxes, purses, belt, straps etc. (lhuoma and Okonkwo, 2001).

The investment and export drive of Nigerian administration to transform the Nation's economy, and generate employment and reduce poverty has received a boost through exportation of finished leather to some part of the world. *Fata* tanning company in Kano, the largest in Africa, recoded a turnover of over 50 million Euros in 2003 with a target of over 100 million Euros in 2004 (Sakaba, 2004). This was almost realized because CBN report (2004) indicated export value of $104,071,573.94 in 2004.

The company (*Fata* Tanning Company)according to Amakon (2006) has entered into a joint partnership with one of the biggest shoe manufacturing company in Italy - FILANTO to set up a shoe making factory in Nigeria all in a bid to exploit the bountiful opportunities in the Nigerian leather sector. It is also estimated that about 4 million Pairs of foot wear are produced in Nigeria annually, while that of leather goods is difficult to estimate (lhuoma and Okonkwo, 2001).

The Nigerian export mirror 1999-2003 shows that leather export were seen to be very vibrant next to petroleum and its products, cocoa and cowpea with a total of US $156 million proceeds which is still lower than US $420 million that was targeted for the year 2004 Amakon, (2006).

Nigerian export of leather from sheep and goats grew at a rate of 18% and 22% per annum, which was just the same as the world growth rate of 17% and 23% respectively. This is a clear indication of high export potential from the products which export is more to Italy and Spain and constitutes 5.8% and 10.1% of the world shares, Anonymous,(2012)

Goats constitute the largest group of small ruminant livestock in Nigeria totaling about 53.8 million and constitute 6.2% of the world's Goat population (FAOSTAT, 2011).The Red Sokoto goat is the predominant, numerous (17.3million) and most widely distributed breed in the northern savannah belts of Nigeria (Ngere *et al*., 1984). It is one of the few well-defined breeds characterized by its uniform dark red coat colour, short and horizontal ears and horns in both sexes, about 60cm long with mean male and female weights of 27 and 25 kg, respectively.

The Kano brown and Borno white are believed to be a strain of Red Sokoto. Skin obtained from Red Sokoto goats are of high quality and are well known as in the tannery trade (Wilson, 1991). In Nigeria, goats are kept not only for meat; the skin is also valuable, especially in leather manufacturing and for other utilities such as parchment and musical instruments (Attah, Okubanjo, Omojola and Adesehinwa, 2004).

Hides and skin are one of the most valuable exports for many developing countries and play an integral role in the livelihoods of communities as a source of income and employment opportunities (Eboh, Oji, Amakom and Ujah*,* 2004). Archaeological studies have shown that hides and skin have been used since antiquity as clothes, vessels, bedding, and possibly structurally in ancient dwelling places. At present, leather is used in various applications. Hides and skin, as basic raw materials for the tanning industry, are renewable and easily perishable resources and their production is dependent on the rearing, management and disposal of the livestock population (Arunga, 1995). The availability of hides and skin through slaughtering or death of livestock is of particular importance to the leather industry (Amakom, 1995).

Tanning is a processing mechanism which prevents the collagen fibrous protein in animal skin from putrefaction to produce a hydrothermally stable product commonly known as leather (Sharphouse, 1995). Traditionally, the origin of leather making started with the use of plant materials that are essentially high in tannin content and which leach out to penetrate skin for the conversion of skin proteins into non-putrescible materials. *Acacia Nilotica* “Bagaruwa” is one of the indigenous plants with high tannin that is well recognized as tan in Nigeria and other sub-Saharan African countries. Its tannin content depends on the parts of the plant from which the extracts are obtained but essentially, the pods are higher in tannin content more than other parts of the plant. A range of 12-50% tannin content was reported for a typical “Bagaruwa” tree and this consists of about 30% catechol and 70% pyrogallol (Fagg and Magedo, 2005). However, a minimum of 15% usage of vegetable tanning materials was documented to secure full penetration of the skin (Bikley, 1992).

In the 1980s, there were over 40 fully operational tanneries in Nigeria. However, by the 1990s due to several constraints this figure fell sharply to only 4 functional tanneries and none of which are indigenously owned (Amakom, 1995). The leather industry offers a huge potential for growth even though it constitutes mainly small and medium scale enterprises (Amakom, 1995).

The heavy dependence on the oil sector is reflected by the fact that the non-oil sector contributed only 6.5% of the GDP (CBN, 2010). Hence, in order to develop a balanced economy there is a clear need to expand the growth of the non-oil sector, one of which is the leather industry. Export figures showed that the leather industry was the strongest non-oil export in 2005 with exports in excess of US$ 160 million UNCTAD,(2009). However, the industry is struggling to maintain export competitiveness, which is evidenced by the fact that the leather industry accounted for 36.84% of non-oil export in 2004 but dropped to 20.4% in 2005 (Amakom, 1995; UNCTAD, 2009).

In most developing countries tanning operation is a family business, carried out in a small to medium scale, very frequently grouped tightly in clusters which used to be outside residential areas. Tanners in such units have no formal education and have little or no understanding of the complexity of leather processing. Their skills are acquired from their elders with hardly any perception of environmental protection and low waste technologies. Generally speaking, traditional tanning require better skilled personnel and closer technical control than conventional processing. Thus, lack of proper training of staff at different levels remains one of the crucial constraints. Other factors that influence leather quality are the breed of the animal, age and skin branding which is acquired during the life time of the animal (Jacinto *et al*., 2011).

1.2 PROBLEM STATEMENT

The leather industry has been facing a lot of crises in recent times ranging from declining number of marketable and mature livestock and incidence of skin pest and diseases especially in the relatively hotter regions of the country (Akanni and Ibrahim, 2008). Other factors such as poor animal husbandry, inadequate feed, poor quality feed and branding with hot iron for identification purposes may contribute to low quality output from the skin (Jabbar*et al,*2002).

The reliance of the Nigerian leather industry on imported inputs, particularly capital (machinery and spare parts) and intermediate goods (chemicals), means that the vagaries of the external economy of the exporting countries directly influence its development (Ihuoma, 1984).

There is serious competition on the use of animal hides and skin between man and the tanneries. For instance, raw hides and skin worth millions of Naira are being consumed by man as “Ponmon” on annual basis (FOS, 2001).According to Amakon (2006), processed skin which constitutes 36.84% of non-oil export in 2004 dropped significantly to 20.4% in 2005 with the amount decreasing from US$ 41,902.7 to US$ 18, 923.

The quality and yield of leather obtained from small ruminants is dependent on environmental and managerial factors. The skin produced in Africa are generally viewed low in the global markets because of various constraints found throughout the production chain starting with animal husbandry conditions, lack of slaughter facilities, inappropriate flaying and poor handling and preservation methods. Recent observation have in fact shown that the skin exported from Nigeria have attracted low price in the international market because of their declining quality (Paiko, 2002).

1.3 JUSTIFICATION FOR THE STUDY

Indigenous leather industries create employment opportunities, promote effective resource utilization and contribute to process of industrialization and national development. The availability of skin through slaughter of livestock is of particular importance to the leather industries. These industries play an important role in Nigerian economy and serve as source of employment and income to individuals involved in the trade (Arunga, 1995; Zemene and Addis, 2012).

Hides and skin are still viewed as by−products of the meat industry instead of raw material for the leather industry; hence, much emphasis is on meat. Improvement in hides and skin processing and handling may enhance the role of leather industries in food security, poverty alleviation and rural development (Adebayo, 2003).

1.4 OBJECTIVES OF THE STUDY

The overall objective of the current study is to evaluate leather quality properties as affected by biological and mechanical factors while the specific objectives are:

i. To determine the effect of Tanning Agent on Leather quality properties

ii. To determine the effect of Age and Strains on leather quality properties of RedSokoto Goats.

iii. To determine the costs and returns of processing Red Sokoto Goat skin into crust leather.

CHAPTER TWO

LITERATURE REVIEW

2.1 BREED INFORMATION

2.1.1 Red Sokoto Goats

Synonyms; The Red Sokoto goats are also known as (Red Skin, Sokoto Red), Kano Brown (Kyasuwa), Katsina Light Brown, Mambilla, Bornu White, Buduma (Chad), Damagaran dapple-grey; Maradi in Niger (Epstein, 1971).

2.1.2 Breed Origin

Red Sokoto goat is one of the Savannah goat group, its relatively small size indicates possible crossing with forest or Dwarf goats before selection in its present area of distribution; the relatively high prolificacy of this goat would tend to support a hypothesis that such a fusion has occurred (Wilson, 1991). The main centres of distribution are northern Nigeria (the Sokoto and Kano States) and southern Niger (Maradi and Tessoua Departments); however, subtypes with colour variations are found to the west and east of this region; they are owned mainly by the Hausa-speaking agricultural tribes. Wilson,(1991).

Ngere *et al*. (1984) argue that populations of the Sokoto Red spread south and east from Sokoto through the savanna belts giving rise to the Kano Brown and, further east, to the Sahel types of Borno State.

2.1.3 Breed Special Characteristics

A relatively small sized goat (60 cm height and weight of 27 kg), but are generally larger in Niger; fine head with prominent forehead; black mucous membrane; both sexes have short to medium horns; ears are short and usually carried horizontally, but longer and semi-pendulous in Niger; toggles are rare. Beard of profuse hair are present in males but usually absent in females; forehead often covered with hair which is often longer, bushier and darker in males than in females; males carry a light mane extending to the shoulders; neck is short, thin and very mobile; coat colour usually red in Nigeria but lighter and occasionally almost chestnut in Maradi. The males are invariably darker than females and may have a black back stripe; tail hair usually black; known for the good quality skin.

The Sokoto Red goat was the source of 'Morocco leather' known in Europe from the medieval period onwards. It acquired this name because it was transported across the Sahara by caravans controlled by Moroccan merchants. The Sokoto Red is still known for its suitability for fine leather (the Moroccan leather) Wilson, (1991).

2.2 STRAINS OF RED SOKOTO GOAT

2.2.1 Red Sokoto Goat

The Red Sokoto goat (RSG) or Maradi is the most predominant goat breed and accounts for about 70% of Nigeria's total goat population which has been estimated at 17.5 million (Ademosun, 1994). It is commonly found among the agro pastoralist mainly within the northern sub-humid and semi-arid zones of the country (Akpa *et al.,* 2001a). The breed is predominantly reddish brown in colour and is found in the savannah zone of Nigeria (8^{O}N - 110N) where it constitutes more than 90% of the goat population in that area. The breed weighs about 1.5-2.0kg at birth and reaches about 12.0kg when weaned at 3 months under good management. Weight of adult does and bucks are 20 – 35kg and 25 – 40kg, respectively (Osuhor *et al.,* 2002). The skin of Red Sokoto Goat is reputed to be of high quality; therefore, it is used in the leather industry locally and internationally (Akpa *et al.,* 1998a).

2.2.2 Kano Brown Goat

The Kano Brown is most typically raised by the Hausa (Ah-oo-sa) peoples of the Kano State of Nigeria and by far the commonest meat breed in the country. The Kano Brown Goat is classed as a medium-sized animal and is about the same size as the Sokoto Red (from which they are descended) but are bulkier and less skinny in appearance, as befits a goat bred for its meat. They are of relatively short size (and may have been crossed with the Nigerian Dwarf

Goat). A typical female stands 54–65cm tall at the weathers, the male is slightly taller, measuring some 60–65cm tall Ngere *et al,* (1985).

These goats are characterized by their fine heads and prominent foreheads. The mucous membranes of the mouth are black. They have short bodies and proportionally long and flexible necks (which help them browse). The ears are short, of medium width and are usually carried horizontally. The males have long beards of profuse hair and the whole head can be hairy. The males also have a mane of hair that extends to the shoulders. Both males and females have short horns. The coats are short and glossy and range in colour from ruddy brown to chestnut. Tail hairs are typically black. The males are typically darker than the females and may have a black stripe along the back. The udder is full and rounded with well-spaced teats. It is much less divided than the udder of other Nigerian goat breeds (Ngere *et al,* 1983).

2.2.3 White Borno Sahelian Goat

The "West African long legged, "Sahel" Fulani", the desert or Sahelian goat is found along the northern border of Nigeria, particularly Borno State, where it is often known as "Balami, although this name has not been adopted as it would lead to confusion with the better known sheep breed Balami. Mason (1988) uses "Sahel, which seems appropriate, as this race is distributed from Senegal to Sudan. This breed has thin appearance, narrow body and shallow chest. Both sexes are horned, about 70% with wattle, pendulous or semi pendulous ears, the coat is white or dapple. The height at wither ranges 65-85cm, while the chest girth is 70–85cm. The first kidding occurs usually at about 18 months, bearing mostly (70%) one or two kids, with lactation persisting to 5-6 months. it is kept primarily for meat (Devendra and Burns, 1983; Mason, 1996).

2.3 ANATOMICAL STRUCTURE OF SKIN

The anatomical structure of a skin can be divided mainly into two principle layers

1. The epidermis or the outer layer also called the epithelium cuticle.

2. The corium or the inner layeralso called dermis, cutis vera, true skin

These two layers, the epidermis and the corium are quite distinct in their structure and function. In bovine animals and living cells, the embryo arrange themselves in three (triploblastic) from the uppermost of these layers, (the ectoderm), the epidermis of the skin is formed. The corium is derived from the middle layer or the loosely arranged parts called the mescenchyme of the developing embryo or the mesoderm. Due to their difference in origin, their physical and chemical properties are different.

2.3.1 Epidermis

In describing the epidermis layer, O'Flaherty *et al.,* (1956), write that the epidermal layer is that portion of the fresh skin or hide which contains the hair, the hair follicles, the epidermis and its appendages such as the sebaceous glands and the sudoriferous glands, which are surrounded and supported by a collagenous fibre bundle structure. Also, throughout this structure, collagenous fibre bundles are dispersed as a network of elastic tissue fibre, erector pili muscles, blood vessels and nerves. From Sharphouse's (1995) perspective of skin structure in correlation to leather making, the epidermis is a protective, hard-wearing layer of keratinous cells.

Those on the outside are dead and, on drying and shirking, fall off the skin as scurf or dandruff. On the underside, next to the "skin proper", Sharphouse,(1998) explains further that they consist of soft, jelly-like living cells, which have little resistance and are readily attacked by bacterial action or enzymes, as occurs with stale skins or in enzyme unhairing. Because the epidermis is loosely connected with the derma during life, (as cited by O'Flaherty *et al*., 1956), in a study of the adherence of human skin, observed its ease of separation or disintegration from the corium by acids, bases and sodium thiocyanate. Separation as a result of swelling caused by these agents could be reversed by shrinking agents, such as sodium citrate and sodium acetate, which result in an increase in adherence.

2.3.2 Dermis

In his perspective, Bienkiewicz (1983), a physical leather chemist says that the dermis consists of two layers: the papillar, called thermostatic (*stratum papllare seutermostaticum*) and reticular (*stratum reticulare*). The reticular layer passes without a clear limit into the subcutaneous tissue (*tela subcutanea*). In the corium cells, the fibril-forming ones-prevail. Beside them in the skin, there occurs the intercellular substance (matrix) and two kinds of fibres: collagen and elastin. He acknowledges that quantitatively, the major part of the solid substance is collagen fibres.

According to Sharphouse's (1995) theoretical description of the dermis, the "skin proper" or corium, consisting of a network of collagen fibres, is very intimately woven together, and in the grain layer these fibres become very thin and tightly woven, and so interlaced that there are no loose ends on the surface beneath the epidermis. Thus, when the epidermis is carefully removed, a smooth layer is revealed–sometimes known as hyaline layer–which gives the characteristic grain surface of leather. In a common acknowledgement of the role of the dermis layer of the skin, writers such as Wilson (1923), Bienkiewicz (1983), Sharphouse, (1995) and Kite and Thomson (2006), emphasized that the corium is the basis of leather making, since it contains the strength properties of leather. Towards the centre of the corium, the fibres are coarser and stronger, and the predominant angle at which they are woven may indicate the properties of the resultant leather. When the fibres are more upright and tightly-woven, one expects a firm, hard leather with little stretch, whereas soft stretchier leather is expected when they are more horizontal and loosely-woven. The corium is generally the strongest part of the skin. The flesh side of the corium, i.e. next to the meat, where the fibres have a more horizontal angle of weave, a fatty (or adipose) tissue may also be present.

Again, Sharphouse (1995), O'Flaherty*et al.,* (1956) and Leafe (1999) explain further that in the living skin, all these collagen fibres and cells are embedded in a watery jelly of protein-like substance. The living collagen fibres are formed from this substance, which consequently ranges in constitution from the blood sugars to substances which are almost collagen. The latter have been called "inter-fibrillary" proteins, also known as non-structural proteins or pro-collagens as shown in figure (1). These are essential for the growth of the skin and also render the fibre structure non-porous. When the skin is dried, they dry to a hard, glue-like material, which cements together all the corium fibres and makes the skin hard and horny. In making leather which is to be soft or supple, it is most important to remove these inter-fibrillary proteins.

2.4. STRUCTURAL COMPOSITION OF SKIN

From the anatomical structural composition, the mammalian skin or hide consists of water, protein, fatty materials, and some mineral salts. Of these, the most important for leather making is the protein, although water is the highest constituent. This protein, according to Sharphouse (1995) consists of many types, and the essential ones are *collagen* which, on tanning, gives leather and *keratin*, which is the chief constituent of hair, wool, horn and the epidermal structures mostly removed during leather making. Diagram below classifies the composition of a freshly-flayed hide or skin as outlined by Sharphouse (1995) and Kite and Thomson (2006).

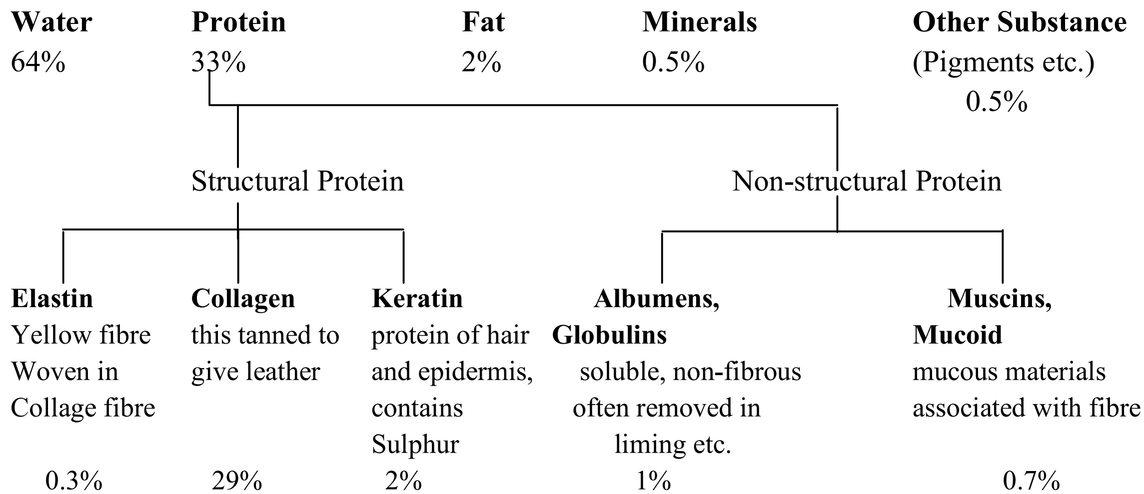

Figure 1.Diagram for classified composition of a freshly-flayed hide or skin as outlined by Sharphouse (1995) and Kite and Thomson (2007).

Although all animal skins follow this basic pattern, and are made up of the above constituents, some factors may cause the figure for keratin or fatty substances or water to vary considerably depending on the source of the skin.

The cross-section of skins and hides has attained much attention by researchers, since the understanding of the structure is known to be vital to the quality of leather produced eventually. As presented by Sharphouse (1995); Sarkar (2005), Thorstensen (1976), FAO (1986); Kite and Thomson (2006), of a typical cross-section of mammalian skin, there are two main layers composed of epidermis (upper layer) and dermis (lower layer), and a number of tissues which can be further subdivided as shown in figure 2 below.

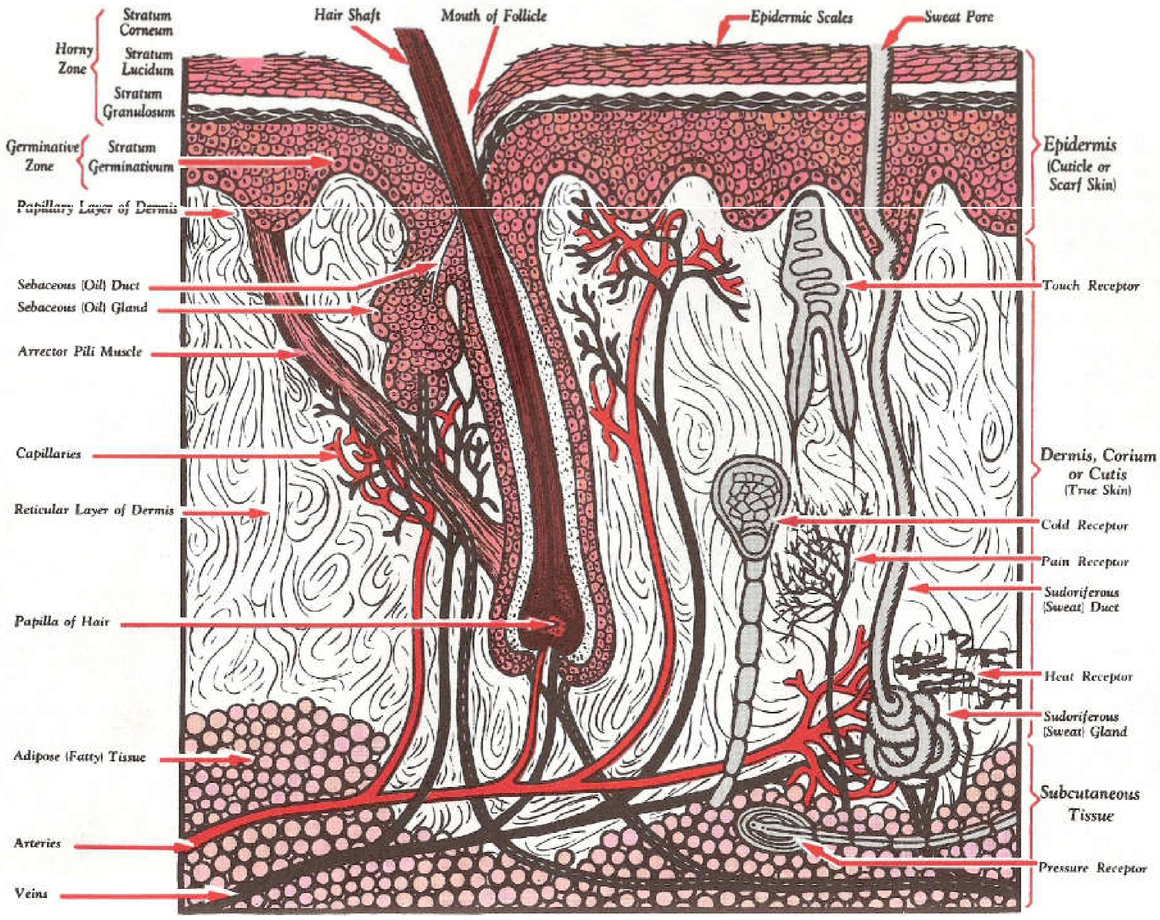

Figure 2: Diagrammatic representation of the structure of a typical mammalian skin (Source: Powitt, 1977)

2.5 STRUCTURE OF GOAT SKIN

In many respects the skin of the goat may be regarded as having a structure intermediate between those of calf and sheep. The epidermis is thicker than in sheep skin and covers approximately 1.5 to 1.8%of the thickness of the skin. Unlike in sheep, hair follicles of a goat are straight and less deeply rooted. The glands and fat cells, which are responsible for the sponginess of sheep leather, are very much less in number in goat skins and the glands are rather smaller in size. Hair muscle is well developed and longer in goat skin than in sheep skin.

The thermostat layer covers approximately 24 to 54% of the total thickness of the skin and is relatively thicker in the neck. A dense network of elastin is found in the goat skin covering approximately two-thirds of its thermostat layer. As in sheep skin, a relatively greater amount of elastin is present in the neck in the goat.

The corium proper in goat skin covers approximately 45 to75% of the total thickness of the skin, the percentage varying considerably over the entire area. The collagen fibers in this layer are fuller and firmer than those of sheep but are hardly equal to those of the calf. Unlike in sheep skin, fat cells and fat droplets are rarely found in this laver of the skin.

2.6 SOURCES AND ACQUISITION OF SKINS AND HIDES FOR LEATHER WORK

With few exceptions hides and skins are by-products of meat industries. Animals are reared for meat, milk and wool, not for the value of their skins Anonymous,(2014). As a consequence, the tanner is not able to control the supply of raw hides. Hides are traded as a commodity all over the world on open markets and in competition with other tanners on a global basis. As a result, when demand is high, prices soar. Additionally, even minor variations in economies and currency may cause major fluctuations in raw hide prices. The availability of cattle hides for leather is however fundamentally dependent upon consumer demand for beef, and this is not different from skins from goats and sheep.

Today worldwide, at least half the leather produced goes into footwear and around a quarter into clothing. Only around 15% goes into upholstery and the rest into small leather goods and other consumer products. Because of its durability and comfort, leather has been used for seating purposes throughout the history of transportation and furniture (Wilson, 1923; De Haas, 1925; O'Flaherty *et al.*, 1956, Sarkar, 2005). The early leathers were made from cowhide, calfskin, pigskin, deerskin, and goatskin either hunted or farmed for food purposes. The present trend is for most upholstery to be made from bovine material (that is to say cattle hides) as this is readily available and best lends itself to the modern demand of designers, producers and consumers. Hides include ox, bull, cow, and buffalo skins, while the reptile skins include snake, lizard, and crocodile skins. In addition to these animals, a number of other exotic animal skins are used to produce specialty leathers. These animals include emus, ostrich, sharks, elephant, kangaroo, bear, elk, turtle feet, and frog skins.

2.7 HIDE, SKIN AND LEATHER PRODUCTION

Hides and skins are obtainable from abattoirs and slaughter houses/slabs located especially in the northern states, finished leathers on the other hand are obtained from tanneries and also from traditional tanners, both of which are also located in the north (Aminu *et al.*, 2010). From field surveys, the human consumption pattern indicates that100% of the realizable hide and skins in the southern state of Nigeria are lost to human being.

2.8 LEATHER PRODUCTION IN NIGERIAN ECONOMY

Nigeria's leather sector is one of the most important sources of foreign exchange earner after the oil industry, exporting over 600 million square feet of leather in 2009, and earning about US $680 million for tanned skin GEMS1, (2012). In the 1980s there were over 40 fully operational tanneries, however by the 1990s due to several constraints this figure fell sharply to only 4 functional tanneries, none of which are indigenously owned Amakon, (1995). The leather industry offers a huge potential for growth even though it constitutes mainly of small and medium scale enterprises Amakon, (1995).

The heavy dependency on the oil sector is reflected by the fact that the non-oil sector contributed only 6.5% of GDP CBN, (2010). Hence, in order to develop a balanced economy there is a clear need to expand the growth of the non-oil sector, one of which is the leather industry. Export figures showed that the leather industry was the strongest non-oil export in 2005 with exports in excess of US $160 million (NEP,1999). However, the industry is struggling to maintain export competitiveness, which is evidenced by the fact that the leather industry accounted for 36.84% of non-oil export in 2004 but only 20.4% in 2005 (Amakon,1995;UNCTAD, 2009).

2.9 DEMANDS FOR LEATHER PRODUCT

The World's leather and leather products industry has changed significantly. Global trade in leather and related products in 2002 is estimated at $70 billion. The United States, India, Brazil, China, Italy and Spain dominate global trade in leather products. The demand for leather products is on the increase for a variety of reasons, the most obvious is an increasing level of disposable income in developing nations, and the demand express itself primarily through the foot wear industry which is the major end-user of leather (FAO, 2000).

According to Chemonics (2002), Nigeria demand of leather for shoe manufacturing is 4 million sq meters (43 million sq ft.), while total demand for leather products is estimated at 5.33 million sq meters (57 million sq ft.). Local tanneries supply less than 10% of the national demand for leather by the shoe manufacturing sector. Domestic production is estimated at not more than 4 million pairs per annum. The supply gap is 20 million pairs and is currently being met by imports, Chemonics (2002).

2.10 DOMESTIC CONSUMPTION OF HIDES AND SKINS

Hides and skins when properly cooked are considered a delicacy among certain population, particularly those from the southern states of Nigeria. In these states generally, the cattle are flayed but the resultant hides are sold to market women for edible purposes. For the smaller ruminants (sheep and goats), the skins are roasted along with the whole animal. The consumers claim that the roasted skins have some delicious taste and thus make the meat more palatable (Ihuoma and Okonkwo, 2001).

Chemonics (2002) also reported that, significant proportion of hides and skins are consumed as food because edible hides and skins are relatively inexpensive in comparison to other meat products and demand is expected to keep growing due to high level of urbanization and population growth, annual demand for edible hides and skins is estimated to be over 2.5 million square meters.

2.11 FACTOR AFFECTING LEATHER QUALITY

The production of good quality leather fully depends on the quality of the raw materials (Gbolagunte *et al*., 2009). According to Chemonics (2002) good quality raw materials, in turn implies good quality leather, low cost of production, high selling price and total growth of the national economy. In some developing countries, the economic loss due damages and defects on skins is very high. In most instances, these damages and defects could be easily identified until the skin is processed in tanneries. Ahmad (2001) and FAIR (2000) outlined mechanical injuries on the live animal or during slaughtering and flying such as branding for identification, scratches by wire, gouge mark, strain mark, cuts etc. and parasitic infections such as a tick mites, mitotic diseases, dermatophylosis, poxes and ringworm to be among the factors reducing the quality of raw skins and indirectly the leather made from them.

Ahmad (2001) further indicated that nutritional diseases such as starvation cause changes in the structure of skin and may reduce the quality of the skin and the leather. Great variation exists among the skins in terms of quality of leather they produce and this is as a result of factors like species, breed, sex, age and nutritional status of the animals from which the skin is obtained. Such variation also exists on the basis of location of the sample of the skin or its health condition (SLTC, 1965; Omojola and Jibrila, 2008). Yakubu, *et al*. (2010) and Blench (1999).The quality of finished leather always depends on the way the animals were reared, flayed and the type of tanning process deployed Amakon,(1995). The quality of processed leather in the country is often of low grade because much of it is produced by traditional tanners, who use unscientific, prolonged soaking methods and out mode surface treatment solution (Jennifer,2014). There are many traditional tanning pits in Nigeria. Many of the artisans are aged and uneducated people and industry watchers actually posit that their method wastes a good percentage of locally available hides and skins that could have fetched the economy much more through modern processing methods.

2.12 IMPACT OF FLAYING ON HIDES AND SKINS QUALITY

Flaying as a process in relation to the production of quality leather is a major concern which cannot be over emphasized. Principally, good flaying is carried out such that the economic potentials of the skin are preserved. The process therefore means a lot to the tanner and holistic stakeholders of the leather industry, especially when the production of quality leather to meet specific demands is in question (O'Flaherty *et al.*, 1956). Though the hide or skin is known to be a by-product of the meat industry, its further applications are uncountable; outstanding among them is converting it into leather by the tanning process which raises the economic value of the pelt enormously and creates a chain of employment for several people.

The above economic reasons render the removal of pelts imperative and flaying technology impeccable, Kite and Thomson, (2006).The object of skinning is to remove the animal's pelt cleanly, neatly, and with minimum damage or none to either the hides or fur. This intention makes it possible for full utility and enhances further applications including leather making, drumheads, lashings, saddles, knife handles, sandals, snowshoe thongs, and leather, to mention but a few. Since any damage caused tarnishes the quality status of the material, expertise is prerequisite to flaying.

According to Back to Basics of the Reader's Digest, (1981), to skin an animal perfectly requires experience. It explains further that for the first time, one is almost certain to damage the hide by slicing too close or else by cutting too cautiously and leaving large chunks of flesh that will mean extra work during the fleshing operation. According to ISO-2822 description of defects, poor flaying may lead to defects such as gouge marks, holes, cuts, scratches, scores, poor trimming and bad shaping of the skin. Sharphouse, (1995) advises that flaying is much easier while the carcass is warm and since heat is lost rapidly the chances of putrefaction is reduced.

2.13 THE TANNERIES (TRADITIONAL AND MECHANIZED)

Leather production was started in Nigeria by the peasant traditional tanning industries in the northern part. Today's tanning industries exist in dualistic pattern (two types). The modern tanneries that produce leather for both domestic and export use and traditional tanneries that mainly produce leather for home consumption the traditional tanning activity has been predominantly in the hands of local tanners using traditional tanning methods. The modern tanning technology was introduced into Nigeria as early as 1949 when John Holt established a tannery in Kano, (Aminu *et al.,* 2010). In 1959, Northern Nigerian Government established a tannery in Sokoto. Five years later in1964 another tannery called Great Northern Tannery (GNT) was established in Kano (Aminu *et al*., 2010).

According to Chemonics,(2002), there are 41 commercial tanneries in Nigeria, with a collective installed capacity of 310,000 hides and 25.5 million pieces of skin per annum 12% of the 41 tanneries are designed to produce finished leather and wet blue; 29 produce wet blue only. Aminu *et al*. 2008 also reported that Kano has well over twenty (20) modern tanneries located within the metropolitan local government of the state. In 1999, operating tanneries produced only 55,000 tanned hides, and then dropped to production of 3,000 units in 2000. This represents operations at 18% and 1% capacity, respectively. At the same time, the operating tanneries produced 7.5 million pieces of skin in 1999, and 6.9 million pieces in 2000. This represented 29% and 27% capacity utilization respectively. From production capacity, it is clear that Nigerian tanneries are designed more to process skins than hides, and are operating at less than 30% of installed capacity for skins and at 1% for hides.

2.14 LEATHER MAKING PROCESS

The leather manufacturing process is divided into three sub-processes: preparatory stages, tanning and crusting. All true leathers will undergo these sub-processes. A further subprocess, surface coating may be added into the sequence. The list of operations that leathers undergo vary with the type of leather

2.14.1Beam-house operation

Leather is made in the beam-house, the beam-house incorporate several different processes. According to the international union of leather technology and chemists societies glossary of leather terms. The beam-house is the section of the tannery where skins are prepared for tanning. The activities carried out are set of operations particularly aimed at removing unwanted parts of the pelt for tanning. Irrespective of the condition in which the skin/hide enters the tannery, soaking is the first major process to carry out in water to result cleaning and purposely rehydrate the pelt (O'Flaherty *et al,* 1956, 1958).Liming which leads to swelling and opening up of the skin fibres, as well as cause depilation of the pelt is accomplished by immersion in a bath of saturated lime and "sharpeners" which may be sulphides, amines or reducing agents. Deliming and bating as recorded by Sharphouse (1995) depend on ammonium salts with proteolytic enzyme at elevated temperature to cleanse the pelt from liming chemicals, deswelling, and reduction of pH to support the subsequent process. Pickling which is usually performed prior to chrome tanning of pelt is performed in a bath of salt and acid to neutralize the residual lime and set the right pH requisite for tanning (Sarkar, 2005).There is no doubt that this stage of processing is critical and needs almost control in order to prevent damage that can persist into the final leather rendering it useless.

2.14.2Tanning

Leather is material created through the tanning of hide and skin of animals. The tanning process converts the putrescible skin into durable, long-lasting and versatile natural materials for various uses. Leather tanning is also refers as the process of converting raw hides or skin into leather. Hides and skin have the ability to absorb tannic acid and other chemical substances that prevent them from decaying, make them resistant to wetting and keep them supple and durable.

Tanning is essentially the reaction of collegen fibres in the skin with tannins, chromuium, Allum or other chemical agent use in Nigeria are trivalent chromium and vegetable tannins extracted from specific tree backs and pod (e.g. *Acacia Nilotica*) and other tanning agent. Best on this research two tanning method was involved.

2.14.2.1 Vegetable Tanning

The vegetable tanning process is the oldest of any process in use in the leather tanning industry. The hides are first trimmed and soaked to remove salt and other solids and to restore moisture lost during curing. Following the soaking, the hides are fleshed to remove the excess tissue, to impart uniform thickness, and to remove muscles or fat adhering to the hide. Hides are then de-haired to ensure that the grain is clean and the hair follicles are free of hair roots. Liming is the most common method of hair removal, but thermal, oxidative, and chemical methods also exist.

The normal procedure for liming is to use a series of pits or drums containing lime liquors (calcium hydroxide) and sharpening agents. Following liming, the hides are de-haired by scraping or by machine. Deliming is then performed to make the skins receptive to the vegetable tanning. Bating, an enzymatic action for the removal of unwanted hide components after liming is performed to impart softness, stretch, and flexibility to the leather. Bating and Deliming are usually performed together by placing the hides in an aqueous solution of ammonium salt and proteolytic enzymes at 27E to 32EC (80E to 90EF). Pickling may also be performed by treating the hide with a brine solution and sulfuric acid to adjust the acidity for preservation or tanning. In the vegetable tanning process, the concentration of the tanning materials starts out low and is gradually increased as the tannage proceeds. It usually takes 3 weeks for the tanning material to penetrate to the center of the hide. The skins or hides are then wrung and may be cropped or split; heavy hides may be re-tanned and scrubbed. For sole leather, the hides are commonly dipped in vats or drums containing sodium bicarbonate or sulfuric acid for bleaching and removal of surface tannins.

2.14.2.2Chrome Tanning

Chrome-tanned leather tends to be softer and more pliable withhigher thermal stability, very stable in water, and takes less time to producethan vegetable-tanned leather. Almost all leather made from lighter-weight cattle hides and from the skin of sheep, lambs, goats, and pigs are chrome tanned. The first steps of the process (soaking, fleshing, liming/de-hairing, de-liming, bating, and pickling) and the drying/finishing steps are essentially the same as in vegetable tanning. However, in chrome tanning, the additional processes of re-tanning, dyeing, and fatliquoring are usually performed to produce usable leathers and a preliminary degreasing step may be necessary when using animal skins, such as sheepskin.

Chrome tanning is performed using a one-bath process that is based on the reaction between the hide and a trivalent chromium salt, usually a basic chromium sulfate. In the typical one bath process, the hides are in a pickled state at a pH of 3 or lower, the chrome tanning materials are introduced, and the pH is raised. Following tanning, the chrome tanned leather is piled down, wrung, and graded for the thickness and quality, split into flesh and grain layers, and shaved to the desired thickness. The grain leathers from the shaving machine are then separated for re-tanning, dyeing, and fatliquoring. Leather that is not subject to scuffs and scratches can be dyed on the surface only. For other types of leather (i. e., shoe leather) the dye must penetrate further into the leather. Typical dyestuffs are aniline-based compounds that combine with the skin to form an insoluble compound. Fatliquoring is the process of introducing oil into the skin before the leather is dried to replace the natural oils lost in beam house and tanyard processes. Fatliquoring is usually performed in a drum using an oil emulsion at temperatures of about 60E to 66EC (140E to 150EF) for 30 to 40 minutes. After fatliquoring, the leather is wrung, set out, dried, and finished.

2.15 CRUST LEATHER

Crusting is when the skin is thinned, re-tanned and lubricated. Crust leather is a semi-finished stage of leather which is processed until it becomes white or cream white colour, full in substances and smooth texture,. Crust leather has an advantage in that it has relatively lighter shipping weight. It is a product of high added value than wet-blue leather. The distinct feature of this product from the wet blue leather is that has a visible physical property such size, thickness, fullness, looseness of grain and grain damages together with other properties of physical and chemical nature. It is rather a product of better tensile and tears strength, chrome and fat content than wet blue leather. Crust leather is used as an input to garment and upper shoe production. It is also used as an indispensible input and for finished leather production (GEMS1, 2012).

2.16 PHYSICAL PROPERTIES OF LEATHER

The physical properties of leather do not only depend on the kind of skin and tanning method but also vary widely from one skin to another of the same kind. Most important physical properties of leather are: leather thickness, tensile strength and percentage elongation, grain burst, water vapour permeability, shrinkage temperature as well as water absorption (IULTCS, 2001). These test methods are excellent for manufacturing control, specification acceptance, and service evaluation in the lasting property of leather and are summarized as follows:

2.16.1 Leather Thickness

The leather thickness is being depended by many properties of leather and it is measured in order to express the test results in relation to the thickness. The hide and skin do not have the same thickness over all its cross-section. On heavy leathers thickness differences can reach 25% and on light leathers 20%. Thickness of leather can be modified by stretching or compressing, splitting, shaving, buffing or skiving. Standard IUP 4/ISO 2589 gives the method of measurement of thickness and specifies the characteristics of the measuring gauge (UNIDO, 1994).

Studies carried out by Oliveira *et al*. (2007) reported high degrees of homogeneity in leather thickness among different genotypes. Teklebrhan *et al.* (2012) opined that local Iamb skin had numerically higher thickness than the cross. However, Craig *et al.* (1987) and Jacinto *et al*. (2005) found poor correlation values that indicate no relationship between the thickness of the leather and the tensile strength and percentage elongation. Teklebrhan *et al*. (2012). Adel and Elboushi, (1994) and Salehi *et al.* (2013) reported that the thickness of the skin differed and was dependent on the breed, varieties, age, sex and different parts of the body.

2.16.2 Tensile Strength and Percentage Elongation

Tensile strength was defined as the force required for breaking a dumb bell-shaped leather sample on the Instron. Strength is the basic property pre-requisite to most materials ability to meet their expected efficiency irrespective of the end use they are purposed for. it measure how easy or difficult it is to break, pull apart, tear or crack a given material in relations to its intended utility.(Thorstensen, 1976: FAO,1986; Kite and Thomson, 2006;). It was expressed in relation to the diameter at the narrowest part of the dumb bell-shaped piece of leather and the thickness of the sample. Elongation at grain break was determined during the test for tensile strength. It was defined as the percentage stretch of the dumb bell shaped leather sample before it broke (Cloete *et al*.,2006). ALCA (2015) defined tensile strength as the force per unit of the original cross-sectional area of the un-stretched leather which is applied at the time of rupture of the specimen. It is calculated by dividing the breaking force by the cross-section of the un-stretched specimen.

Tensile strength and percentage elongation are determined using test methods of ISO-3376 (2011)/IUP 6. The tensile strength test gives a reliable indication of the quality of the leather. Improperly lubricated and partially degraded leathers give low values for tensile strength. The orientation of the specimen in relation to the backbone and the location of' the specimen on the hide influence the results significantly. This test method is excellent for development, control, specification acceptance, and service evaluation of leather (ASTM, 2010).The recommended minimum industrial standard values for tensile strength and percentage elongation are 12N/mm2 and 40%, respectively (SON, 2012).

Stosic (1994) suggested that leather of goat had more tenacity and strength in comparison to the leather of sheep, which is likely due to the grain and protein fibers, so it makes them a very good stuff for making hoots and 'garments. Snyman and Jackson-Moss (2000) reported that Damera sheep (wool type) produced leather with higher tensile strength (22.56 Mpa) and Merino (mutton type) produced least tensile strength value (11.86 Mpa). The same authors indicated that hair type Dorper produced leather that had significantly higher tensile strength (18.72 Mpa) than wool type Dorper (14.48Mpa).

2.16.3 Grain Burst Test

Grain burst is primarily considered as a measure of the strength of the grain layer within the tested material. The strength and distension at grain burst and break of a leather act as a guide as to how the material will perform when a multi-directional stress is applied. Generally, these variables are more important in shoe upper leather, although optionally used in garment leather as physical quality parameter (Teklebrhan *et al.,* 2012). Standard IUP 9/ISO 3379 (2005) gives the method of measurement of grain strength and distention by ball burst (UNIDO, 1994). This test method was designed to measure the force required to burst the grain of leather by steady hydraulic pressure on a diaphragm of definite diameter applied to the flesh side of the specimen to form a sphere. The bursting of the grain is a result of failure under elongation or stretch (IULTCS, 2001). The minimum recommended value for grain burst and burst is 7mm (SON, 2012).

2.16.4 Water Vapour Permeability

Water vapour permeability is one of the most precious physical properties of leathers, which may greatly affects the breathability and the comfortable feeling of leather goods (Kellert *et al.,* 2004). There are plenty of capillaries among collagen fibers in leather as well as lots of hydrophilic groups on the collagen chain. They may endow leathers with good water vapour permeability, compare with other synthetic-closing materials (Kyoji.2000).

2.16.5 Shrinkage Temperature

Shrinkage temperature refers to the temperature at which measurable shrinkage occurs when leather is gradually heated in an aqueous medium (ALCA. 2015). Shrinkage occurs as a result of hydrothermal denaturation of the collage protein molecules which make up the fibre structure of the leather. It is considered to be one of the physical quality requirements for leather industry. Shrinkage temperature of leathers may differ depending on the type and amount of tanning andretaining agent used in processing (Bitilisli *et al.*, 2004; Teklebrhan *et al.*, 2012).

Generally, the higher the shrinkage temperature, the better the heat resistance of the leather, so measurement is useful for judging the suitability of leather for moulding on footwear. It is indicated that leather processed using chrome has shrinkage temperature above 100°C. Frequently; the shrinkage temperature has to be determined in water under pressure (SATRA, 2012). Teklebrhan *et al.* (2012) reported that leather produced from the Ethiopian breeds of lambs crossed Dorper had similar shrinkage temperature above 100°C. However, Jibir *et al.*(2013c) reported slightly less than 100°C for Nigeria's native small ruminant breeds. The industrial requirement for shrinkage temperature is 100°C (SON, 2012).

2.16.6 Water Absorption

The percentage of water in leather as function of the relative ambient atmospheric humidity, the water absorption of leather is refers to the binding of gaseous water in the leather. This naturally depends on the ambient atmospheric humidity, which may be very high or low.

2.17 CHEMICAL PROPERTIES OF LEATHER

A chemical property describes a substance based on its ability to change into new substances with different properties in leather and these include volatile matter, water soluble organic matter and water soluble inorganic matter, Hide substances, pH value of difference figure, water soluble magnesium salt and sulphated total ash and water insoluble ash (IULTCS, 2001).

2.17.1 Volatile Matter

Volatile matter describes the loss of mass by leather when dried to constant mass at 102 °C ± 2 °C. The moisture content of leather usually changes depending on the external conditions to which it is exposed and this may often be the cause of changes in the physical properties of leather. Ideal moisture content is often considered as being I 2¬14 per cent and is determined by drying a sample of leather to constant weight at 102^{o}C. and calculating the weight loss (SATRA, 2012). The loss of small amounts of volatile oils, or solvent's may also be included in this weight and so this is often termed as being a determination of volatile matter (IULTCS. 2010). In real terms these substances are only a very small part of the total loss and so it is a very good estimation of the moisture present.

Jibir *et al.* (20I3b) reported that Sahelian white goats had the highest amount of volatile matter' (81.63%), followed by Uda (77.03%) and then Sokoto red goat (71.00%). This is why Sahelian goat can withstand hash environmental temperature than any other breed of small ruminant as described by Blench, (1999). The same sludgy reported that Matured animals had higher amount of volatile matter (75.56%) than young animals (72.49%).

2.17.2 Water Soluble Matter, Organic and Inorganic Matter

Water soluble matter, organic and inorganic matter, can be determined by evapouration at 102$\pm$2^{o}C, after aqueous extraction of a prepared sample under specified conditions. Sulphating and ashing of the residue at high temperature yields the water-soluble inorganic matter. The water soluble organic matter is derived by difference (IULTCS 2010)

2.17.3 Nitrogen and Hide Substances

The determination of hide substance from nitrogen content is based on the fact that according to Schroder and passler(1905), the grease-and ash-free dry substance of the pelts of various animal has somewhat different, but practically constant, nitrogen for certain types of animals.

2.17.4 pH of Aqueous Extract

The pH of aqueous extract is a measure of the strength of acids and bases of the leather (UNIDO, 1994). The majority of leather has a pH value in the range 3.2 - 5.5 which considered as acidic. This is as a result of the tanning process used which convert animal skin into leather this acidic form of the may not present any problems to those working with the leather itself or to users of the finished goods (SATRA. 2007). However, a very low pH may indicate that the tanning process has not been carried out correctly. Leathers with low pH values may degrade prematurely and other materials used in the finished product may also be affected, such as threads or cotton fabrics.

The study carried out by Jibir *et al.*(2013b) reported pH of aqueous extract of 3.73 for mature and 3.61 for young sheep and goats indigenous to Nigeria. The same author revealed higher pH difference of (0.46) for matured than the young (0.38) Nigeria's native sheep and goats.

2.17.5 Magnesium Salt in leather

The Epsom salt content of leather is defined as the quantity of magnesium salts calculated as magnesium sulphate $Mgso_4 \times 7\ H_2o$ (Epsom salts) obtained by extraction with water under certain conditions. Magnesium is determined in the water soluble mineral substance by complex metric titration, SLTC,(1965).

2.17.6 Sulphated Total Ash and Sulphated Water Insoluble Ash

The residue left from burning leather in an open crucible at 800^oC after sulphating is defined as Total Ash. The residue obtained, after extracting the leather with water, ashing and sulphating are defined as water insoluble ash.

The amount of mineral substance found by ashing could differ from the actual content owing to decomposition, reduction, or the escape of certain salts, SLTC,(1965). By treating the ash with sulphuric acid, the salts and oxides are converted into sulphate, but some salts may again be transformed into oxide at the selection temperature of ignition.

CHAPTER THREE

MATERIALS AND METHODS

3.1 STUDY AREA

The experiment was conducted at the Tannery Unit of Nigeria Institute of Leather Research, Science and Technology (NILEST) Samaru Zaria and Livestock Teaching and Research Farm of the Department of Animal Science, Bayero University Kano. Kano lies between latitude of9^{o}30' North and longitude of 8^{o}42' and 9^{o}30' in semi-arid region of North Nigeria (Olofin, 2007).

The climate of the study area is characterized by defined wet and dry seasons, which normally begins in June and ends in September. The environment is conducive to different species of livestock (cattle, sheep, goats, donkeys, rabbits, horses, camels and poultry). It is also favoured with abundance of grassland for grazing by animals and free from tsetse fly infestation. Cereal crops grown in the region includes millet, sorghum, maize, cowpea, groundnut, soybean and sesame (Muhammad *et al.,* 2009).

On the other hand,Samaru Zaria is located in the Northern Guinea Savannah zone of Nigeria which lies between latitude of 11^{o}09', 11^{o}10' North and longitude 7^{o}39', 7^{o}39' East. The zone is characterized by three major seasons the rainy season stretches between May to October, the Dry season commences from March to April while Harmattan from November to February (Igono *et al.*, 1982;Ayo *et al.,* 1999). The study Area has Annual rainfall ranges between 1200 -1500mm with maximum peak period in August; the economy of the area is primarily based on Agriculture.

3.2 EXPERIMENTAL DESIGN

The experiment was conducted in a 2 X 2 X 3 factorial arrangement in a Completely Randomized Design (CRD) involving 2 tanning agents (*Acacia nilotica* and chromium sulphate), 2 age groups (1-1½ yearsand 2-3years) and skins from 3 strains (Kano Brown, Red Sokoto and White Borno) of red Sokoto goats in 3 replications as shown in the Table below.

Table 3.1 Experimental Layout

Factors					
		Strains of Red Sokoto goats			
Tanning agent	Age	Kano Brown	Red Sokoto	White Borno	Total
Acacia Nilotica	Young (1-1½ year)	3	3	3	9
	Matured (2-3years)	3	3	3	9
Chromium sulphate	Young (1-1½ year)	3	3	3	9
	Matured (2-3years)	3	3	3	9
Total		12	12	12	36

3.3 SAMPLE COLLECTION AND SAMPLING LOCATION

A total of 36 fresh goat skin samples were used for the experiment following flaying of the animal and appropriate tagging. The skin samples were collected from Daura Central Abattoir in Katsina State (N 13^0 02' 24.3", E 8^0 19' 005"), Maigatari Market Abattoir in Jigawa State (N 12^0 48' 50.3", E 9^0 26' 30.4") and Kano Central Abattoir in Kano State (N 12^0 00' 45.5", E 8^0 31' 17.1"). The cited coordinates were obtained using Geographic Positioning System (GPS) equipment (GARMIN 2007model).

The above-mentioned locations shared similar environmental, vegetation and climatic conditions with unique dry-land features such as high temperature during most part of the year up to 44^o C, low biomass productivity, low soil organic carbon and nutrient content, prone to soil degradation and desertification, variable and erratic rainfall ranging from 780 mm to 1320 mm from June to December. The relative humidity ranges from 11% in March to 68% in August (KNARDA, 2001; Maharazu, 2013).

3.4 SKIN TREATMENT AND TANNING PROCESS

The skin samples collected were preserved using 35% common salt and transported to the NILEST (Tannery unit) for further processing, tanning and quality analysis according to standard procedures of the International Union of Leather Technician and Chemists (IULTCS, 2010) the skins were processed to the chrome- crusted and vegetable-crusted stages as shown in Figure 3 below (Shivam *et al*., 2007).The experiment was carried out at Nigerian Institute of leather, Science and Technology Samaru, Zaria.

TANNING PROCESS

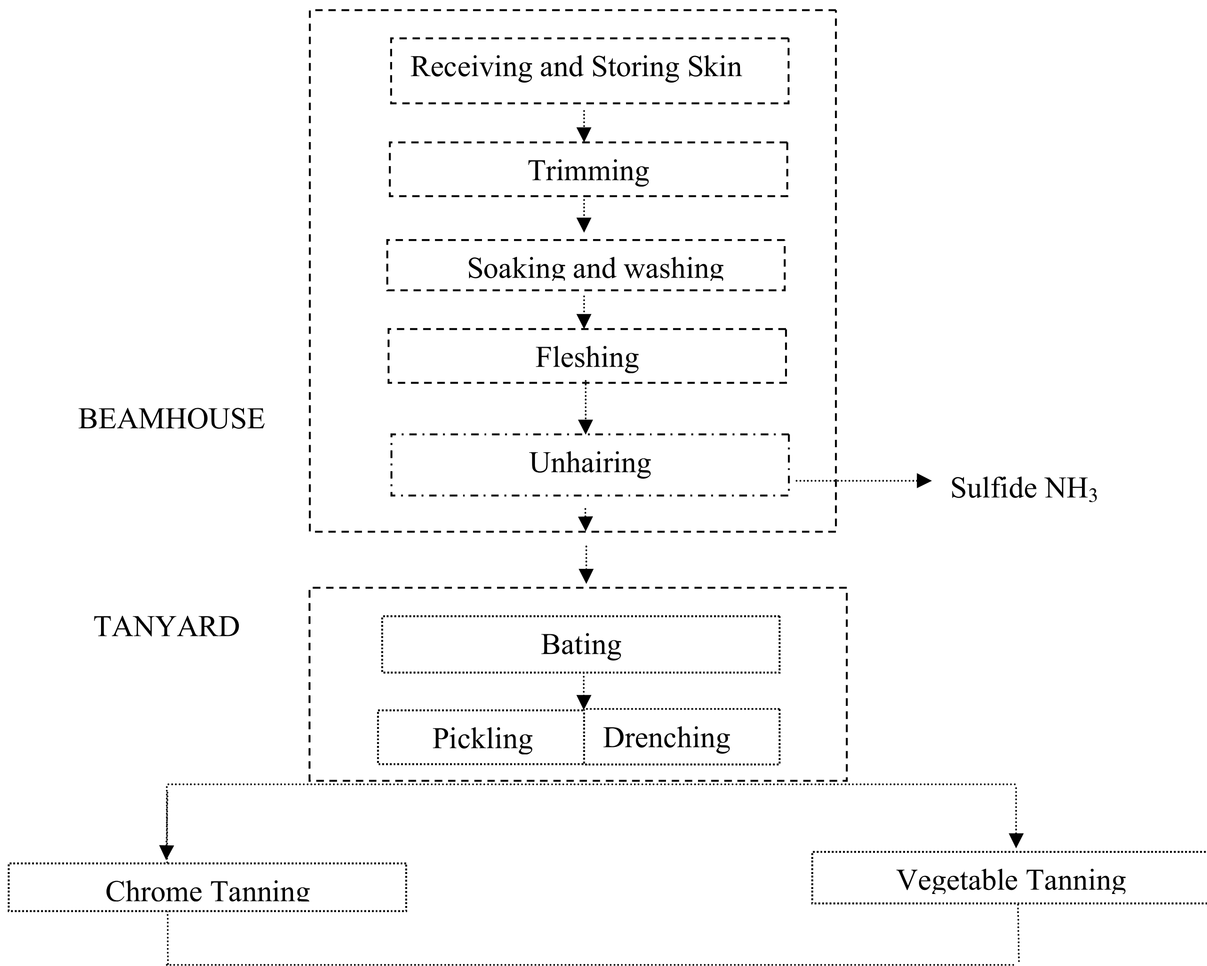

Figure 3. Diagram showing tanning process

Source: Shivam *etal*., (2007). Note: Chrome tanning Conventional tanning; Vegetable tanning Indigenous tanning

3.5 TANNING PROCESS

The tanning process was conducted according to the methods of (IULTCS, 2010).The process involves series of steps as described below:

3.5.1 Soaking and Washing

The cured skins were first soaked in water using large rubber bowls for 24 hours, (drape test was carried out to ensure proper soaking). The excess salt and dirt were eliminated and the moisture lost during the curing process was replaced.

3.5.2 Liming/Unhairing

Pulp unhairing was carried out using 3% Na_2S and 100% water run for 60 minutes to loosen the base of the hair, then 3% concentrated $Ca(OH)_2$was added and the water volume was increased by 70% for swelling and plumping of pelt for 24 hours at pH of 12-12.5 (using universal indicator).

3.5.3 Fleshing

After ensuring that the limed pelt is properly swelled and plumped, fleshing was done to remove hypodermis using fleshing machine at room temperature.

3.5.4. Deliming

Deliming was done to De-swell the limed pelt and also to adjust the pH to 8-8.5 using 2% $NaHSO_4$ and 75% H_2O run for 45-60 minutes and proper Deliming was checked using phenolphthalein indicator (Colorless).

3.5.5 Bating

Bating was done using proteolytic-enzymes (Verma batzyme) which removed excess proteins and rendered the skin soft and flexible. The delimed float is reduced by 50% and bating powder was added into it. This is to improve the perspiration properties of the resistance leather by digesting the inter fibrillary hairs enabling air to pass through fiber freely. 0.5% of bating powder was used in rotating drum run for 45 minutes at room temperature and wash with water to reduce enzymatic activities.

Bating is the final stage where to decide what appropriate tanning agent to be used for tanning the skin either by A- mineral (Chromium sulphate) or B-vegetable (*Acacia nilotica*). Hence (36 skin samples were divided into two, 18 skin samples for Chrome tanning while the remaining 18 skin samples were tanned using *Acacia nilotica.* Hence the process went as follows:

(A) Chrome Tanning process

3.5.7 <u>Pickling</u>

Pickling was done by adding salt (NaCl) and de-pickling by using Tetraoxosulphate (VI) acid which lowered the pH of the pelt to3.0 for effective tanning.This was done to acidify the bated pelt prior to tanning using 10% NaCl and 100% H_2O and run for ten minutes, then 0.6% fumic acid (HCOOH) as masking agent was added at the ratio of 1:10 and then 0.4% H_2SO_4 at the ratio of 1:10 is added. All this was run for 60 minutes, until pH of 2.3-2.5 was achieved using pH paper.

3.5.8 <u>Chrome Tanning</u>

During the chrome tanning process 6% of Cr_2O_3 (Chrome Powder) was added and run for 120 minutes cut cross-section to ensure penetration, drain, pile and allowed for Olation/Oxyolation (complex formation) at pH of 2.5-2.8 for 48 hours and shrinkage temperature (98^{o}C) was checked.

The pelts were chrome tanned into wet blue using basic Chromium Sulphate $(Cr_2SO_4)_3$ and then re-chromed to crust leather as shown in *figure 3*.

3.5.9 <u>Neutralization/De-acidifications</u>

Atthis stage, the leathersamples were washed with water to adjust acidity by removing the loose acid and drain. This was done by adding 100% water and 2% $NaHCO_3$ and run for

45-60 minutes, and pH was checked using pH paper/bromocresol blue. pH 3.5 – 3.8 was regarded.

3.5.10 Fatliquoring

The tanned leather was lubricated by adding 4% fatliquoring at 60^oC run for 60 minutes in rotating drum to lubricate the fibres drain, pile to dry.

3.5.11 Post Tanning Processes

The crust leather was conditioned with water (sprinkling) and staking machine was used to enhance softness and finally toggling was carried out to dry the leather.

(B) Vegetable Tanning process (using *Acacia nilotica*)

3.5.12 Drenching

This was carried out using 0.4% of HCOOH and 100% H_2O in rotating drum at the ratio of 1:10 and run 120 minute and allowed for stabilization.

3.5.13 Vegetable Tanning (using *Acacia nilotica*)

Immediately after drenching the leather samples for vegetable tanning were put in a rotating drum and 15% *Acacia nilotica* powder, 100% water was mixed and run for 60 minutes, fiscal study was carried out by cutting the cross-section to check penetration of the tanning materials,and then the shrinkage temperature (84^oC) was determined. 4% of fatliquor and 50% water were added at 45^oC and allowed to run for 30 minutes, drain, rinse and hang up before drying.

3.5.14 Post tanning process

Setting out to carries out grain pattern, drying the leather, then staking to soften the leather and toggling to dry on a toggling/drying frame for 24 hours.

3.6 PHYSICAL AND CHEMICAL TEST

After tanning, the crust leather samples were taken to Quality Control Laboratory at NILEST, Zaria, for various physical and chemical tests.The 36 crust leather samples wereconditioned at 20±2^{o}C and 65± 2% Relative Humidity (RH) over the period of 48hours as per IULTCS standard. The leather quality parameters were measured as follows;

3.6.1 Physical Tests

Physical properties such as leather thickness, tensile strength and percentage elongation, Grain test by ball-burst, water vapour permeability, shrinkage temperature and water absorption, have been measured as per standard procedures.

3.6.1.1 Leather Thickness (IUP 4)

The thickness of the crust leather was measured with automatic thickness gauge according to ISO (2002). The leather samples were place beneath automatic thickness gauge while readings (values) were taken at three difference strategic areas and mean average readings were determined as the thickness of the sample.

3.6.1.2 Tensile Strength and Percentage Elongation (IUP 6)

Tensile strength and percentage elongation were determined according to 1S0 (2011). A universal testing machine model 1122 (instron) was used for the procedure with a speed of 100mm/minute. The leather samples were placed for testing and load applied, a string gauge extensometer was used to measure elongation. The stress obtained at the highest applied force was the tensile strength; percentage elongation describedthe extent to which the sample stretched before fracture.

Measurement of Tensile Strength and Percentage elongation was done as follows:

$$\text{Tensile Strength} = \frac{\text{breaking load (N)}}{\text{Cross sectional area (m}^2\text{)}} \quad \text{Equation} \quad \text{----------------------------------} \text{ (i)}$$

Percentage elongation = length at break – initial length × 100 Equation ------------- (ii)

3.6.1.3 Grain test by ball burst (IUP 9)

Grain burst was determined using the ball burst test method according to ISO (2015). Electronic lastometer model 5077-ET (MUVER) was used for the test. In grain burst, theclamps held the rim of the circular flat disc of the test leather leaving the central portion free to more. The force was applied via the still ball (6.25m diameter) which was advanced manually at a steady rate approximately 1/5mm per second. The amount of distension (mm) and the applied load (N) was noted when the grain surface first cracked and the steel burst through the sample.

3.6.1.4 Water Vapour Permeability (IUP 15)

This test was carried out according to ISO(2012) by the use of water vapour permeability machine model 5011-ET (MUVER). The method use was to determine mass of water vapour which permeates from area with higher vapour pressure to area with lower pressure in a specified amount of time.

The tested sample was placed on opened neck of a clean dry vessel (designed for this method) which was half filled will silica gel. Each sample was weighted with a vessel, and then located in a specifically designed six-star holder. Then place the vessels and the holder in air conditioned room, the vent was place over the holder, start holder with vessels and acclimatize for 24hours as time elapses dismount the vessels from the holder and then it was weigh. Water vapour permeability that permeat through 1 cm^3 of sample surface in 1 hour was calculated in milligram from a formula:-

□□− □−□2 [mg/24h] Equation -- (iii)

Where:

X = water V.P [$mg/1000mm^2/24h$]

g = increase of vessel mass with sample (mg)

t = total time of test procedure (h)

.r^2 = tested sample surface (cm^2)

3.6.1.5 Shrinkage Temperature up to 100^{o}C (IUP 16)

Shrinkage temperature of the crust leather sample were determined using test method according to IS0 (2015) with the use of shrinkage apparatus. The leather samples were heated in water to about 100^{o}C on a microscope slide with a concavity positioned on a micro-hot table, the temperature was increased by 20^{o}C/min, during heating the fibres started to shrink at a certain temperature which depend on the stability of the collagen. (Shrinkage occurs as a result of hydrothermal denaturation of collagen protein molecules which make up the fibre structure of the leather).

3.6.1.6Water Absorption (IUP 7)

Measurement of static water absorption was done according to 1S0 (2015) with the use of Kubelcal apparatus. The crust leather sample was immersed in distilled water for one hour inside the apparatus, after one hour the apparatus was turn so that the liquid drain in to the bulb, after one minute the sample was started to drain, than the volume of the liquid absorbed was measured. The water absorption by the sample was calculated using the following formula:-

Q = 100(v/m) Equation -- (iv)

P = 100(v/v) Equation -- (v)

Where :

m = mass of the sample

V = its volume

v = The volume of water absorbed in millitres.

3.6.2 Chemical test of leather

The following chemical test determination on leather sample was carried out. The determination of volatile matter, water soluble organic matter, water soluble inorganic matter, sulphated total ash and sulphated water insoluble ash , water soluble magnesium salt (Epson salt), nitrogen and hide substances and pH value of different figure.

3.6.2.1 Determination of volatile matter (IUC 5)

The volatile matter content of the leather sample was determined using the test method according to ISO (2005). Approximately 3g of the chopped leather sample was used, the sample was dried to a constant weight at 102 ± 2°C the drying period is normal oven 5hr's, then the sample was weight and allow to cool in a desiccator for half an hour and the weight was check withan analytical balance after further one-hour drying andhalf hour cooling, the samples was allowed to re-dry and weight reduction wasobserved forabout 0.1% of the original weight. Drying continued but not longer than 8 hours. The percentage volatile matter was calculated using the following equation.

- volatile matter in % $= \frac{G_1 - G_2 \times 100}{G_1}$ Equation ---------------------------- (vi)

Where:

G_1 = weight of sample before drying

G_2 = weight of sample after drying

3.6.2.2 Determination of water soluble organic andinorganic matter (IUC 6)

The determination of water soluble organic and inorganic matter tests was carried out inaccordance with ISO (2006), the grinded leather sample was mechanically shake at 50±10 revolution per minute for 2 hours, 10g of grinded anddichloromethane extracted leather with 500ml distilled water at 22.5 ± 2.5°C in a wide-necked flask then the content of the flask was filtered through a fluted filter until clear, 50ml of the first filtrate was discarded.The remaining 50ml of the subsequent filtrate was used to determine the soluble organic and inorganic substances.

Total water soluble substance evaporate on the water bath until dry exactly 50ml of the filtrate in a previously weighed dish heated at 800^0C dry at 102±2°C for approximately 2hrs; then cool in a desiccator ; weighed quickly, then the drying was repeated for several times until reduction in weight amount to less than 2gm but not for more than 8 hours.

$$\text{Total water soluble (\%)} = \frac{\text{(g dry residue)} \times 10 \times 100}{\text{g original weight of leather}} \qquad \text{Equation -------- (vii)}$$

- Water soluble organic substance (%) = difference between total water soluble and water insoluble. Equation --- (viii)
- $$\text{Water insoluble (\%)} = \frac{\text{g residue from ignition} \times 10 \times 100}{\text{g original weight of leather}} \qquad \text{Equation ----- (ix)}$$

3.6.2.3 <u>Determination of Nitrogen and Hide substances in leather (IUC 10)</u>

The determination of Nitrogen and Hide Substances in the Leather samples was carried out in accordance with ISO (1984). Accurately 3g of the ground leather sample of vegetable leather (with chrome leather 2g) in small weigh bottle and the sample wastransferred quantitatively into the kjeldahl flask by lightly tapping the bottom of the bottle then 30ml of concentrated or fuming sulphuric acid and approx. 5g catalyst mixture then the solution was heated to boiling , first with a low and later with a higher flame until one hour after all the carbon has been oxidized the digest was cooled with approximately 50ml distilled water, then transfer to the distilling flask, raise the kjeldahl flask twice with 20 ml of distilled water the solutions was further diluted with additional distilled water. Few drops of phenolphthalein was added and made alkaline with an excess 35% caustic soda solution (approx. 70ml) and stream distilled, then connect the flask with vertical condenser by means of tube bent twice preferably including a spray trap. The ammonia was distilled with water vapor into a receiver containing 100ml saturated boricacid and indicator solution. Thecooling tube was dipped into the boric acid. The distilled ammonia coloured the indicator green. The distillation continued until the value reached 150-200mls.Then the ammonia was titrated with 0.5 normal sulphuric to pH of 4.6.

3.6.2.4 <u>Determination of pH Value of Leather (IUC 11).</u>

pH value was determine using standard test method ISO (2008) Three (3g) of ground leather sample was dissolved in a conical flask with 100ml of distilled water and well shakenby hand for about 30 seconds, until the leather sample was uniformly wet. The wetted leather was then shaken mechanically in the shaker apparatus for 6 hrs. The extract was allowed to settle before decanting. After standardizing the pH meter with two buffer solutions: one below the expected value and other above the expected value, the pH value of the extract was determined within 30-60 seconds after rinsing the electrodes in the extract, and the reading was recorded.

3.6.2.5 Determination of Water Soluble Magnesium Salt (Epsom salt) (IUC 9)

Water soluble magnesium salt was determined in the leather sample according to ISO (1998). The residues in the crucible after the determination of water soluble ash was treated with a little 2 normal hydrochloric acid and dissolved by gentle warming then the solution was transferred into a 300ml Erlenmeyer flask. The crucible was rinsed for several times with a very little 2 normal hydrochloric acid and distilled water,the solution was neutralized against methyl orange with 2 normal sodium hydroxide solution and boiled up briefly. The solution was diluted in the Erlenmeyer flask with 150ml distilled water, 20mls buffer solution was added, then temperature was adjust to 50°C by cooling and the indicator was added until the solution becomes a clear red.

The solution was titrated with 0.01m DETA solution until the colour changes to pure blue with no red tint. Then the reading indicated was used to calculate the Epsom salt content of the sample by using the formula.

$$\frac{(\text{ml } 0.0\text{im DETA solution})\ 0.002465 \times 10 \times 100}{\text{g leather taken}} = \%\ \text{Epson salt in leather.Equation -------- (x)}$$

0.01m DETA solution corresponds to 0.002465g $MgS0_4 \times 7H_2O$ (Epson salt).

3.6.2.6 Determination of Sulphated total Ash and Sulphated Water Insoluble Ash (IUC 7)

The sulphated total ash and sulphated water insoluble ash contents of the leather were determined using test method as reported by ISO (1977). Leather samples were grounded and weighed 3gm using a weighing balance, after weighing, the samples were placed in crucible and carefully carbonized over a low flame and continue heating to about 800°C in furnace, cooled and weighed so that the leather burns with a small flame.

The leather samples were thoroughly moisten with 2 normal sulphuric acids and heated over a low flame until sulphuric acid fumes were no longer visible. The samples were heated vigorously until ignited and completely became ashes. The samples were cooled in the desiccator and weighed. The processescontinued until the weight of the residue is constant, then the volume is calculated using the following formula:

$$\text{Total ash content in \%} = \frac{\text{g total ash sulphated} \times 100}{\text{g original weight of leather}} \quad \text{Equation ----------------- (xi)}$$

Content of water insoluble ash as a percentage obtained by calculation = % total ash content (sulphated - percentage sulphated ash of water soluble).Equation --- (xii)

3.7 COSTS AND RETURNS OF PROCESSING LEATHER

Processing margin as described by Olukosi *et al.* (2005) was used to estimate the profitability of processing Sokoto red skins into crust leather. The model was specified as

$NR = TR - TC$ Equation --- (xiii)

Where:

NR= Net return in naira (₦) per square meter leather

TR = total revenue (value of sale in naira per square meter leather)

TC = Total cost (total processing cost in Naira per square meter skin)

Where, $TC = X_1 + X_2 + X_3 + X_4 + X_5 + X_6$

X_1 = cost of skin

X_2 = cost of salt

X_3 = Cost of labour

X_4= cost of loading and offloading

X_5 = cost of transport

X_6= cost of tanning

The financial success of the processing was determined by evaluating the rate of return ratio (RRR) of the business in accordance with Olukosi *et al*. (2005). The model was specified as:

RRR = NR/TC…………………………….. Equation (xiv)

Where:

RRR= rate of return ratio

NR = Net return in Naira (₦) per square meter leather

TC = total processing cost

3.8 DATA ANALYSIS

Data were subjected to analysis of variance using univariate procedure of General linear Model (GLM) to determine the effects of Tanning Agent, Age and Strain and their interaction for physical and chemical properties of leather. Means were separated using Turkey test. All analyses were carried out using Statistical Packages SPSS version 16.0 (2007), t-Test was also used. Processing margin was used to determine the costs and returns of processing leather.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 RESULTS

4.1.1 Effect of Tanning Agent on Physical Properties of Goat Leather

The effect of tanning agent on physical properties of goat leather is presented in table 4.2 The results revealed that there wasno significant difference (P>0.05) was recorded on leather thickness, where's significant (P<0.05) differences between the two tanning agent with respect of tensile strength, percentage elongation, grain test, water vapour permeability shrinkage temperature and water absorption.

Table: 4.2 Effect of Tanning Agent on Physical Properties of Goat leather

	Tanning Agent		
Physical properties	Chrome	Acacia	t value
Leather Thickness(mm)	0.82	1.25	0.827
Tensile Strength(N/mm^2)	14.43^b	16.36^a	2.098
Percentage Elongation (%)	51.39^a	45.03^b	2.809
Grain Test (Ball-burst) (mm)	38.49^b	53.92^a	5.330
Water V Permeability(g/cm^3)	0.09^b	0.29^a	6.061
Shrinkage Temperature (^oC)	80.5^a	70.56^b	31.356
Water Absorption (%)	245.3^a	161.00^b	7.492

ab means along the same row with different superscripts differed (P< 0.05) significantly

The result showed that leather tanned with *acacia* recorded higher value of 16.36n/mm^2 while chrome tanned leather recorded 14.43N/mm^2 on tensile strength. With percentage elongation, leather tanned with chrome recorded higher value of 51.39% while that of *acacianilotica*recorded 45.03%.The higher value of 53.92mm for Grain test by ball-burst was obtained on leather tanned with acacia while 38.49% was recorded for chrome tanned leather. Water vapour permeability value of0.29% was recorded for*acacia nilotica* tanned leather while chrome tanned leather recorded 0.09%.

Leather tanned with *acacia Nilotica* were significantly ($P<0.05$) in similar way where both shrinkage temperature and water absorption of chrome tanned leather recording significantly ($P<0.05$) higher values compared to the vegetable tanned leather.

Table: 4.3 Effects of Age on physical properties of goat Leather

Physical properties	Age		t value
	1-1½ year	2-3 years	
Leather thickness (mm)	0.87	1.2	0.625
Tensile strength (N/mm^2)	16.34^a	14.44^b	2.065
Percentage elongation (%)	49.17	47.25	0.848
Grain test (Ball-bust) (mm)	41.77^b	50.64^a	3.064
Water Vapour Permeability (g/cm^3)	0.15^b	0.22^a	1.939
Shrinkage temperature (^OC)	75.72	75.33	1.230
Water absorption (%)	160.6^b	245.7^a	7.564

ab means along the same row with different superscripts differed ($P< 0.05$) significantly

4.1.2 Effects of Age on Physical Properties of Goat Leather

The results indicated thatage significantly difference (P>0.05) affected ontensile strength, grain test and water absorption. However, no significant differences (P>0.05) were recorded on leather thickness, percentage elongation, water vapour permeability and shrinkage temperature.The results revealed that the higher value of 16.34Nmm^2 was recorded on tensile strength, 50.64mm on Grain test by ball-burst and 245.7% recorded on Water absorption were significantly higher in matured goat leather.

Table: 4.4 Effect of Strain on Physical Properties of Goat Leather

	Goat strain			
Physical properties	KNB	RS	BW	S.E
Leather thickness (mm)	1.07	1.10	0.93	0.063
Tensile strength (N/mm^2)	17.29	14.36	14.54	1.126
Percentage elongation (%)	52.25	47.96	45.42	2.773
Grain test (Ball-bust) (mm)	48.64	50.27	39.71	3.545
Water Vapour Permeability (g/cm^3)	0.33^a	0.15^b	0.09^c	0.04
Shrinkage temperature (^oC)	75.33	75.67	75.58	0.388
Water absorption (%)	188.00^c	202.63^b	218.86^a	13.78

abc means in the same row with different superscripts differ significantly ($P<0.05$),KNB = Kano Brown, RS = Red Sokoto, BW= Borno White, S.E = Standard Error,.

4.1.3 Effect of Strain on Physical Properties of Goat Leather

From theresults (table4), on the effect of strain on physical properties of goat leather, leather thickness,tensile strength, percentage elongation,grain test(ball burst) and shrinkage temperature were not affected by the strain of goats. That is all the three strains; Kano brown Red sokoto and Borno white had similar ($P>0.05$) physical properties mentioned above. However water vapour permeability of Kano brown was observed to significantly ($P<0.05$) higher compared with the red sokoto and Borno white. Similarly red sokoto had higher ($P<0.05$) water vapour permeability when compared with Borno white.

Table: 4.5 Effects of Tanning Agent and Age Interaction on Physical Properties of Goat Leather

	Tanning agent				
	Chrome		Acacia		
Physical Properties	Young	Mature	Young	Mature	S.E
Leather Thickness (mm)	0.63[d]	1.01[c]	1.11[b]	1.39[a]	0.073
Tensile Strength (N/mm^2)	14.89	13.96	17.80	14.93	1.3
Percentage Elongation (%)	55.83[a]	46.94[a]	42.50[b]	47.56[a]	3.202
Grain T. (Ball-burst) (mm)	37.72[d]	39.27[c]	45.83[b]	62.01[a]	4.093
Water Vapour Permeability (g/cm^3)	0.06[d]	0.13[c]	0.26[b]	0.31[a]	0.046
Shrinkage Temperature (^oC)	80.44[a]	80.56[a]	71.00[b]	70.11[c]	0.448
Water Absorption (%)	195.2[c]	295.49[a]	126.08[d]	195.94[b]	15.91

abcd means in the same row with different superscript differ significantly ($P<0.05$),M=Month,S.E = Standard error, 4.1.4 Effect of Tanning Agent and Age Interaction on Physical Properties of Goat Leather

The results showed that there weresignificant difference ($P<0.05$) on Tanning agent and Age on leather thickness, percentage elongation, Grain test, Water vapour permeability, shrinkage temperature and water absorptionNo significant difference ($P>0.05$) was recorded on Tensile strength.

The finding showed that matured goat Leather tanned with acacia recorded highest value of 1.39mm on leather thickness followed by young Goat leather 1.11mm of the same tanning agent while the least value of 0.63mm was obtained on young chrome tanned leather. The highest percentage elongation value of 55.83% obtained on young goat chrome tanned leather was similar ($P>0.05$) to the value of 46.94% recorded young goat of the same tanning agent and 27.56% obtained on Matured Goatleather tanned with *acacia nilotica*.

With Grain test by ball-burst the highest value of 62.01mm was recorded on matured Goat leather tanned with acacia followed by 45.83mm value obtained from young goat leather tanned with the same tanning agent while the least value of 37.72mm obtained on young Goat leather chrome tanned. The result also revealed that matured Goatleather tanned with *acacia nilotica* recorded highest water vapour permeability with the value of 0.31% followed by young Goat leather 0.26% tanned with the same tanning agent, the lowest value of 0.06% was obtained on young Goatchrome tanned leather.

With respect of shrinkage temperature, the highest temperature value of 80.56^{o}C was recorded on matured Goat chrome tanned leather followed by temperature value of 80.44^{o}C recorded on young Goat leather tanned with the same tanning agent (chrome) while the lower temperature of 70.11^{o}C was obtained on maturedGoat leather tanned with *acacia nilotica*, the highest water absorption value of 205.49% was obtained on matured Goat leather tanned with chrome followed by matured Goat leather 195.94% tanned with *acacia nilotica* while the lowest water absorption value of 126.08% was recorded with young Goat leather tanned with *acacia nilotica*.

Table:4.6 Effects of Tanning Agents and Strains Interaction on physical Properties of Goat Leather

	Tanning Agent						
	Chrome			Acacia			
Chemical properties	KNB	RS	BW	KNB	RS	BW	S.E
Leather thickness(mm)	0.79[c]	0.82[d]	0.85[c]	1.35[a]	1.39[a]	1.02[b]	0.09
Tensile strength(N/mm)	19.28[a]	10.54c	13.45[b]	15.29[a]	18.18[a]	15.62[a]	1.593
Percentage elongation (%)	59.58[a]	56.25a	48.88[a]	42.92[b]	39.37[c]	52.50[a]	3.922
Grain test (Ball-burst) (mm)	41.02[c]	37.46[d]	37.01[e]	56.27[a]	63.09[a]	42.41[b]	5.013
Water vapour perm.(g/cm^3)	0.10[b]	0.08[d]	0.10[b]	0.55[a]	0.21[a]	0.09[c]	0.057
Shrinkage temperature (%)	80.50[a]	80.17[a]	80.83[a]	70.17[b]	71.17[b]	70.33[c]	0.549
Water absorption (%)	215.17[a]	247.33[a]	273.48[a]	160.87[c]	157.93[d]	164.23[b]	19.488

abc-e means in the same row with different superscripts differ significantly, (P<0.05), KNB= Kano Brown Goat , RS= Red Sokoto Goat, BW= Borno White Goat, S.E = Standard error, 4.1.5 Effects of Tanning Agents and Strain Interaction on Physical Properties of Goat Leather.

From the results (table6), significant difference ($P>0.05$) for all the physical properties of Goat leather on tanning agents and strains interaction were observed. The results showed that Red Sokoto Goat leather tanned with *acacia nilotica* recorded highest leather thickness of 1.39mm which was similar ($P>0.05$) to the value of 1.35mm obtained from Kano brown Goat. Leather tanned with the same tanning agent, while the least leather thickness of 0.79mm was recorded on Kano brown chrome tanned, the highest values 19.28N/mm of tensile strength obtained on Kano brown goat chrome tanned leather was statistically similar ($P>0.05$) to the value of 18.18N/mm^2, 15.62N/mm^{2}and 15.29Nmm^2 obtained for Borno white, Red Sokoto Goat and Kano brown Goat leather tanned with *acacia*, while the lowest value of 10.54N/mm^2 was recorded on Red Sokoto Goat leather tanned with chrome.

With regard to percentage elongation, highest value of 59.58% was obtained on Kano brown Goat leather chrome tanned which was similar($P>0.05$) to the values of 56.25%, 52.50% and 48.88% recorded for Kano brown, Born white Goat leather tanned with chrome and Borno white Goat leather tanned with *acacia nilotica*, the results also showed that highest Grain test value of 63.09mm recorded for Red Sokoto Goat leather tanned with *acacia nilotica* wascomparable ($P>0.05$) to the value of 56.27mm obtained with Kano brown Goat leather tanned with *acacia nilotica* and was significantly ($P<0.05$) higher than other parameters for all strains and tanning agents.

For water vapour permeability, Kano brown Goat leather recorded highest value of 0.55% which was similar to 0.021% obtained for Red Sokoto goat leather tanned with *acacia*. The highest shrinkage temperature value of 80.83^oC was obtained from Borno white Goat leather tanned with chrome was statistically similarto 80.50^oC recorded for Kano brown leather tanned with same tanning agent and was significantly($P<0.05$) higher than rest of Goat leather tanned with both tanning agents. With water absorption, highest value of 273.48% was obtained on Borno white Goat leather tanned with chrome which was statistically similar (P>0.05) to Red Sokoto and Kano brown Goat leather chrome tanned while the least water absorption value of 157.93% was obtained on Red Sokoto Goat leather tanned with acacia

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Table: 7Effects of Age and Strain Interaction on Physical Properties of Goat Leather

	Age						
	Young			Mature			
Physical Properties	KNB	RS	BW	KNB	RS	BW	S.E
Leather thickness(mm)	0.89	0.98	0.75	1.25	1.23	1.12	0.9
Tensile strength(N/mm)	18.57[a]	14.27[a]	16.19[a]	16.01[a]	14.44[a]	12.88[b]	1.593
Percentage elongation (%)	51.25[a]	52.50[a]	43.75[b]	51.25[a]	43.42[c]	57.08[a]	3.922
Grain test (Ball-burst) (mm)	48.93	43.30	33.09	48.35	57.24	46.33	5.013
Water vapour permea. (g/cm^3)	0.33[b]	0.70[a]	0.70[a]	0.33[b]	0.22[c]	0.12[b]	0.057
Shrinkage temperature (%)	75.33	76.33	75.50	75.33	75.00	75.67	0.549
Water absorption (%)	142.23[d]	157.28[c]	182.35[b]	233.80[a]	247.98[a]	255.37[a]	19.488

abc means in the same row with different superscripts differed significantly (P<0.05), KNB= Kano Brown goat, R S = Red Sokoto Goat, BW = Borno White Goat,S.E = Standard error, 4.1.6 Effects of Age and Strain Interaction on Physical Properties of Goat leather

The results revealed that there weresignificant difference ($P<0.05$) on tensile strength, percentage elongation and water absorption.Howeverno significant ($P>0.05$)differences recorded on leather thickness, Grain test and shrinkage temperature.Theresults indicated that the highest Tensile strength value of 18.57Nmm^2, 14.27mm^2 obtained on Young Borno white and Red Sokoto Goat leather and the value of 16.01Nmm^2, 14.44N/mm^2 recorded with maturedKano brown and Red Sokoto Goat leather tanned with *acacia*, while maturedGoat Borno white leather recorded the least value of 12.88Nmm^2.

The highest percentage elongation value of 57.08% was obtained with matured Borno white goat leather which was statistically similar ($P>0.05$) to value of 52.5% and 51.25% recorded on youngKano brown and Red Sokoto goat leather which was significantly higher than remaining goat leather obtained from the same strain of matured goats.

With water vapour permeability, the values of 0.70% obtained on young Red Sokoto and Borno White Goat leather were significantly higher ($P>0.05$) when compared with the rest of the strains. Water absorption recorded highest value of 255.37% on matured Borno white goat leather which was comparable to the values of 247.98% and 233.8% obtained on matured Red Sokoto and Kano Brown goat leather respectively and significantly ($P>0.05$) higher than the strain of matured goat leather. Leather thickness, Grains test and shrinkage temperature showed no significant differences ($P>0.05$).

Table 4.8: Effects of Tanning Agents, Age and Strain Interaction on physical Properties of Goat Leather

Factors			Leather Thickness (mm)	Tensile strength (N/mm^2)	Percentage elongation (%)	Grain test (mm)	Water vapour perm. (g/cm^3)	Shrinkage temperature (%)	Water absorption (%)
Tanning agent	Age	Strain							
Chrome									
	Young								
		KNB	0.64^{i}	18.29^{a}	62.50^{a}	46.42^{b}	0.06^{h}	80.67^{a}	197.77^{e}
		RS	0.65^{h}	9.56^{e}	65.00^{a}	30.71^{g}	0.06^{h}	79.67^{a}	183.57^{h}
		BW	0.59^{j}	16.83^{a}	40.00^{f}	36.03^{g}	0.05^{i}	81.00^{a}	204.17^{d}
	Matured								
		KNB	0.93^{f}	20.28^{a}	56.67^{a}	35.61^{f}	0.15^{c}	80.33^{a}	232.57^{c}
		RS	0.99^{e}	11.52^{c}	47.50^{b}	44.20^{c}	0.10^{e}	80.67^{a}	211.10^{a}
		BW	1.10^{d}	10.07^{d}	46.67^{c}	37.99^{d}	0.14_{d}	80.67^{a}	242.80^{a}
Acacia									
	Young								
		KNB	1.13^{c}	18.85^{a}	46.00^{d}	57.44^{a}	0.60^{a}	70.00^{e}	186.70^{f}
		RS	1.30^{ab}	18.99^{a}	46.00^{d}	55.90^{a}	0.08^{g}	73.00^{b}	134.00^{k}
		BW	0.90^{g}	15.55^{a}	47.50^{b}	30.15^{c}	0.09^{f}	70.00^{e}	160.53^{j}
	Matured								
		KNB	1.57^{a}	11.74^{b}	45.83^{e}	61.09^{a}	0.15^{c}	7033^{d}	235.03^{b}
		RS	1.47^{a}	17.36^{a}	49.33^{a}	70.27^{a}	0.34^{b}	69.33^{f}	184.87^{g}
		BW	1.14^{b}	15.68^{a}	57.50^{a}	54.67^{a}	0.09^{f}	70.67^{c}	167.93^{i}
S.E			0.127	2.252	5.547	7.09	0.08	0.776	27.56

abc-k means in the same column with different superscripts differed significantly ($P<0.05$) KNB= Kano Brown goat, R S = Red Sokoto Goat, BW = Borno White Goat, S.E = Standard error, 4.1.7 Effects of Tanning Agents, Age and Strain Interaction on Physical Properties of Goat leather

The result showed significant (P>0.05) difference in all the physical properties of goat leather. The result revealed that matured Kano brown goat leather tanned with *acacia* recorded highest leather thickness valued 1.57mm which was statistically similar to maturedRed Sokoto goat leather 1.47mm and youngRed Sokoto goat leather 1.30mm and was significantly(P<0.05) higher than the others leather tanned with chrome at varying age. The least leather thickness of 0.59mm was obtained with young Borno white chrome tanned. Similarly, higher tensile strength of 20.28N/mm^2 observed with Kano Brown goat leather Chrome tanned was significantly higher (P<0.05) and similar to the rest of goat strains leather of varying aged tanned with two different agents.

The 65.00% value of percentage elongation was obtained on youngRed Sokoto goat leather tanned with chrome which is statistically similar to values of 62.50% obtained on young Kano Brown goat leather tanned with the same tanning agent while 49.33% and 57.50% values recorded on matured Red Sokoto and Borno white goat leather tanned with acacia while the lowest value of 20.00% was obtained on youngBorno white goat leather chrome tanned. The highest value of 70.27mm of Grain test was recorded on maturedRed Sokoto goat leather tanned with acacia which is statistically similar to values of 61.09mmand 54.57mm recorded on maturedKano Brown and Borno white goat leather tanned with *acacia,* the value of 57.44mm and 55.9mm obtained on youngKano Brown and Red Sokoto goat leather tanned *acacia* while the least value of 30.71mm was obtained on youngRed Sokoto goat leather chrome tanned.

The highest water vapour permeability value of 0.34% was recorded on matured Red sokoto goat leather tanned with acacia while the lowest value of 0.05% was obtained from youngBorno white goat leather chrome tanned. The shrinkage temperature value of 81.00^{o}C was obtained on youngBorno white goat leather chrome tanned which is statistically similar to the values of 80.67^{o}C, 79.67^{o}C obtained on youngKano brown and Red Sokoto goat leather chrome tanned and the value of 80.33^{o}C, 80.67^{o}Cand 80.67^{o}C obtained on maturedKano Brown, Red Sokoto and Borno white goat leather chrome tanned. While the lowest value of 69.33^{0}C was recorded on matureRed Sokoto goat leather tanned with acacia. With water absorption, the highest value of 342.8% was obtained on youngBorno white goat leather tanned with acacia which is statistically similar to the value of 211.1% obtained on matureRed Sokoto goat leather chrome tanned while the least value of 134% was recorded on youngRed Sokoto goat leather tanned with *acacia.*

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Table: 4.9 Effects of Tanning Agents on Chemical Properties of Goat Leather

Chemical Properties	Tanning Agent		t value
	Chrome	Acacia	
Volatile Matter (%)	11.92[b]	12.31[a]	1.450
Water Soluble Organic (%)	19.28[b]	26.17[a]	3.162
Water Soluble In Organic (%)	11.17[a]	6.89[b]	2.611
Hide Substances (%)	6.71	8.85	1.776
pH Value	5.36	3.65	24.783
Water Soluble Magnesium (%)	29.23	25.65	2.739
Sulphated Total Ash (%)	1.80	1.47	3.201
Water Insoluble Ash (%)	1.74	1.45	3.078

ab means along the same row with different superscripts are significantly ($P<0.05$) different.

4.1.8 Effects of Tanning Agents on Chemical properties of Goat Leather

From the results of the study (table 9), it could be observed that, the chemical properties affected by the tanning agents were the volatile matter,water soluble organic matter and water soluble in organic. The volatile matter of the leather tanned with chrome was significantly ($P>0.05$) lower compared with the vegetable tanned leather. The water soluble organic matter wax also affected ($P<0.05$) in the same way with the volatile matter.However, the results of water soluble inorganic matter of the leather tanned with chrome had significantly ($P<0.05$) higher values compared with the leather tanned with vegetable (*acacia nilotica*).all other chemical properties such as hide substances, pH value, Water soluble Magnesium, Sulphated total ash and Water insoluble ash were not affected($P>0.05$) by the tanning agents.

Table:4.10 Effects of Age on Chemical Properties of Goat Leather

Chemical Properties	Age		t value
	Young	Mature	
Volatile Matter (%)	11.75[b]	12.48[a]	2.714
Water Soluble Organic (%)	25.28[a]	20.17[b]	2.345
Water Soluble in Organic (%)	6.17[b]	11.89[a]	3.490
Hide Substances (%)	7.38	8.18	0.664
pH Value	4.39	4.61	0.319
Water Soluble Magnesium (%)	26.2	28.69	1.905
Sulphated Total Ash (%)	1.60	1.67	0.775
Water Insoluble Ash (%)	1.56	1.63	0.693

ab means along the same row with different superscripts are significantly ($P<0.05$) different.

4.1.9 Effects of Age on Chemical Properties of Leather

From the result of the study (table 10), it revealed that there were significant difference ($P<0.05$) on water soluble organic matter, volatile matter and water soluble in organic matterhowever no significant differences ($P>0.05$) were recorded on pH value, sulphated total ash, water soluble magnesium salt, water insoluble Ash and hide substance. The findings indicated that matured goatleather recorded higher volatile matter and water insoluble organic matter value of 12.48% and 11.89% than the young goatleather while young goat leather showed significantly($P<0.05$) higher water soluble organic matter. However, pH value, water soluble magnesium salt, sulphated total ash and water insoluble ash were not affected by age.

Table: 4.11Effects of Strains on Chemical Properties on Goat Leather

	Goat Strains			
Chemical properties	KNB	RS	BW	S.E
Volatile Matter (%)	11.97	12.67	11.71	0.33
Water Soluble Organic (%)	20.83	24.25	23.08	2.668
Water Soluble In Organic (%)	10.67	6.75	9.67	2.007
Hide Substances (%)	9.1	8.94	5.31	1.475
pH Value	4.62	4.42	4.47	0.084
Water Soluble Magnesium (%)	27.49	27.54	27.3	1.601
Sulphated Total Ash (%)	1.58	1.71	16.17	1.232
Water Insoluble Ash (%)	1.54	1.67	15.76	1.201

No significant difference (P>0.05), KNB= Kano Brown Goat, RS= Red Sokoto Goat, BW= Borno White Goat, S.E = Standard error, 4.1.10 Effects of Strains on Chemical Properties of goat leather

From the results on (table 11) it could be seen that the strain of goats used had no any significant ($P>0.05$) influence on all the chemical properties of the leather.

Table:4.12Effects of Tanning Agents and Age interaction on Chemical Properties on Goat Leather

	Tanning agent				
	Chrome		Acacia		
Chemical properties	Young	Mature	Young	Mature	S.E
Volatile Matter (%)	11.49	12.35	12.01	12.61	0.381
Water Soluble Organic (%)	22.22[a]	16.33[b]	28.33[a]	24.00[a]	3.81
Water Soluble In Organic (%)	5.78	6.56	8.00	5.78	2.317
Hide Substances (%)	7.28	6.15	7.49	10.22	1.703
pH Value	3.53[c]	3.76[b]	5.26[a]	5.46[a]	0.097
Water Soluble Magnesium (%)	27.78[a]	30.68[a]	24.61[b]	26.7[a]	1.848
Sulphated Total Ash (%)	1.82[a]	1.78[a]	1.37[b]	1.57[a]	1.423
Water Insoluble Ash (%)	1.76	1.72	1.35	1.53	1.387

abc-e means in the same row with different superscripts differed significantly ($P<0.05$), S.E = Standard error, 4.1.11 Effects of Tanning agents and Age interaction on Chemical Properties of Goat leather

The results(table 12), indicated that significant difference (P<0.05) were observed on water soluble organic matter, pH, Water soluble magnesium salt and Sulphated total ash.No significant difference (P>0.05) recorded on volatile matter, water soluble inorganic, hide substances and water insoluble ash. The results showed that young goat leather tanned with *acacia* recorded highest valued of 28.33% of water soluble organic matter which was similar (P>0.05) to value of 24.00% and 22.22% obtained with matureand young goatleather tanned with *acacia* and chrome, while least value of 16.33% was obtained on mature goatleather tanned with chrome. The highest pH value of 5.46 was obtained with matured goatleather tanned with *acacia* which was comparable to young goatleather tanned with the same tanning agent, while the least value of 3.53 was obtained with young goatleather chrome tanned. With respect to sulphated total Ash, both young and matured strain chrome tanned observed significantly (P<0.05) higher values which was similar to the values obtained with young goat leather tanned with *acacia*.

Table: 4.13 Effects of Tanning Agents and Strain Interaction on Chemical Properties of Goat Leather

	Tanning agent						
	Chrome			Acacia			
Chemical properties	KNB	RS	BW	KNB	RS	BW	S.E
Volatile matter (%)	11.71^{b}	12.05^{a}	12.01^{a}	12.24^{a}	13.29^{a}	11.42^{c}	0.466
Water soluble organic (%)	25.00^{a}	14.83^{d}	18.00^{b}	16.67^{c}	33.67^{a}	28.17^{a}	3.774
Water soluble inorganic (%)	8.00	6.17	9.33	8.33	7.33	10.00	2.838
Hide substances (%)	7.53	8.96	5.66	10.68	8.92	6.96	2.086
pH value	3.64^{d}	3.62^{e}	3.68^{c}	5.60^{a}	5.21^{bc}	5.26^{a}	0.119
Water soluble magnesium (%)	31.14^{a}	26.56^{a}	30.00^{a}	23.83^{b}	28.52^{b}	24.61^{a}	2.264
Sulphated total ash (%)	1.83	1.73	1.83	1.33	1.70	1.40	1.743
Water Insoluble ash (%)	1.77	1.68	1.78	1.32	1.65	1.37	1.699

abc-d means in the same row with different superscripts differ significantly ($P<0.05$), KNB= Kano Brown goat, RS = Red Sokoto Goat, BW = Borno White Goat, S.E = Standard error, 4.1.12 Effects of Tanning Agents and Strain Interaction on Chemical Properties of Goat Leather

From the results (table 13), it revealed that there were significant difference (P<0.05) in volatile matter, water soluble organic matter, pH and Water soluble magnesium salt. No significant difference (P>0.05) were observed in water soluble inorganic matter, hide substances, sulphated total ash and water insoluble ash,.Higher water soluble organic matter was observed with Red sokoto goat leather tanned with *acacia*,the value was similar (P<0.05) to the results obtained with Borno white and Kano brown goats leather tanned with *acacia* and chrome respectively.

With regard to pH, all the strains tanned with *acacia* showed the same pH values and were significantly (P<0.05) higher while the least pH value was observed with Red sokoto goat leather chrome tanned. Similarly, water soluble magnesium salt of all the strain (Kano brown,Red sokoto, and Borno white) chrome tanned and Borno white tanned *acacia* showed similar values while the least value was recorded in Kano brown and Red sokoto goat leather tanned with *acacia.*

Table: 4.14Effects of Age and Strain Interaction on Chemical Properties of Goat Leather

	Age						
	Young			Mature			
Chemical Properties	KNB	RS	BW	KNB	RS	BW	S.E
Volatile Matter (%)	11.79[b]	12.06[a]	11.41[c]	12.15[a]	13.28[a]	12.02[a]	0.466
Water soluble organic (%)	22.83	26.33	27.67	19.83	22.17	18.5	3.774
Water Soluble inorganic (%)	11.33	9.00	15.33	10.00	14.5	14.00	2.838
Hide Substances (%)	8.88	8.99	4.29	9.33	8.9	6.33	2.086
pH Value	4.68[a]	4.16[b]	4.35[a]	4.56[a]	4.68[a]	4.6[a]	0.119
Water soluble magnesium (%)	28. 59	25.56	24.42	26.38	29.5	30.19	2.264
Sulphated total ash (%)	1.50[a]	1.43[b]	1.86[a]	1.67[a]	2.00[a]	1.37[c]	1.743
Water insoluble ash (%)	1.47[a]	1.40[b]	1.81[a]	1.68[a]	1.98[a]	1.35[c]	1.699

abc means in the same row with different superscripts differ significantly (P<0.05) KNB= Kano Brown goat, R S = Red Sokoto Goat, BW = Borno White Goat, S.E = Standard error, 4.1.13 Effects of Age and Strain Interaction on Chemical Properties of Goat Leather

The results indicated on (table 14),there wassignificant difference ($P<0.05$) on volatile matter, pH, Sulphated total ash and water insoluble ash. However, no significant difference ($P>0.05$) were recorded on water soluble organic matter, water soluble in-organic matter, hide substance and water soluble magnesium salt. The results indicated that maturedRed Sokoto Goat leather recorded highest volatile matter content of 13.28% which was similar to the value of 12.02% and 12.06% obtained for Borno white and youngRed Sokoto goat leather respectively, the lowest value of 11.41% was obtained with youngKano brown leather.

The highest pH value of 4.68 was obtained with young and maturedKano brown and Red Sokoto leather which was comparable ($P>0.05$) to the values of 4.35 and 4.60 recorded for youngand maturedBorno white goat leather while the least value of 4.16 was obtained on youngRed Sokoto goat leather. With sulphated total Ash highest value of 20.00% was obtained with maturedRed Sokoto leather and is statistically similar to the value of 15.00% recorded on youngKano brown, 18.67% youngBorno white and 16.67% maturedKano brown goat leather respectively, with least value of 14.33% obtained from red Sokoto goat leather. The highest value of 19.38% water insoluble Ash was obtained with maturedred Sokoto goat leather which is significantly higher than the rest, lower value content of 13.35% of obtained from matured Borno white goat leather.

Table 15: Effects of Tanning Agents, Age and Strain Interaction on Chemical Properties of Goat Leather

Factors			Chemical properties							
			Volatile matter (%)	Water soluble matter (%)	Water soluble inorganic matter (%)	Hide substances (%)	pH value (%)	Water soluble magnesium (%)	Sulphated total ash (%)	Water insoluble ash (%)
Tanning agents	Age	Strain								
Chrome										
	Young									
		KNB	11.34^{f}	26.67	10.00	9.49	5.54^{a}	33.37^{a}	1.80^{a}	1.75^{a}
		RS	11.72^{c}	26.33	10.67	8.78	4.99^{bc}	27.13^{b}	1.53^{a}	1.49^{a}
		BW	11.41^{e}	23.67	16.67	5.56	5.25^{a}	22.85^{i}	2.13^{a}	1.25^{b}
	Matured									
		KNB	12.07^{b}	23.33	16.00	5.57	5.66^{a}	28.91^{a}	1.86^{a}	1.79^{a}
		RS	12.38^{a}	23.33	11.67	9.13	5.44^{a}	25.99^{d}	1.93^{a}	1.87^{a}
		BW	12.61^{a}	22.30	12.00	5.75	5.27^{a}	27.20^{a}	1.53^{a}	1.51^{a}
Acacia										
	Young									
		KNB	12.25^{a}	27.00	12.67	8.27	3.81^{e}	23.81^{g}	1.20^{c}	1.18^{c}
		RS	12.39^{a}	36.33	17.33	9.18	3.33^{h}	24.02^{e}	1.33^{b}	1.30^{a}
		BW	11.41^{e}	31.67	14.00	5.01	3.44^{g}	26.00^{c}	1.60^{a}	1.57^{a}
	Matured									
		KNB	12.23^{a}	26.33	14.68	13.09	3.46^{f}	23.85^{f}	1.46^{a}	1.44^{a}
		RS	14.18^{a}	31.00	17.33	8.65	3.91^{d}	33.01^{a}	2.06^{a}	2.03^{a}
		BW	11.42^{d}	24.67	16.00	9.91	3.92^{c}	23.22^{h}	1.20^{c}	1.16^{d}
S.E			0.667	5.337	4.014	2.95	0.169	3.201	2.465	2.402

abc-h means in the same column with different superscripts differ significantly ($p<0.05$), KNB = Kano brown goat, RS = Red Sokoto goat, BW = Borno white goat, S.E= Standard Error.

4.1.14 Effects of Tanning Agents, age and Strain Interaction on Chemical Properties of Goat leather

From the (table15), the results indicated thesignificant difference (P<0.05) on volatile matter, pH, water soluble magnesium salt, water insoluble organic matter, sulphated total ash. However,no significant difference (P>0.05) was observed on water soluble inorganic matter, water soluble organic matter and Hide substance. The result showed that, maturedRed Sokoto goat leather tanned with acacia had highest volatile matter of 14.18% and is significantly higher than the rest, while the lowest value of 11.34% was recorded on YoungKano brown leather tanned with chrome. The highest pH value of 5.66% was obtained with matureKano brown goat leather tanned with chrome and is significantly higher than the rest while lowest pH value of 3.33% was obtained from youngRed Sokoto goat leather tanned with *Acacia*. For water soluble magnesium salt, highest value of 37.20% was obtained with maturedBorno white goat leather tanned with chrome which is statistically similar to the value of 33.37% recorded on youngKano brown goat leather tanned with chrome, 28.91% obtained with maturedKano Brown and 33.01% matureRed Sokoto goat leather tanned with *acacia*, while the lowest value of 22.85% was obtained on youngBorno white goat leather tanned with chrome. The highest sulphated total Ash value content of 2.13% was recorded on youngBorno white leather tanned with chrome which is statistically similar to the rest of youngand maturegoat strain leather tanned with same tanning agent and youngBorno white and maturedKano brown and Red Sokoto goat leather tanned with *acacia,* while the lowest value (1.20%) was recorded on maturedBorno white and youngKano brown goat leather tanned with *acacia* and chrome respectively. Water insoluble ash recorded highest of 2.03% from mature Red Sokoto goat leather tanned with *acacia* which significantly higher than the rest while the lowest value of 1.25% was obtained on youngBorno white goat leather tanned with chrome. No significant difference ($P>0.05$) was recorded on hide substance, water soluble organic and inorganic matter, there are statistically similar.

Table 16 Costs and Returns of Crust Leather from Red Sokoto Goat Skin

Variable	Unit price (N/m^2)	% Total processing Cost (₦)
Selling price/total revenue (TR)	2230	-
Purchasing price (Fresh skin)	450	35.86
Salt	50	3.98
Labour (salting)	35	2.79
Loading and offloading	40	3.18
Transportation	100	7.97
Tanning	580	46.22
Total cost (TC)	1255	100.00
Net return (NR)	975	-
Rate of return ratio (RRR)	0.78	-

4.1.15 Costs and Returns of Processing Goat Skin into Crust Leather

The costs and returns of processing red Sokoto to Goat skin into crust leather is presented in table 16. The results revealed that fresh skin of Red Sokoto Goat was purchased at ₦450 per square meter constituting (35.85%) of the total processing cost, tanning cost at ₦580 per square meter (46.22% of TC),Transport fee at (₦100) per square meter (7.97% of TC), cost of salt at ₦50 per square meter (3.98% of TC), cost of loading and offloading at ₦40 per square meter (3.18% of TC) and labour (salting) cost at ₦35 (2.79% of TC) Total processing cost was estimated at ₦1,255 per square meter (100% TC) The selling price of leather per square meter was indicated at ₦2,230, net return at ₦975.00 and red return ration at ₦0.78 per square meter.

4.2 DISCUSSION

The average leather thickness recorded in the present study ranged between 1.57mm to 0.64mm with higher value of 1.57mm recorded on matured Kano Brown Goat leather tanned with *Acacia nilotica*, the finding was almost in agreement with the value of 1.34mm reported by Hylli *et al.*(2012) and higher than the values of 0.97±0.01m, 0.98±0.04 and 0.83mm reported by Salehi *et al.,* (2014); Yusuf *et al.* (2013) and Oliveira *et al.* (2007). Muhammad*et al.* (2015) on leather quality of Sudan Nubian and Desert goat to be 1.57±0.1mm and 1.34±0.1 for young and matured goat leather tanned with Chrome. These values fall within the range obtained in the current finding.

The average tensile strength range recorded was between 19 – 19.56 N/mm^2 for all goat with higher value of 19.28N/mm^2 obtained for Kano brown goat leather tanned with Chrome. This was in agreement with minimum of 19.6N/mm^2 recommended by BASF,1984. Oliveira *et al.* (2007) reported numerically higher value of tensile strength of 29.42N/mm^2 for native sheep which is higher than the value reported in the current study. The tensile strength values of 24.39N/mm^2, 22.3N/mm^2 reported by Jibir *et al.* (2013) and Hylli *et al.*(2012) werealso higher when compared with the value obtained in the present study. Goat's leather requires higher tensile strength (15.0N/mm^2) than sheep (12.0N/mm^2) before they conform to Nigeria industrial Standard (SON, 2012). The higher tensile strength value obtained in the present study could be attributed to the nature of raw materials and degree of tannage.

The higher grain test (ball-burst) value of 53.92mm was obtained on leather tanned with *Acacia nilotica*, was slightly higher than the minimum reference value of 49.10mm set for good quality leather and confirmed with finding of Seid *et al,* (2012) who reported 53.40mm Grain test value of Bati and HH goats but lower than 72.30mm for Brazilian goat reported by Oliveira *et al.*(2007).The variation in grain test value could be due to breed difference and degree of tannage. Grain test (Ball burst) is the measure of the resistant of the upper leather due to tear or puncture. All goat strain used in the current study produced leather with higher grain strength above the minimum standard value of 7mm set for quality leather (BASF, 1984).

The higher shrinkage temperature value of 80.50 ^{0}C obtained on goat leather tanned with chrome contrasts the finding of Jibir *et al.* (2013), who reported higher shrinkage temperature value of 99.33^{0}C.

Mohammed *et al.* (2015) reported percentage elongation value of 58.7±2.6 and 61.8±2.9 obtained with young and matured goat leather tanned with chrome. The result is slightly higher than the value of51.39% obtained in the current study, but fall within the acceptable range of 40-80% reported by Salehi *et al. (*2013). Jibir *et al*(2013) reported higher percentage elongation value of 63.84% while the value of 44.30% obtained by Hyllin *et al.*(2012) is lower than the reported value of the current finding. The higher value of51.39% percentage elongation obtained in the present study was similar to the values reported by these authors. The higher percentage elongation value obtained in the current study could be attributed to improvement of thermal stability and grain properties of the tanned leather.

The result of the current study revealed higher water absorption value range of 205.49% - 126.08% on matured goat leather tanned chrome and acacia respectively, the result is in close agreement with finding of Dereje *et al.,* (2015) on performance evaluation of local goat types of Ethiopia, who reported water absorption value of 184%, 173.8% and 190.9% of Bati, HH and SS goat types.

On the effects of breed and age of sheep and goat Jibir *et al.* (2013) reported water absorption percentage of 15.94%, 145.36 and 134.46% of young and matured goat respectively, which is lower than the value reported in this study. The higher water absorption percentage recorded in the present study could be attributed to means of conditioning and inter fibrils spaces of the leather.

The ideal volatile matter content of leather is considered to be between 12-14% which correspond with finding of the present study, Charles (1948); Ebrahiem *et al*.(2015) reported moisture/volatile matter content of 13.8% with chrome while 10.8% on vegetable and moisture content of 14.8±1.83%, 13.10±2.22% and 12.84±2.33% recorded on Nubian, desert and taggar goats. The higher moisture content obtained on matured goat leather tanned with *Acacia nilotica* was lower than the value reported with Nubian and desert goat respectively. The higher Volatile Matter obtained with mature goat leather tanned with acacia is attributed to high water, minerals, and fat content of the leather.

Even though no significant difference was recorded on pH, the higher pH value of 5.36 was recorded on matured goat leather tanned with chrome, when compared favourable with results of Jibir *et al,* (2013) who reported pH value of 3.73 and 3.63 for matured Nigeria's native sheep, the value is lower than the reported value obtained in current finding. Hylli*et al*. (2012) reported pH value of 4.9, 4.64 and 4.66 and 4.24, 4.24 and 4.38 on crust goat leather and finished sheep leather respectively while determining some chemical and physical indicator of Albanian leather. These values agree with finding of the present study. The higher pH value obtained in the present study could be attributed tohigh concentration of organic acid (sulphuric acid) in the chrome tanned leather.

The results of the present study revealed higher water soluble organic matter content of 25.8% obtained on young goat leather tanned with acacia, comparatively the value was significantly higher than the value reported by Charles,(1948). Maksym and Viktoria. (2014) on problems of efficient processing and used of collagen containing materials who reported water soluble content value of 12.6%, which agreed with results obtained in the current study.

The result of the present study indicated higher hide substance contents of between 48.85% and 48.18% obtained on matured goat leather tanned with acacia which is in line with result obtained by Musa and Gasmelseed, (2013) who reported hide substance content value of 46%. Maksym and Viktoria, (2014) and Charles, (1948) on problem of efficient processing and used of collagen containing material and effect of temperature on the volume of leather and collagen in water reported hide substance content value of 62.1% and 73.7% and 44.8% for chrome and vegetable tanned leather respectively which is significantly higher to the value recorded in the current study.

Ebraheim *et al*, (2015) in skin /leather quality of some Sudan goats under range condition reported total ash content of 4.8% and 1.0% the same author also reported total ash content value of 2.93, 2.02 and 1.96 for Nubian desert and tagger goat, these reported values tallied with the values recorded in the current findings. Musa and Gasmelseed, (2013) in semi chrome upper leather from rural goat vegetable tanned crust reported total ash value of 3.20 and 2.70 for semi chrome and garad tanned leather, the same author also reported water insoluble ash value content of 3.00% and 1.20% for semi chrome garad tanned leather these values were comparably similar with the finding of the current study.

4.2.1 The costs and returns of processing goat skin to crust leather.

The costs and returns of processing Red Sokoto Goat skin to crust leather found out that fresh skin was the major contributor of the total capital investment. The finding further revealed that for each naira invested in processing Red Sokoto Goat skin to cross leather a profit of ₦ 0.78 was obtained. Processing Red sokoto Goat skin into leather contributed positively to the earning from the resources invested. This means that, the more the number of skin processed the more the profit earn.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATION

5.1. SUMMARY

The study was carried out to determine the effect of tanning agent, age and strain on quality properties of Red Sokoto goat leather. The experiment was conducted in a 2x2x3 factorial arrangement in a completely randomized design (CRD).The factors being (2) two tanning agent (Chrome sulphate and *Acacianilotica*),(2) two age group (young 1-1½ years and matured 2-3years) and the (3) three strains of Red Sokoto goat (Red Sokoto, Kano brown and Borno white) in three replications.On the effect of tanning agent on physical properties of goat leather, the results showed significant difference ($P<0.05$) in tensile strength, percentage elongation, grain test, water vapour permeability, shrinkage temperature and water absorption. However, no significant difference ($P>0.05$) in leather thickness, but significant difference was observed in the interaction effect.

The results indicated that leather tanned with *Acacia nilotica* recorded higher values of leather thickness, tensile strength, grain test and water vapour permeability while higher percentage elongation, shrinkage temperature and water absorption was obtained with leather tanned with chromium sulphate, interaction effect also recorded higher values on these quality properties.

With respect to Chemical Properties the result further revealed that leather tanned with *Acacia nilotica* showed higher values in volatile matter, water soluble organic matter, hide substances and pH. On the other hand leather tanned with chromium sulphate recorded higher water soluble magnesium salt, sulphated total ash, and water insoluble ash respectively. Interaction effect also showed higher values on these properties.On the effect of age, the result showed that the significance ($P<0.05$) was observed in leather thickness, percentage elongation, water vapour permeability and shrinkage temperature, but interaction effect were found to be significant. The results revealed higher value in grain test and water absorption with matured goat leather while young goat leather recorded higher value of tensile strength.

The results also showed significant ($P<0.05$) difference in water vapour permeability and water absorption. However, no significant ($P>0.05$) differencein the rest of other properties but interaction effects were found to be significant. The result further showed that Kano brown goat leather recorded higher water vapour permeability, followed by Red Sokoto goat while Borno white recorded the least. However, Borno white recorded highest water absorption followed by Red Sokoto while Kano brown goat leather recorded the least.

5.2. CONCLUSION

It is concluded that leather tanned with *Acacia nilotica* had higher tensile strength, percentage elongation, grain test, water vapour permeability, shrinkage temperature and water absorption, meanwhile matured goat leather recorded higher tensile strength, grain test and water absorption than young goat leather.

It could also be concluded that matured Kano brown goat leather tanned with *Acacia nilotica* had the best quality leather followed by Red Sokoto Goat leather tanned with same tanning agent (*Acacia nilotica*)

5.3. RECOMMENDATIONS.

The following recommendations are presented based on the finding of this study:

1. For good quality leather production among the three strain, Kano brown goat skin should be obtained from matured goat aged 2-3years
2. *Acacia nilotica* should be used in leather processing asit is a locally available, accessible and affordable material.
3. Processing Red Sokoto goat skin into crust leather should be done for profit maximization.

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