SOME PHYISICAL AND CHEMICAL PROPERTIES OF CASHMERE TYPE FIBERS FROM LONG HAIRED ARSI BALE GOATS

MSc THESIS

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Some Physical and Chemical Properties of Cashmere Type Fibers from Long Haired Arsi Bale Goats

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Dedication

This piece of thesis work is dedicated to my late brother Guye Kilta; he had been nursing me to pursue my educational achievement and during my childhood.

STATEMENT OF AUTHOR

I declare that this thesis is my bonafide work and all sources of materials used in this thesis have been duly acknowledged. This thesis has been submitted in partial fulfillment of the requirements for M.Sc. degree at Hawassa University and is deposited at the University Library to be made available to borrowers under rules of the Library. I also declare that this thesis is not submitted to any other institution anywhere for the award of any academic degree.

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LIST OF ABBREVIATIONS AND ACRONOMYS

µM	Micro Meter
A	Ash
AB	Arsi Bale
AnGR	Animal Genetic Resources
B	Burr
BIS	Bureau Of Indian Standard
CSA	Central Statistics Agency
CV	Coefficient Of Variation
PD	Pure Diameter
PT	Pure Type
FAO	Food and Agriculture Organization
SD	Standard deviation
GLM	General Linear Model
HRFD	Hairy Fiber Diameter
HRFT	Hairy Fiber Type
HtFD	Hetero Fiber Diameter
Htft	Hetero Fiber Type
M.A.S.L	Meters Above Sea Level
NC	Number Of Crimp
Nos	Numbers

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Some Physical and Chemical Properties of Cashmere Type Fibers from Long Haired Arsi Bale Goats

By Bali Tesfaye

Major Advisor: Sandip Banerjee (PhD)

Co-Advisor: Mestawet Taye (PhD)

Abstract

A study was carried out to access the fleece quality parameters of long haired Arsi Bale goats which are reared at Dinsho and Agarfa District of Oromia regional state. The long haired Arsi Bale goats are raised in the cold areas of Bale zone and have very long hairs and warm undercoat. Earlier studies have indicated that the goats are raised primarily for their skin and pelt which are used as saddle cover and also for covering of furniture's in the home. This study was carried out to access the physical and chemical quality of the fleece obtained from healthy bucks and does reared in the selected kebeles of Dinsho and Agarfa District. Proportional sampling method was used to identify the bucks and does. Based on the same 21 bucks from Dinsho district and 17 from Agarfa district and 29 does from Dinsho district and 33 from Agarfa district were selected. The age of the bucks was determined by their dentition and only adult (>1 year old) goats were selected for the fleece. The fleeces were combed from the neck region of the healthy goats and then they were packed in plastic bags before being transported to the laboratory at School of Animal and Range Science laboratory. The fleece were studied for staple length, numbers of crimps/inch, numbers of hairy, hetero and fine fibers, average diameter of the hetero, hairy and fine fibers (in micron). The chemical properties of the fleece included the percentages of ash, wax, scouring yield and burr. The numbers of fleece and their diameter was accessed using a digital microscope at 40X magnification. The data were analyzed for the effects of location and sex on the fleece quality parameters. The findings for the bucks indicated that there were differences (P<0.05) only in crimp, numbers of pure fibers and scouring yield of the bucks reared in the two locations. While among the does there were differences P<0.05 in staple length, crimp, fiber diameters (hairy, hetero and pure), in percentages of ash, scouring yield and wax of the bucks reared in the two Districts. The study also shows that there was a wide variation in the numbers of pure, hetero and hairy fleece while, differences in the fiber diameter were minimum. The study pertaining to the effects of sex further indicated that there were differences in the fiber wax parameter among the bucks and does raised at Dinsho. In Agarfa district there were differences (P<0.05) in staple length, numbers of hairy fibers, hetero and pure fibers, hetero and pure fiber diameters. The within sex differences due to location can be due to the adaptability of the goats to the locations and also due to crossings of the bucks/does with the short haired Arsi Bale goats. The differences between the sexes within locations can be ascribed due to sexual dimporphism and also the traditional breeding objectives which differ across the sexes. There was a possibility of selection within the genotypes for the parameters studied and thereafter further improving the same.

Key word: Arsi Bale goats, fleece, physical, chemical properties, Oromia, Ethiopia

1. INTRODUCTION

Agriculture is the base for Ethiopian economy and livestock sub sector is an integral part of agriculture. Ethiopia has the largest livestock population in Africa and the livestock sector has been contributing immensely to the livelihood improvement of the country in general and smallholder farmers in particular (CSA, 2017).This sub sector plays a significant role in reducing poverty, a certain food security; contribute towards gross domestic product; contribute to national exports and foreign exchange earnings; besides they also contribute towards climate mitigation and adaptation (Shapiro *et al.*, 2015). Livestock production is one of the important agricultural activities in the majority of the African countries.

Animal Genetic Resource (AnGR) comprises livestock species, breeds and strains that have economic, scientific and cultural values for the mankind in terms of food and agricultural production. The majority of these breeds are reared in the developing countries characterized by marginalized production environments (Gibson *et al.,* 2005). The predominant livestock species include cattle, sheep, goats, pigs, chickens, horses and buffalo. Several other domesticated animals like camels, donkeys, elephants, reindeer and rabbits are also valuable to different regions of the world. Cattle, sheep, chickens, are predominantly found all over the world, while goats and pigs are less uniformly distributed. Ethiopia harbors diverse caprine population in the country, which playing an important role in the livelihood of resource-challenged farmers.

Very few goat breeds in the world have long cover fibers, the hair of the goat consists of two kinds of fibers, the first is the fiber covering the body of the animal, known as guard hair. The second is the fiber called down hair, which protects animals from cold weather in the winter, such down fibers are commonly known as Cashmere, Pashmina, Bahare, Kork and Kaşgora in some regions of the world (Ansari-Renani *et al.,* 2013). Animal fibers impart beauty, softness, colour, texture, brightness, durability and elasticity to the fabric in which they are used (Jensen 1992, Leeder *et al*., 1998, Shakyawar *et al*., 2013). These properties make it possible for cashmere fibers to be a desirable animal fiber in the textile industry.

The use of animal fibers for clothing and allied activities outdates the beginning of recorded history (Feki, 2013). Among the fibers used are the hairs, fleece and wool which have been used in both woven and unwoven/felted form (Maskiell, 2002). Large quantities of animal fibers and fur fiber are used long side that of wool to produce special effect in the final product with respect to beauty, colour, softness and luster (Von Bergen, 1963). Specialty type hairs of animal origin with desirable vary with species and breeds for softness, luster, warmth, natural color and other functional properties (Pokharana, 1988).

Fibers of animal origin are basically natural proteins, and posses' scales (externally) to prevent their degradation from the vagaries of nature (McGregor &Postle, 2009). Such fibers provide warmth and physical comfort that are most desirable for both apparel as well as home textiles viz. shawls, rugs, blankets and floor coverings. The specialty hairs obtained from Angora goat, Cashmere goat and common goat, known as Mohair, Pashmina and common goat hair respectively have become popular over the years (William Ternaux,1922).

Cashmere goats produce a double fleece that consists of a fine, soft undercoat or under down of hair mingled with a straighter and much coarser outer coating of hair called guard hair.

(McGregor and Butler, 2008). Cashmere is the fine, down-like undercoat of the Cashmere goat (*Capra hircus Laniger*), which serves as a layer of insulation during the cold winter months. During the spring, the cashmere molts spontaneously, or is harvested by the farmer before its shed. (Wool Products Labeling Act of 1939.The Cashmere produced from goats is a raw material that has been used in the textile industry for centuries; these materials, in turn, constitute raw materials in the fashion industry (Leeder *et al.*, 1998). These materials can be used in the textile industry either in their pure natural state or mixed with other animal fibers, such as sheep fleece, to achieve the desired physical structure. Although fashion changes and prices in the textile sector have fallen, the value of these fibers remains the same (Leeder *et al.*, 1998)

The total population of goat in Ethiopia is estimated as 32.74 million heads of goat, Out of these total goats, 70.49 % are does and about 29.51 % are bucks almost all the goats are indigenous origin (CSA, 2018). Despite their large population their contribution at the national level are far below their expected potential which might be attributable to their genetic nature, a long side that of managerial and socio-economical factors. Important constraints pertaining to their sub optimal productive and reproductive performances can be ascribed to seasonal scarcity of feed and forage, lack of management related infrastructure, high prevalence of diseases and parasites, lack of poorly maintained records, suboptimal marketing infrastructure and management and high levels of inbreeding (Zewdie and Welday, 2015).

In general the population density of goats are high in the mid- and low-altitude areas, the long haired Arsi Bale goat is uniquely adapted to the highlands of Bale mountains,Oromia region of Ethiopia (CSA, 2017).The goats in Ethiopia in generally are raised under extensive production system and for various products viz. chevon, milk and skin (Workneh, 2003). Sale of goats and allied products (meat, skin and milk) by many of the farming communities constitute a large chunk of their family earnings (Tesfaye, 2004). Traditionally, goats have reared as a means of ready cash and also reserve against economic hardship.

The long haired Arsi Bale goats are raised specifically for their pelt and skin. The skin and pelt of these goats are generally used for bedding materials of the saddles and also for the house of the owners. Bale zone is characterized by diverse agro-ecology where goats play significant roles for the communities rearing them. The existing long haired goat breeds in the Bale zone are of indigenous Arsi Bale (AB) type and are reared in a traditional manner (Dawit, 2012). The Bale highlands are potentially important zone when it comes to agrarian activities and livestock rearing in particular. Small ruminants among the livestock system play important role in boosting the economy of the smallholder farmers in the zone (Usman *et al*., 2012).

Based on both the breed characterization studies the Arsi Bale is considered as a phenotypically distinct breed which are distributed across wide agro–ecological zones, the majority in semi-arid areas (Kebede *et al*., 2012). However, the long haired ecotypes of Arsi Bale goats are distributed throughout the highlands of Bale region to an altitude of around 4000 masl and higher altitudes (Farm-Africa, 1996).

The phenotypes of the goats are ascribed to the influence of socio-cultural and economic values of the communities rearing them (Zewdie and Welday, 2015). From the total population of Arsi Bale goats, it is estimated that around a quarter of them are of long hair types (Farm Africa, 1996). However, it has been reported from various sources that the population of the long haired Arsi Bale goats are declining over the years (Israel *et al.*, 2013).

This can be ascribed to the socio cultural and also anthropogenic changes (FAO, 2007). Therefore, it is feared that this strain of Arsi Bale goat may be diluted by breeding them with the short haired type. However, in spite of the usages of the pelt and hair of these goats by the local residents, there have been no scientific efforts to study the fleece quality of the long haired Arsi Bale goats. Therefore, the present study was conducted with the following objectives.

1.1. Objectives

1.1.1. General Objective

To assess some physical and chemical properties of cashmere type fibers from long haired Arsi-Bale goats

1.1.2. Specific Objectives

- To assess some physical properties (Staple length, Crimp, Hairy Fiber, Hetero Fiber, Pure Fiber, Hairy Fiber Diameter, Pure Fiber Diameter, Hetero Fiber Diameter)of cashmere type of fibers of Longhaired Arsi-Bale goats
- To assess some chemical properties (Ash (%),Burr (%),Scouring Yield (%),Fiber Wax (%))of cashmere type of fibers from Longhaired Arsi-Bale goats
- To compare effects of non-genetic factors and sex on the fleece quality of the Arsi-Bale goats.

2. REVIEW OF LITERATURES

2.1. Origin and Domestication of Goat

Domesticated goats are originated from their wild ancestors the wild Bezoar goats (*Capra hircusaegagrus*) and the Markhor goat (*Capra falconeri*) and are belong to the subfamily Caprinae or "goat antelopes (Rahmann and Akademie, 2007). It is estimated that around 10,000 years ago, wild ovines and caprines were domesticated in Mesopotamia (around the Tigris and Euphrates) and were a part of the transition from nomadic to settlement of their owners (Rahmann, 1999).

2.2. Goat Development Activities in Ethiopia

Studies on goat breeding in Ethiopia has been focused on improvement of their carcass traits and to some extent on dairy related parameters;- However, in spite existence of such an unique genetic resource in the country there has been no scientific studies on the fleece related parameters of goats within the country. Several research projects however aimed at assessing the socio-economic impact of pure and crossbred goats has been subject of study in several research projects (Habte Mariam *et al*., 2000; Workneh 2000; Teressa 2004). These developmental interventions were/are mainly focused on improving milk production and growth rates through crossbreeding.

However, despite better performance of crossbreds (over the indigenous breeds) under on-station conditions, such superiority was not replicated at the village conditions. The adoption rates of crossbred genotypes by farmers were found to be very low. It has also been seen that the small holder farmers were unable to maintain the crossbred goats due to lack of feed and also allied factors. Hence adoption of these genotypes were dismally low in many cases lower than 20%. The adoption was slightly better among the better off farmers who were able to provide the basic needs for the sustenance of the genotypes (Solomon *et al.,* 2014).

2.3. Goat Production Systems in Ethiopia

There are a number of ways to classify production systems. There are three major and two minor production systems are described. The major production systems are: Highland sheep barley system, mixed crop–livestock system, pastoral and agro-pastoral production systems. Other production systems are not currently practiced widely however studies haveindicate that they have a future are: Ranching and Urban and peri-urban (landless) sheep and goat production system (ESGIGP, 2008).With increases in human population, declining land holdings and shrinking grazing land, the relative importance and population of goat in these systems is increasing (Workneh, 2000). Milk production from goats is important in some mixed crop–livestock and pastoral areas (Takyi, 2008).

Along with kid growth which increases income from sale of animals Major feed sources include natural pastures, crop residues, industrial by-products, and tree legumes under cut and carry system (Kidus, 2010; Dereje, 2011 and Dhaba *et al*., 2012). In some areas, tethered grazing is also practiced (Workneh, 2000; Kidus, 2010). Meanwhile, the most common methods of grazing are either free or herd grazing, browsing or admixture of both on communal land (Deribe, 2009). Water availability doesn't appear to limit production in most areas under this production system. In most cases, goats are housed with the family (Endeshaw, 2007; Deribe 2009 and Kidus, 2010) or in separate housing (Belete 2009; Kidus, 2010, and Dhaba *et al*., 2012).

2.4. Characteristics of Fiber

Fleece contains primarily two types of hair, outer coarser hair and inner fine hair known as "wool" and percentage of fine hair differ according to animal species, breed and climatic conditions. Thus, fleece characteristic is an important yard stick to determine the quality and price of the hair (Koratkar and Patil,1984).The quality of the tested fleece mass, staple length, diameter, kemp content and medullation of mohair a long side staple length, medullation and grease yield, show significant differences due to genetic and environmental factors while the fiber diameter and Kemp content showed non-significant difference between seasons. The physical quality of fiber is determined by the following factors, fiber diameter, crimp, yield, color and fiber length (MSA, 2006), while the chemical properties including scouring yield, burr, wax and ash content.

2.5. Physical and Chemical Properties of Fiber

The main quality of cashmere is that it is very soft, even softer than wool. It also provides warmth and can be worn for a long time. The average fiber diameter is the main determinant of quality for the textile sector (McGregor, 2006, Ansari-Renani *et al.*, 2013, Quispe *et al.*, 2014). The fiber diameter of processed cashmere must be less than 19 μm. A value between 16 and 19 μm on average is considered appropriate (Jensen, 1992). The average fiber diameter of Chinese cashmere is less than16.5 μm and used in luxury tricot as the best fibers. Cashmere with a fiber diameter of more than 16.5 μm is generally used in a fabric weave mixed with wool. Fibers with a diameter of 18.5 μm are produced in Iran, Afghanistan and Siberia (Ryder, 1993).

Fiber length of hair type goats have been reported to be around 9.1cm (Cak *et al*., 2016). It has been reported by (Deger *et al*., 2008; Dellal *et al.*, 2014 and Soylemezoglu *et al.*, 2002) that the average fiber length of the goats from Turkey were 13.63, 11.8 and 12.2cm respectively. However, (Negahdari and Salehi, 2012) reported that the fiber length of long hair goats were 5.5 cms. The differences among the studies in terms of fiber length could be related to management, shearing method, shearing time and analysis methods. (Helal and Hekal, 2014) found that fiber length of Shami goat's hair was 9.91cm. The fiber diameter is a very important economical trait in textile and carpet industry. Therefore, the fiber diameter is an important selection criterion. The mean value of fiber diameter determined as 80.9µm. Findings study by Dellal *et al*., (2014) indicated that the diameter of hairy goat fibers was between 64-93µm. The mean value of fiber diameter in another study was between values reported by (Dellal *et al*., 2014). Salehi *et al*., (2013) reported that fiber diameter in hair goats was 82.6µm.

Furthermore, (Deger *et al.,* 2008) reported that fiber diameter of hair goats was assessed as 76.70µm. Soylemezoglu *et al.,* (2002) reported that fiber diameter of Hair goats was 96.1µm. The mean value of fiber diameter higher than the result reported by (Deger *et al.,*2008), was lower than the result of (Soylemezoglu *et al.,* 2002). Also, fiber diameter in study was lower than the value (101 µm) reported for Baladi goats by (Helal *et al.*, 2010). An average value of 18 µm for fiber diameter in Raeini cashmere goats has been reported. Furthermore, studies by Shamsaddini- Bafti *et al.,*(2012) indicated that the average fiber diameter was influenced by non genetic factors district, staple length and age of goat. Staple length was affected by district, mean fiber diameter, gender and age of goat.

Cashmere is the fine inner-coat (down) produced from domesticated goats (*Capra hircus Laniger*) (Franck, 2001) and is considered one of the most luxurious and softest of the animal fibers in textile use (Leeder, McGregor & Steadman, 1998). It’s softness of handle, gives cashmere garments their luxury appeal (McGregor, 2007). The main producers of cashmere are China, Mongolia, Afghanistan and Tibet with smaller quantities produced in Iran, central Asia, Australia and New Zealand (Franck, 2001). Chinese cashmere is considered to be the best quality fiber and has a narrow diameter range between 14 to 16 µm (Franck, 2001).

2.5.1. Physical Properties of Goat fibers

The physical properties of fleece play very important role in determining the fiber quality. The physical features of an animal hair vary within wide limit depending on the breed and geographic location of animal on one hand and the fleece shorn from different part of the animal on the other (Adams *et al*., 2000).The physical properties of the fleece are lowly to moderately heritable but are also subjected to variations due to non-genetic factors.

Commercial value of cashmere is often optimized from other such types of fleeces due to their high yield, long staple length, white color, small diameter and minimum contamination with guard hairs. Each of these quality attributes affects the speed of processing processed yield as well as yarn and fabric quality. Mean values, variances and ranges for the recorded traits are presented.

Table 1:- Physical properties of the goat fiber

Traits	Breed	Location	Mean ± SE (min- max)	CV	Reference
Staple length,(cm)	Cashmere goat	US	4.6 ± 0.1 (2.8-7.7)	22.2	Nagal.(2006)
Cashmere (average fiber diameter, µm)	Cashmere goat	Australian	18 ± 0.1 (15.6-19.5)	4.7	McGregor.(2015)

Mean fiber diameter, (µm)	Raeinin cashmere goat	Iran	20.9 ± 0.4 (15.6-27.2)	14.7	Shamsaddini-bafti.(2012)
Cashmere from total fiber, (%)	Raeinin	Australia	66.1 ± 1.5 (42-91.2)	16.3	Mehrdad and Shamsaddini-Bafti.2012
Guard hair, (% of total fiber)	Cashmere	New Zealand	33.8 ± 1.5 (7.8-58.0)	16.3	Syed and Syed (2009)
Diameter (µm)	Cashmere goat	Australia	20 (40-30)		McGregor.(2015)
Staple length (mm)	Cashmere goat	Australia	130 (80 – 180)		Nagal.(2006)
Medullation (%)	Angora, Cashmere	France	1.0 (0.3 – 2.8)		Sailu.(2000)
Crimp/inch (wave frequency)	Angora	France	4.5 (2.5 – 6.5)		Allian and Roguet,(2006)

2.5.1.1. Fiber diameter

Fiber diameter (FD) refers to the average width of a single cross section of wool/fleece fiber (Gillespie and Flanders, 2010). It is measured in microns (µm) which equates to one thousandth of a millimetre (Cottle, 2010; Poppi and McLennan, 2010; Rowe, 2010). FD is widely acknowledged as the most important wool characteristics when assessing wool/fleece quality and value (Kelly *et al.*, 2007; Rowe, 2010). Mean fiber diameter of Cashmere averaged 17.0–19.5 µm between breeds with an individual range of 15.5–24.5µm.

The relationship between MFD of the Raeini goats with MFD of 19.5 µm had the coarsest fiber, and Nadushan goats with 17.0 µm had the finest cashmere. But males tend to increase fiber diameter whereas females tend to decrease it with the overall cashmere fiber diameter of 18.7±0.2 µm.

According to (FAO,1995) Iranian cashmere was described as having a range of diameter of 17-21 µm and that it is chiefly used for weaving, the study further indicate that 28 and 21% had a fiber diameter between 14.90–17.50 and 17.51–18.50 µm respectively which is similar to low premium Chinese and Mongolian cashmere which is suitable for knitwear. Furthermore, 51%of the cashmere was coarser than 18.50 µm. A study of McGregor *et al.*, (2009) indicated that 42% of cashmere samples tested from (Osh and Naryn provinces of Kyrgyzstan) had a fiber diameter of 16.0 to 18.0 µm which is suitable for either knitwear or weaving. A further 30% and 21% of the goat cashmere was between 18.51 to 20.0 and greater than 20.0 µm, respectively.

2.5.1.2. Staple length

It was assessed as the length of individual fiber (in centimeters) from the base to the tip of the fiber. The staple length was determined by placing the staple against a ruler. Stable length is a function of individual fiber lengths and the extent of crimping; the fiber length component is related to growth rate and the duration of growth period (Muhammad *et al.*, 2012). Fiber staple length (SL) is becoming an increasingly important determinant of wool quality and value (Edriss *et al.*, 2007; Valera *et al.*, 2009; Gillespie and Flanders, 2010), and is expressed in millimeter (mm) units (Thompson *et al.*, 1988).

Average cashmere SL was 42.8 mm with an average range of 30.4–55.2 mm between breeds with an individual range of 20.2–70.5 mm. The relationship between SL and other fleece characteristics of Raeini goats with SL of 55.2 mm had longest, and Nadushan goats with

30.4 mm had shortest length. In another study with cashmere goats of different Tajikistan districts, (McGregore *et al.,* 2011) found significant effect on cashmere staple length.

In the same study they indicated that there was a significant effect of gender on cashmere staple length with longer SL observed among the bucks. The study also indicated that SL of 38% of all samples taken was between 40 and 50 mm, 51% of the samples had shorter than 40 mm while 29% of the samples were longer than 50 mm in length(). As cashmere fiber longer than 34-36 mm are used for worsted spinning (World Textile Publications, 2010), the results indicate that majority of cashmere of goats would qualify for worsted and semi-worsted industry.

2.5.1.3. Wool/ fiber- crimp

According to paul (1995) crimp is the visual estimation of the number of natural waviness of a single fiber per inch; it is an important characteristic to influencing the fiber quality. Well crimped fibers usually pass a high tensile strength. Fibers lacking in crimp have a tendency to break during the processing. Uniformity of the crimp throughout the length of the stable is very desirable trait. Traditionally the crimp frequency was used by fiber buyers as a visual indicator of the underlying average fiber diameter of sale lots (McMahon and Whiteley, 1965; Purvis, 1997).

2.5.2. Chemical Properties of fibers of goats

Chemically wool, mohair, alpaca, yak, camel and all other hair fibers may be considered as variants of the same fundamental structure (Tester, 1987). Animal hair unlike others is made of long chain molecules, more or less aligned along with the fibers. Other than silk, all animal fibers are composed of similar chemical substance, the sulphur containing protein keratin which consists of polypeptide chains of carbon and nitrogen with hydrogen and oxygen atoms attached.

Findings of a study by Roberts (1973) indicated that the surface of cashmere was more hydrophilic than the surface of the wool. It was also observed that cashmere had more of the polar amino acids, serine, threonine and mtyrosine than wool in its cuticle. Results of a study by Sugumar, (1988) too indicated that cashmere fiber were found to be more sensitive to alkalies, acids and bleaching agents when compared to wool and Mohair, this is because of the fineness associated with the same.

2.5.2.1. Wool / fiber grease (wax)

Wool grease (wax) and suint/burr are secretions from the sebaceous and sudoriferous (suint) glands within the skin, which mingle, forming "yolk" in the follicle shafts, and coat the developing fiber (Venter, 2012). Apart from the fact that wool wax is considered essential for the well-being of the animal, it further proves to be associated with certain characteristics of the fleece. Comparing greasy and non-greasy wool samples of the same quality, (Winson, 1929) noted that greasy samples were distinctly finer and more uniform in fineness, and that they showed less variation in size and shape of cross-section, as well as being more circular.

Suint occurs in raw fiber to an extent of 4 to 30 %. It contains relatively large proportions of potassium salts, is water-soluble and has excellent emulsifying properties. It also imparts high wettability to a raw fleece. These factors are put to good use in wool scouring (Veldsman, 1965).

Suint/Burr content is an effect of major importance in the fleece is rendered questionable by the histological observation that only the primary fibers are equipped with accessory sudoriferous glands (Fraser &Truter, 1960), Apart from the production characteristics and various fiber properties formerly discussed, the wool wax and suint content was also determined and expressed as a percentage of the clean dry wool.

2.5.2.2. Scouring yield (SY) of fibers of goats

The scouring yield indicate the clean yield of the wool and hence of commercial importance. Scouring yield too is influenced by both genetic and non-genetic factors and is influenced by the season of wool growth. The actual separation of dirty, grease and foreign matter from grease wool; this is usually done in a lukewarm, mildy alkaline solution followed by a rinse. The scouring yield estimation is important for the commercial point of view, as this measure is used in determining the price of the greasy wool, and is perhaps one of the oldest bases employed for this purpose (Qureshi *et al.*, 2013).

2.5.2.3. Burr Content of the fleece (vegetable matter)

Vegetable matter in fiber comes from feed particles as well as burs, seeds, twings, leaves, and grasses. It is removed from a fleece using a process called scouring. A certain amount of vegetable matter is accepted on wool, however, an excessive amount is considered a defect and the wool may be discounted in price. The high amount of burr caused problems in the carding of the wool and the quality of the fiber as a whole is affected thereby reducing the price of the same (Banerjee, 2013)

2.5.2.4 Ash Content of the fiber

The ash is a nonvolatile inorganic matter of a compound which remains after subjecting it to a high decomposition temperature. It is expressed as a percentage of the subsample mass and is taken to represent the dirty (sand and soil) not removed during the scouring of the grease sub sample.

Table 2: Chemical properties of goat fiber

Trait	Average	Breed	Location	Reference
Vegetable Matter (%)	0.3 (0 – 2)	Mohar	Australia	
Ash content (%)	0.45 (0.3 –0.6)	Kazak goat		Cak(2017)
Grease (%)	5 (2.0 –8.0)	Mohair	Cambridge	Hunter (1993)
Suint (%)	2.5 (1.8 –4.0)	Mohair, cashmere	Greece	Franck (2001)
Scoured/Clean yield (%)	85 (70 – 95)	Silk, mohair, cashmere	Cambridge	Hunter (1993)

2.6. Effect of Sex on the Fleece Quality

The sex of goat did not significantly affect the mineral composition of cashmere fibers, although there were some differences between two sexes in the physical characteristics of their fleeces. The report showed that none of the measured parameters except for the coefficient of variation of cashmere fineness and cashmere tenacity (staple strength) was influenced by sex of goat (P <0.05; Fiber from bucks showed significantly stronger staple strength than the does .Its response is consistent with the slightly higher fiber sulfur content for males than females.

Female goats tended to have more cashmere percentage and copper and zinc contents than males but these differences were not statistically significant In Australian cashmere goats, males tended to have a lower body weight and cashmere weight than females, but both sexes were similar in diameter and length of fibers. Unlike Australian goats, in Chinese goats at all ages, bucks have coarser Cashmere than does with an increasing trend as their age increased. Another reported that adult bucks were significantly heavier than adult does in cashmere weight, fiber diameter and length, and body weight. That report shown that an adjustment for sex and age effects would be necessary for fleece weight and fiber diameter for Angora goats reared in Argentina.

Table 3. Effects of the both sex on the fleece quality of goats

	Effects	**No.**	**Traits**	**C %**	**VFD, (μm)**	**CVFD, %**	
Sex	Bucks	24	4.8 ± 0.2	64.1 ± 2.1	18.0 ± 0.2	21.7 ± 0.6	McGregor BA.2011&
	Does	24	4.4 ± 0.2	68.2 ± 2.1	18.0 ± 0.2	20.0 ± 0.6	Shakeri P.2005
P value			Ns	Ns	Ns	*	

$^{*}P < 0.05$; $^{**}P < 0.001$; ns: Not Significant.

Results obtained from black and brown goats reared at Birjand in eastern Iran indicated that the length and diameter of raw Cashmere fibers were 47.5 ± 8.9 mm and 16.6 ± 1.2 μm, respectively. In these goats, the effects of flock, region, sex and type of birth were significant for these parameters. A previous study indicated that the effect of sex was significant on cashmere percentage, fiber diameter and staple length of Raeini goats and the amount of cashmere fibers for bucks and does was 63 ± 10% and 68 ± 10%, fiber diameter was 21 ± 2.1 and 19.4 ± 1.7 μm; and length of fiber was 6.4 ± 1.9 and 6.5 ± 1.8 cm, respectively .

3. MATERIAL AND METHODS

3.1. The Study Area Description

Bale zone (Dinsho,Goba,Agerfa) is situated Altitude (m.a.s.l) 2,000-3,600, 2400-4,377, 1,250-3,855 latitudes $6^{0}44'$-$7^{0}06'$N and longitudes $39^{0}46$-$40^{0}14'$E.Rainfall per annum(mm) between 800-1230. It is bounded between Somali National Regional State in the East, East Harar in the North East, West Harar and Arsi zone in the North, West Arsi in west and Guji in the South. Bale zone has 18districts with 2 urban administrative towns. Bale Zone is bounded by Genale River to the West and South and Wabe Shabele River on East and North (BOFED, 1999).

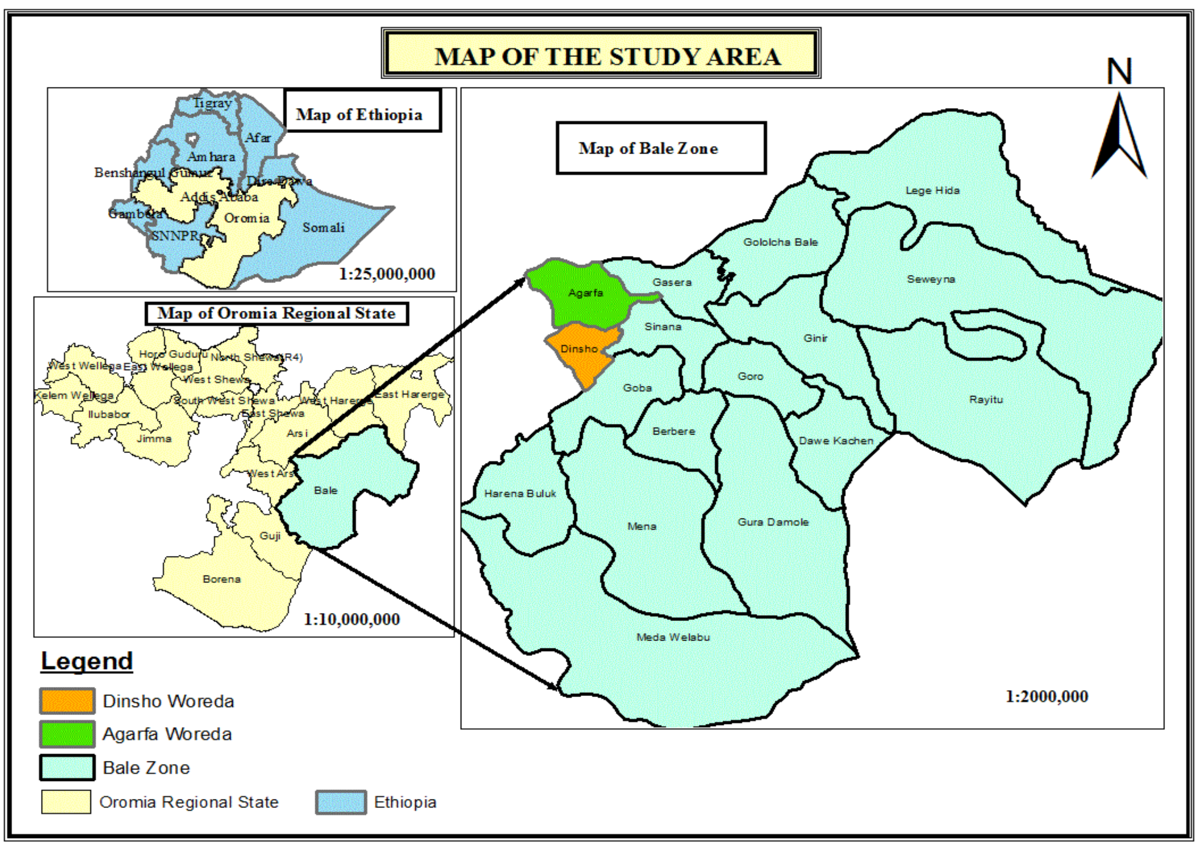

Figure 1. Map of the study areas

3.2. Site Selection and Sampling Techniques

This was done to ascertain the breeding tract of the goat type. Based on the results purposive multi-stage stratified sampling technique was used for the study. In the first stage two districts from both the highland of Bale Zone and midland (which have higher population of long haired goat and connected with all-weather roads) Dinsho district (*Garanba, Hora soba* and *Gojera kebeles*) from high land Bale zone and Agarfa district (*Qaaso Manso,Darra Honsho* and *Galama Hebano*) from mid land of Bale zone was selected respectively, based on discussion with the Zonal livestock and fisheries office experts.

In the second stage (depending on the information obtained from the livestock experts) sample peasant associations was identified. Thereafter from the identified Kebeles three Kebeles was randomly selected from each district. Furthermore, the farmers rearing such long haired goats was identified (within a particular Kebele) and there after farmers who have at least 2- 3 adult goats (of both the sexes) were included the number of bucks 21 from Dinsho district and 17 from Agarfa district and does 29 from Dinsho district and 33 from Agarfa district was selected proportionally based on the flock demography identified and randomly 20% of such farmers was selected.

3.3. Sample Collection

The fiber samples was collected from 50 goats from high lands and 50 goats from mid land. The age of the bucks and does was assessed using recall method and also further clarified using the dentition of the bucks and does (adult goats).

Standard methods were used to collect the fleece samples from the goats. A patch of approximately 10 cm^2 of both hair and down fibers was sampled from the neck region of healthy goats of the experimental animals. The samples was placed in nylon bags and labeled. Fleece characteristics including the percentage of cashmere in a fleece, the percentage of hair in a fleece, staple length, crimp, cashmere fiber diameter and coefficient of variation of cashmere fiber diameter were measured. The staple length was determined by placing the staple against a ruler. The chemical properties of the wax, scouring yield, burr content and ash content end of the femur von Bergen (1963) and Singh (1997).

Figure 2 Method of sample collection from long hair Arsi Bale goat at Dinsho district

Figure 3 Long haired Arsi Bale Goat at Dinsho district

Figure 4 Combing of fleece to collect fiber samples at Agarfa district

3.4. Physical Fiber Quality Analysis

A) **Stable length (SL)**: It was taken as the length of individual wool fiber. The values have been averaged of (50 Nos) fibers from buck and does and average of the same results are presented as mean ± SD

B) **Crimp number (C)**: It was taken as a visual estimation of the natural waviness of a single fiber. The values have been obtained by averaging the number of individual fibers of unstructured fiber the values too all values as mean number of for 50 fibers.

C) **Fiber type**: It was visually observed and counted with the help of digital microscopies under 40 x magnifications. A fine cashmere fiber was identified by the absence of medulla (the central core found in coarse and medium fiber). A hetero fiber was identified by the presence of intermittent modulation.

$$\text{Fiber type} = \frac{\text{W/HTW/HW}}{\text{Total number of fibers counted}} \times 100$$

D) Fiber diameter of fine, hetero and hairy fibers: Fiber diameter viz. fine fiber diameter (FWD), hetero fiber diameter (HTD) and hairy fiber diameter where under a digital microscope at 40 x magnification. The mean fiber diameter was calculated statistically as follows.

$$\text{Average fine / hetero / hairy fiber diameter} = \frac{\textbf{FWD / HTD / HWD}}{\text{Total number of fibers counted}}$$

The above study was carried out as per the standard procedures laid down by Werner Von Bergen (1963) and Singh (1997).

3.5. Chemical Analysis of Fiber Obtained From Cashmere Fiber Type Goat

Clean fiber yield is the weight of fiber free from dirt, grease, vegetable matter or any other impurities. The following chemical analysis was carried out as per Werner Von Bergen (1963), and vides Bureau of Indian Standard, BIS: 1349 (1964).

A) Laboratory scouring yield (SY): It is defined as the total weight of fibers and vegetable matter free from grease, dirt and other impurities.

(i) Apparatus and reagents:

a) Four bowls / breakers

b) Scouring bags

d) Sodium carbonate (anhydrous)

e) Non-ionic detergent

c) Balance (electronic)

(ii) Material to scouring liquor ratio – 1.60

(iii) Temperature of bath, 50^0C (appox.)

(iv) Time of immersion per sample 3-6 minutes

Figure 5 Assessment of scouring yield of fleece

B) Adjusting the concentration of liquor

0.1% (appox), non-ionic detergent and 0.3% (appox) sodium carbonate was prepared. Beakers number 1 to 3 contains same concentration of scouring liquor and the fourth beaker contained plain water for rinsing the samples.

Method of scouring: About 5 grams of the representative samples was collect in triplicate. One sample was kept overnight in a desiccator for conditioning. Three beakers containing the scouring liquor were arrange. The fiber sample was kept in the first breaker for 3 to 5 minutes, the sample was agitated from time to time and the excess liquor was squeezed away before transferring the sample in the second beaker. The used up liquor was drained down.

This procedure was repeated with the sample for two more times i.e. in the second and third beaker. The sample was then washed thoroughly in plain water present in the fourth beaker. The sample (after being thoroughly cleaned) was squeezed dry and allowed for drying overnight at room temperature. Then it was transferred to a desiccator the next day. Constant weight is taken for the control sample and scoured sample after conditioning.

$$SY\ (\%) = \frac{W_2}{W1} \times 100$$

Where:- SY = scouring yield, W_1 = Conditioned weight of the control sample, W_2 = Conditioned weight of the scoured sample

C) Burr content / vegetable matter contents (B): Animals while grazing unintentionally take up many seeds or other cellulose matter which get entangled in their fiber. These vegetable matters are undesirable and affect the market value of the fiber.

(i) Apparatus and reagents.

a) Beakers

b) Balance (electronic)

c) Ventilated oven (hot and oven)

d) Muslin cloth

e) 5% Sodium Hydroxide solution (NaOH)

f) Heaters.

(ii) Materials: Triplicate representative scoured sample 5 grams each.

(iii) Material and liquid ratio 1:30 (approx.)

Methodology: Scoured fiber samples was dissolved in the beaker containing boiling 5% NaOH solution for 5 minutes. The samples was cooled and 250ml water was added from a beaker and the samples was filtered with a muslin cloth, and the vegetable matter was collected and sprinkled with 0.1% acetic acid for neutralization. The sample was then washed with water thoroughly. The vegetable matter (neatly wrapped in a filter paper) was transferred in the oven for drying. Controls sample (appox. 5grams fiber) was also put in the oven for comparison. Constant weight was taken at 105±20^{0}C.

$$B (\%) = \frac{W_2}{W_1} \times 100 \times c.f.$$

c.f. = correction factor

Figure 6 Laboratory analysis for burr content of fibers

D) Greasy fleece yield / Alcoholic Extractable matter (WW): Fiber contains some sought of fatty matter that is waxy in nature. There is a significant correlation between fatty matter and fiber quality. Better the fiber quality more was the extractable fat. To determine the alcoholic extractable matter of the scoured fiber specimen the following method was used.

I. Apparatus and Reagent

a) Soxhlet apparatus

b) Balance electronic

c) Hot air oven / ventilated oven

d) Heating bench

e) Thimbles

f) Petroleum ether (60^0-80^0) grade

II. Material

a) 5 grams of scoured fiber sample

III. Number of siphons per sample: 10 times.

IV. Method: 5 grams of was sample were taken in triplicate, put one of the sample in the hot air oven for drying (i.e. control sample) at 105 ± 20^0C. Two test specimen samples was wrapped in filter paper and inserted in the thimble, the loaded thimbles were then put in the extraction chamber of the sox let apparatus.

Then it was fitted to the flask and the condenser respectively. The flasks was filled (2/3) with the petroleum ether. It was then heated at a low temperature and up to 10 siphoning were carried out.

The excess alcohol was then removed and put in the ventilated / hot air oven for drying at a temperature of 105 ± 20^0C. Both the control samples and the alcohol-extracted sample were put in the desiccator for overnight. A constant weight of both the control and alcoholic extracted sample was taken.

$$WW(\%) = \frac{W_2}{W_1} x\ 100$$

Where:- W_1 = oven dry weight of the control sample,W_2 = oven dry weight of the alcohol extractable sample, WW = Alcohol extractable matter content, percentage by weight.

Figure 7 Assessment of greasy fleece yield/Alcoholic extractable matter (WW)

E) **Fiber ash content (A)**: There was a small amount of mineral matter that appears to be an essential constituent of the fiber itself. It was left as an ash when the scoured sample is ignited.

(i) Material and Apparatus.

a) 5 grams clean test fiber samples in triplicate.

b) Ventilated / Hot air oven

c) Balance electronic

d) Muffle furnace

e) Silica crucibles.

(ii) Method: 5 grams each of clean scoured fiber samples were taken in triplicate. One sample was kept as control sample for oven drying at 105 ± 20^{0}C. The two other samples were used for determination of ash content.

A(%)=a/bx100

a=weight of ash in gram

b=oven dry weight of scoured sample

A(%)=Ash content

Figure 8 Analysis the ash content of the fibers

3.6. Statistical Analysis

The data on physical and chemical properties of cashmere fiber type long haired Arsi Bale goat was analyzed using generalized linear model (GLM) of SPSS version 20 (SPSS,2011) for windows. Means were compared using Duncan's multiple range test and significance limits were assessed. Pearson's correlation studies were also carried out between the parameter studied based on their genotype.

$Yij=\mu+Ai+Bj+(AixBj) + eijn$

Yij= Observation

μ=over all mean of the trait.

Ai= Effects of agro ecology (midlands and highlands)

Bj= effect of sex (bucks and does)

eij= random errors

(AxB)ij=interaction of agro ecology and sex

4. RESULTS

4.1. Some Physical and Chemical Properties of Fleece of Arsi Bale Bucks Reared in Different Agro Climates

The findings from Table 4, indicates that there were significant differences (P<0.05) between districts for the numbers of crimp, scouring yield (%), wax(%) and burr(%) of the bucks. The findings also show that the numbers of crimps and scouring yield (%) were higher on the bucks reared at Dinsho.

Table 4: Physical and Chemical Properties of fleece of Bucks reared at the two locations

No	Trait	Dinsho Mean±SD	Agarfa Mean ±SD	P_{cal}
1	Staple length (Inch)	5.92±1.67	4.70±1.30	0.19
2	Crimp(nos/inch)	1.98±.47*	1.53±.23	0.001
3	Hairy fibers (%)	58.00±31.30	72.83±20.42	0.10
4	Hetero fibers (%)	17.80±14.50	14.47±9.15	0.41
5	Pure fibers (%)	24.19±23.70	12.70±13.43	0.08
6	Diameter of hairy fibers (mm)	.31±.052	.30±.042	0.210
7	Diameter of hetero fibers(mm)	.31±.05	.29±.05	0.262
8	Diameter of pure fibers(mm)	.31±.060	.30±.054	0.375
4	Scouring yield (%)	86.80±2.60*	81.27±2.72	0.000
5	Fiber wax (%)	2.05±.23	3.33±.30*	0.000
6	Burr (%)	6.37±2.40	10.2±3.50*	0.000
7	Ash (%)	3.35±.581	2.82±1.21	0.086

**P<0.05 values across columns are different*

The study also indicates that fiber wax and the burr percentage were higher (P<0.05) on the bucks reared at Agarfa. The study also shows that the numbers of hairy fibers are numerically more (through not significantly higher) among the bucks reared at Agarfa while the converse is true for the numbers of hetero fibers.

4.2. Some Physical and Chemical Properties of Fleece of Arsi Bale does Reared in Different Agro climates

The findings from Table 5, pertain to the physical and chemical properties of fleece from the long haired Arsi Bale does reared at Dinsho and Agarfa. The study shows that there were differences (P<0.05) in the staple length, numbers of crimp, diameter of hairy, hetero and hetero fibers and scouring yield across the two studied locations.

Table 5: Physical and Chemical Properties of fleece of Does reared at the two locations

No	**Trait**	**Dinsho Mean±SD**	**Agarfa Mean ±SD**	**Significance**
1.	Staple Length (Inch)	5.38±1.30*	3.6±.442	0.000
2	Crimp (nos/ inchs)	1.76±.437*	1.43±.138	0.000
3	Hairy fibers (%)	58.41±27.50	50.73±29.26	0.293
4	Hetero fibers (%)	22.83±13.81	21.21±9.60	0.591
5	Pure fibers (%)	18.76±17.64	27.45±22.24	0.096
6	Diameter of hairy fibers(mm)	.31±.040*	.27±.027	0.000
7	Diameter of Hetero Fibers(mm)	.30±.037*	.27±.026	0.000
8	Diameter of Pure Fibers(mm)	.31±.052*	.26±.028	0.000
9	Scouring yield (%)	87.50±2.40*	81.68±4.10	0.000
10	Fiber wax (%)	2.30±.183	3.37±.380*	0.000
11	Burr (%)	5.28±2.24	9.36±3.80*	0.000
12	Ash (%)	3.63±.70	3.31±.72	0.082

**P<0.05 values across columns are different*

The above values being higher among the does reared at Dinsho. The findings further indicate that the fiber wax and burr percentage were higher (P<0.05) among the fibers of the does raised at Agarfa. The study also indicates that there were numerical differences (though not statistically significant) among the numbers of hairy, pure fibers.

4.3. Some Physical and Chemical Properties of Fleece of Arsi Bale Does and Bucks Reared in Dinsho District

The results as presented in Table 6, shows the differences in the physical and chemical properties of the fleece collected from the bucks and does reared at Dinsho also indicate that there were differences in the fiber wax (%) between the two sexes. The differences between the other parameters were though not significant.

Table 6: Physical and Chemical Properties of fleece of Bucks and Does reared at Dinsho

No	Trait	Bucks Mean±SD	Does Mean ±SD	P_{cal}
1.	Staple Length (Inch)	5.92±1.67	5.38±1.30	0.208
2	Crimp(no/inch)	1.98±.46	1.75±.44	0.078
3	Hairy (%)	58.00±31.30	58.41±27.50	0.961
4	Hetero (%)	17.81±14.50	22.83±13.81	0.220
5	Pure (%)	24.20±23.69	18.76±17.64	0.357
6	Hairy fiber diameter(mm)	.31±.052	.31±.040	0.979
7	Hetero fiber diameter(mm)	.32±.053	.30±.037	0.402
8	Pure fiber diameter(mm)	.31±.060	.31±.052	0.885
9	Scouring yield (%)	86.80±2.60	87.50±2.40	0.325
10	Fiber wax (%)	2.05±.23	2.30±.18*	0.000
11	Burr (%)	6.37±2.40	5.28±2.24	0.107
12	Ash (%)	3.34±.581	3.63±.70	0.132

**P<0.05 values across columns are different*

4.4. Effects of Sex on the Physical and Chemical Properties of Fleece of Arsi Bale Goats Reared in Agarfa District

The findings from the Table 7, pertain to the physical and chemical properties of the fleece from bucks and does reared at Agarfa. The study shows that there were differences (P<0.05) in the staple length, numbers of hairy fibers, numbers of pure fibers and also hetero and hairy fiber diameter. While the other parameters did not vary significantly

Table 7: Physical and Chemical Properties of fleece of Bucks and Does reared at Agarfa

No	**Trait**	**Bucks Mean±SD**	**Does Mean ±SD**	**Significance**
1.	Staple Length (Inch)	4.70±1.30*	3.61±.442	0.000
2	Crimp(numbers/inch)	1.53±.230	1.43±.140	0.070
3	Hairy fibers (%)	72.82±20.42*	50.73±29.27	0.008
4	Hetero fibers (%)	14.48±9.15	21.21±9.60*	0.021
5	Pure fibers (%)	12.71±13.43	27.45±22.24*	0.016
6	Hairy fiber diameter(mm)	.29±.042	.27±.028	0.130
7	Hetero fiber diameter(mm)	.29±.051*	.270±.026	0.025
8	Pure fiber diameter(mm)	.29+.054*	.26±.027	0.013
9	Scouring yield (%)	81.27±2.72	81.68±4.10	0.712
10	Fiber wax (%)	3.33±.31	3.37±.380	0.697
11	Burr (%)	10.24±3.50	9.36±3.80	0.428
12	Ash (%)	2.82±1.21	3.31±.72	0.078

**P<0.05 values across columns are different*

The findings as presented in Table 7, indicates that the staple length varied (P<0.01) across the sexes with the values being higher among the bucks. The results also indicated that the numbers of hairy fiber too varied across the sexes with higher (P<0.05) proportion of hairy fibers record among the bucks .The results further indicates that the proportion of the pure fibers were higher (P<0.05) among the bucks. The study also shows that the diameter of hetero and pure fibers were higher among the bucks. The study further indicates that there were no differences between the sexes for the other traits studied.

4.5. Correlation between the Different Fleece Parameters of Arsi Bale Does and Bucks Reared in the Two Study Areas

The correlation between the fiber collected from does reared at Dinsho and Agarfa are presented in Table 8and 9. The results show that from the does reared at Dinsho the staple length (SL) was positively correlated (P<0.01) with the crimp, while it's lowly negatively correlated with the numbers of hetero fibers (HtF), pure fibers (PF). The results further indicate that the crimp was negatively correlated (P<0.01) with scouring yield (SY) and ash (%) (A). Correlation with the numbers of crimp (C) and burr (%) (B) were also (P<0.01). The numbers of hairy fibers (HF) are also correlated (P<0.01) with the numbers of hetero (HtF), and pure fibers (PF).

The numbers of hetero fibers (HtF) was negatively correlated (P<0.01) with those of the pure fibers (PF). The study further shows that the diameter of the HF was correlated (P<0.01) with those of the hetero, pure fiber diameter and ash (A). The study also indicates that the hairy fiber diameter was negatively correlated (P<0.01) (but negatively) with B. The diameter of hetero fibers too indicate similar trend with (P<0.01) positively correlations with the diameter of pure fibers and also the A, while it’s also correlated ($P<0.01$) though negatively with B. The study further indicates that diameter of pure fibers was correlated ($P<0.01$) A values and also with the B values though negatively. The study further indicates that the B was negatively correlated ($P<0.01$) with those of A values.

Table **8**: Correlation between the physical and chemical properties of and Does reared at the study areas

	Staple length	**Crimp (Nos/inch)**	**Hairy fiber%**	**Hetero Fiber%**	**Pure Fiber %**	**Hairy Fiber Diameter**	**Hetero Fiber Diameter**	**Pure Fiber Diameter**	**Scouring Yield%**	**Fiber Wax %**	**Burr%**	**Ash%**
Staple length	1	.587**	.291	-245	-.261	.083	.105	.268	-147	-062	.020	.015
Crimp (Nos/inch)	725*	1	-.265	.325	.158	-.322	-.277	-.279	-.492**	-.042	.619**	-.445*
Hairy fiber%	.183	.218	1	-.836**	-903**	-.014	.027	.185	.221	.153	-.321	.284
Hetero Fiber%	.156	-.041	-.754**	1	.520**	-.070	-.090	-.265	-.131	.033	.310	-.231
Pure Fiber %	-.271	-.238	-.957**	.557**	1	.076	.029	-.080	-.241	-.264	.257	-.262
Hairy Fiber Diameter	.129	-.016	.015	.007	.009	1	.907**	.911**	.246	-.023	-561**	.532**
Hetero Fiber Diameter	.073	-.093	.144	-.167	-.108	.886**	1	.879**	.275	-.040	-522**	.381*
Pure Fiber Diameter	.153	.014	-.035	-.049	.078	.875**	.923**	1	.292	-.026	-626**	.495**
Scouring Yield%	.278	.114	.379*	-.107	-.415*	-.014	-.064	-.117	1	.024	-743**	.324
Fiber Wax %	.422*	.356*	.115	.131	-.168	.048	-.038	.003	.404*	1	.007	-.124
Burr%	-.386*	-.211	-.336	.047	.367*	-.167	-.072	-.058	-905**	-.469**	1	-.622**
Ash%	-.138	-.210	.086	-.060	-.102	-.136	-.025	-.088	-.143	-.169	.117	1

***. P<0.01 *P<0.05, Dinsho (upper diagonal) and Agarfa (lower diagonal)*

The findings pertaining to the correlations between the physical and chemical parameters of fibers of long haired Arsi Bale does reared in Agarfa are presented as lower diagonal (Table 8). The study shows that the SL values are correlated (P<0.05) with the C and also fiber wax values. The study also indicates that the numbers of hairy fibers are correlated (P<0.05) though negatively with those of hetero and pure fibers. The study also indicates that the numbers of hetero fibers are correlated (P<0.01) with those of the pure fibers.

The numbers of pure fibers are negatively correlated (P<0.05) with scouring yield and also correlated (P<0.05) with B. The hairy fiber diameter is also correlated (P<0.01) with those of Hetero and Pure fiber diameter. The study also indicates that hetero fiber diameter is correlated (P<0.01) with the pure fiber diameter. The scouring yield is negatively correlated (P<0.01) with those of B, while its also correlated (P<0.05) with those of Fiber wax. While the fiber wax and B are negatively (P<0.01) correlated.

Table 9: Correlation between the physical and chemical properties of Bucks reared at the study areas

	Staple length	Crimp (Nos/inch)	Hairy fiber%	Hetero Fiber%	Pure Fiber %	Hairy Fiber Diameter	Hetero Fiber Diameter	Pure Fiber Diameter	Scouring Yield%	Fiber Wax %	Burr%	Ash %
Staple length	1	.668**	.443*	-.427	-.324	.159	.244	.204	-.105	.317	-.107	-.067
Crimp (Nos/inch)	.881**	1	.294	-.255	-.232	-.241	-.221	-.250	-.075	.176	.011	-.366
Hairy fiber%	.286	.203	1	-.692**	-.897**	.056	.203	-.008	.093	.418	-.123	.117
Hetero Fiber%	-.310	-.203	-.857**	1	.302	.002	-.150	.055	-.224	-.471*	.298	.006
Pure Fiber %	-.223	-.171	-.936**	.621**	1	-.076	-.176	-.023	.014	-.263	-.020	-.158
Hairy Fiber Diameter	.598*	.541*	.250	-.204	-.241	1	.911**	.956**	-.010	.128	-.020	.568**
Hetero Fiber Diameter	.670**	.573*	.227	-.203	-.207	.966**	1	.918**	-.128	.232	.004	.574**
Pure Fiber Diameter	.696**	.582*	.244	-.185	-.244	.896**	.891**	1	.008	.085	-.063	.509*
Scouring Yield%	.181	.043	-.006	.200	-.128	-.065	-.078	.009	1	.307	-.712**	.087
Fiber Wax %	-.140	-.328	.066	.008	-.106	.141	.111	.017	-.001	1	-.392	.346
Burr%	.034	.184	.045	-.230	.089	.516*	.490*	.326	-.781**	.075	1	-.189
Ash%	-.479	-.495*	-.241	.297	.164	-.936**	-.896**	-.798**	.241	-.125	-.681**	1

***. P<0.01 *P<0.05, Bucks Dinsho (upper diagonal) and Agarfa (lower diagonal)*

The findings as presented in Table 9 show that the fibers of the bucks reared at Agarfa are presented as upper diagonal. The findings show that the staple length is correlated (P<0.01) with the numbers of crimp and also those (P<0.05) of numbers of hairy fibers.

The numbers of hairy fibers are negatively correlated (P<0.01) with those of hetero and pure fibers, while the numbers of hetero fibers are negatively correlated (P<0.05) with the wax percentage. The diameter of hairy fibers is correlated (P<0.01) with those of hetero and fine fibers besides also that of A. The study also indicates that the numbers of hetero fibers are also correlated (P<0.01) with those of diameter of the pure fiber and also that of A. The diameter of the pure fiber is also correlated (P<0.05) with those of A. The study further indicates that scouring yield is negatively (P<0.01) correlated with B.

The results pertaining to the correlation results from Agarfa (lower diagonal) indicate that the numbers of crimp, hetero and pure fibers are correlated (P<0.01), while numbers of crimp are correlated (P<0.05) with hairy, hetero and fine fiber diameters while it is negatively correlated (P<0.05) with A. The study also indicates that the numbers of hairy fibers are negatively correlated (P<0.01) with the numbers of hetero and fine fibers. The study also indicates that the numbers of hetero fibers are correlated (P<0.01) with those of the fine fibers. The diameter of the hairy fibers are correlated (P<0.01) with those of hetero and pure fibers, while the numbers of hetero fibers are correlated (P<0.01) with those of fine fibers and in both the cases its negatively correlated with those of the A percentage .The study also indicates that the scouring yield is negatively (P<0.05) correlated with the B values, while the B and A values are negatively (P<0.01) correlated.

5. DISCUSSIONS

5.1. Some Physical and Chemical Properties of Fleece of Arsi Bale Bucks Reared in Different Agro Climates

The differences in the numbers of crimp between the bucks population reared in the two locations may be ascribed to the nutrition received by the bucks in the two locations. Studies by (Reis, 1998) indicted that the numbers of crimp are correlated with the sulphur content in the diet. The staple length of the bucks as obtained in this study was in close accordance with the findings of (McGregor and Umar, 2000) from (Australian cashmere) breed of goats. However, the SL as reported in this study was lower than those reported by (Reza-Yazdi *et al.,* 2002) from (Chinese goats). The crimps as reported too are in close accordance with the differences in the numbers of pure fiber may also be ascribed to the genetic makeup of the bucks (Gedgaudas, 2017). Studies by (Bawden *et al.*, 1998) have also indicted that there can be differences in the proportion of pure fibers due to deficiency of copper in the diet of the bucks. Deficiency of copper in the diets often lead to steely wool condition which leads to thinning of fibers and hence the proportion of the fine fibers seems to increase, however this condition is reversible with the availability in dietary copper (Reis *et al.,* 1989, and Aupperle *et al.,* 2001).

The Scouring yield determines the amount of usable fleece for commercial purposes (McGregor, 2007). Higher proportion of scouring yield is indicative of the condition of usable fleece which is higher and is correlated with low wax and burr % (McGregor, 2003). Differences in the wax percentage of the fleece as reported in the study may be ascribed to the secretions from the body surface of the animals (Ferguson *et al.,* 1949). The secretions are usually correlated with the agro ecology with higher secretions in the mid altitude regions in comparison to the higher altitude areas (Celi *et al.*, 2001). High fleece wax also prevents the animals to get wet in the rainy season (McGregor, 2007) and hence facilitates grazing even in the harshest weather (Stapleton, 2007). Thus, seasonal variation in the fleece wax has also been reported by (McGregor, 2007) which may be due to the type of feed and also the incidences of ecto parasites (Dc Bersaques, 1999, Walkden-Brown, 2007). High amount of wax also attracts higher dust and vegetable matter in the fleece thereby reducing the scouring yield and the quality of the fleece (McGregor *et al.*, 1991; McGregor, 2003b).

5.2. Some Physical and Chemical Properties of Fleece of Arsi Bale Does Reared in Different Agro climates

The results from the table 5, shows variation in SL of the does, the differences as obtained may be ascribed to the quality of the feed besides the genetics of the does (Ansari-Renani, 2004; Allain, 2003). The SL as observed in the study are in close accordance with the observations of (Selçuk, 2018), however higher values are reported by (McGregore *et al.*, 2011) from (Raeini goats from Iran). It has been reported that fleece with low SL have poor spinning properties.

However the SL as observed in this study is adequate for ensuring proper spinning. Crimp is also associated with the spinning capacity of the fiber. The fibers with higher crimp per inch usually have good spinning properties (McGregor, 2000). The crimp as observed in the study are quite low in comparison to what has been reported by (McGregor, 2001) from (Chinese cashmere).The amount of crimp too indicated variation which can be ascribed to the amount of sulphur containing amino acids in the diets (Qi *et al.*, 1992). Lower the numbers of crimp was higher among the goats (irrespective of both the sexes) reared at Dinsho which may be ascribed to both genotype and the quality of the feed (Ansari, 2012).

The diameter of the hairy, hetero and also the hairy fibers varied among the does reared across the locations, which can be ascribed to the genetic differences (Lupton *et al.*, 2004). The lower the diameter of the hetero and pure fibers indicate a good quality fleece (McGregor, 1991). However, the opposite is true for the hairy fibers, as the hairy fibers serve as guard fibers and are helpful in protecting the goats from the rain at the time of grazing (McGregor, 2007).The results relating to the scouring yield too is in close accordance with the findings of the previous table. The low scouring yield is correlated with higher amount of wool wax and burr content which too is in close accordance with the findings of (Banerjee, 2009). Scouring yield determines the overall usable fleece for commercial purpose (McGregor, 2007). The scouring yield values as obtained in this study are higher than those reported by (Simmonds, 2001) from (Australian Angora goat), however there are differences in the value due to season and the management of the animals themselves (Chaffey, 2006).

The amount of fleece fat is also influenced by the environment where the animal resides and it is a secretion from the skin surface and while in one hand it protects the animal from the rain, it also tends to attract the dust and other foreign matters which lower the overall recovery of the fleece for commercial purposes (Banerjee, 2009; Taherpour *et al.,* 2012; Bottomley, 2001, and Yeates *et al.,* 1999). The burr percentage are correlated with the pasture management and better the pasture management lower the incidences of grasses and weeds on the fleece and lesser is the burr percentage (Taherpour *et al.,* 2012). The burr percentage is associated with the thorns and seeds of some pasture grasses which tend to entangle with the fleece and hence impair with its quality (Hansen, 1924).

5.3. Some Physical and Chemical Properties of Fleece of Arsi Bale Does and Bucks Reared in Dinsho and Agarfa Districts

The findings from Table 6, indicate the differences across the sexes (bucks and does) raised in the Dinsho indicate that there were differences due to sexes in fiber wax values, the findings are in close accordance with those of (Couchman and McGregor, 1983) . The higher fiber wax as observed in this study may be due to sexual dimorphism and androgenic causes (Kelley, 1988). The differences have also been recorded in the numbers of hetero and hairy fibers (though statistically not significant) while the hetero fiber which is higher among the does indicates that they may be selected for carpet wool (Chapman and Ward, 1999) while the bucks may be selected for appeal (Watkins and Buxton, 1992). The differences in the scouring yield of the bucks and does are ascribed to their grazing behavior and the distances covered while grazing (McGregor, 1992).

The differences in the physical and chemical properties of fleece of the bucks and does reared at Agarfa District indicate differences due to sexes, the differences in the staple length and the numbers of guard fibers (hairy fibers), the observations are in close accordance with those of (Jin and Zhang 1995, Kuloğlu, 2010) in (Chinese goats, turkey goats) breed. The differences as observed may be due to androgenic causes attributable to higher testosterone secretion leading to longer and thicker hairs (Randall, 2008). The thinner hetero and hairy fibers as have been reported among the does may facilitate their usages as carpet and appeal grades which again will help in their commercial usages (Chapman and Ward, 1999). The wider variability in the hairy and pure fiber values indicate that within genotype selection is possible in the traits thereby indicating a chance of improving the same (Peters, 1987).

5.4. Correlations between the Physical and Chemical Properties of Fleece from Arsi Bale Does and Bucks Reared in Two Agro Ecology

The findings as presented in Tables 8 and 9, indicate that staple length and crimp was have positive correlation (P<0.01) this was in consonance with the findings of (McGregor and Umar, 2000). This is because the crimp is usually formed due to disulphide bonds the numbers which usually increase with the length of the fiber (Qi *et al.,* 1992; Staple *et al.*, 1993). The numbers of hairy fibers are negatively correlated with those of the hetero and pure fibers, this is because animals living in the cold climate usually have more pure fibers to protect them from cold while those in the warm climate usually have fewer pure fibers to protect them from cold and have more numbers of guard or hairy fiber to protect the animals from ecto- parasites and rain (Ansari-Renani *et al.,* 2013).

The numbers of hetero and pure fibers too are correlated as the hetero have intermittent medullation while the pure fibers are devoid of any medullation (Allain, 1992; Mitchell *et al.,* 1991; Nixon *et al.,* 1991; Ryder 1966; Carter and Clark 1943; Petrie 1995) The correlation between the diameters of hairy, hetero and pure fibers as obtained in this study are in close accordance with the findings of (Hunter, 1993). Thicker the fibers lower is its cost and market acceptability hence within genotype selection has to be carried to identify animals which have lower fiber diameter (Ansari-Renani *et al.,* 2013). Thicker the fiber higher will be the incidences of mineralization and therefore the ash content. The findings also indicate that the fiber diameter are negatively correlated with the burr percentage higher the fiber diameter lesser are chances of entanglement with the vegetative matter and vie versa (Taddeo, *et al.,* 1998).The negative correlation between ash content and the burr may be ascribed to the fact that burr is a vegetative matter and higher burr content is indicative of lower mineralization percentage in the fleece (Ansari-Renani *et al*., 2013).

The findings from Table 9, is indicative of the staple length is also correlated with the numbers of hairy fibers; the observations are in close accordance with the findings of (Lavvaf, 2013). This may be because the guard / hairy fibers are usually longer and serve as a protection against rain; the other values for the correlations are in accordance with the discussions for Table 8.

6. SUMMARY AND CONCLUSION

The findings from the study indicated at there were differences in the physical and chemical properties of the fibers due to the location. The differences were observed across both the sexes. The differences as observed can be due to the traditional selection objectives which vary across the agro ecologies. This is besides the crossings of the long haired does and bucks with goats of other genotypes. The numbers of pure fibers were higher among the bucks reared at Dinsho which can be attributed to the adaptability of the bucks in the cold agro climate of the region. The scouring yield was higher among the bucks reared at Dinsho because of lack of agricultural activities which resulted in less dust and dirt, besides the same wax and burr was higher in Agarfa, which can result in diminishing the quality of fleece, similar findings were also recorded among the does. However, among the does the fiber diameter (pure and hetero) was less from Agarfa.

The differences across the sexes could be attributed to sexual dimorphism and also hormonal differences between the sexes. The correlations between the physical and chemical properties of the fleece will help in selection of the bucks and does from correlated traits in absence of equipment's like digital microscopes, besides it also indicates the parameters which can be improved in tandem. The study also shows that the numbers of long haired Arsi Bale goats are fast dwindling due to crossings with short haired Arsi Bale goats especially at Agarfa District. Hence immediate conservation efforts are desired. The wide variation in the fleece quality traits show that there is a possibility of within genotypes for the traits and hence an insitu and exsitu conservation program for the genotype need to be initiated by National Animal Genetic conservation Institution.

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8. APPENDICES

Appendix 1; Equipment and Chemicals for Chemical Analysis

Equipment and chemicals used for laboratory scouring yield.

I. Apparatus and reagents

A. Four bowls/breakers

B. Non-ionic (neutral) detergent

C. Digital balance (0.001 gram)

D. Sodium carbonate

E. Non-ionic detergent

II. Material to scouring solution ratio-1:60

III. Temperature of bath, 50^0c to60^oc(appox).

IV. Time of immersion per sample 3-6 minutes

Equipment and chemicals used for vegetable matter

I. Apparatus and reagents

A. Beakers

B. Digital balance

C. Ventilated oven(hot and oven)

D. Filter paper

E. 5% sodium hydroxide solution (NaOH)

F. Heaters

II. Materials: representative scoured sample 3 grams each

III. Material and liquid ratio 1:30 (approx.)

Equipment and chemicals used for wool wax

I. Apparatus and reagents

A. Soxhlet apparatus
B. Heating bench
C. Digital balance (electronic
D. Filter paper
E. Hot air oven/ ventilated oven
F. Petroleum ether (60o-80oc) grade

II.Material

A. 5 grams of raw fiber sample

III. Number of siphons per sample: 10 times.

Equipment used for ash determination.

I. Material and apparatus

A. 3 grams scoured fiber sample
B. Ventilated/Hot air oven
C. Digital Balance (0.001)
D. Muffle furnace
E. Silica crucibles

Appendices 2. Figures of Research Work

Figure 9 Fiber sample collection at Dinsho &Agarfa districts

Figure 10, Fiber analysis at laboratory

BIOGRAPHICAL SKETCH

The author was born in the month of June 1990 in Bule Hora district of West Guji Zone (Oromia), Ethiopia. He attended his elementary education from 1998 to 2003 at Gerba Elementary School. He attended his junior secondary education school education from 2004 to 2005 at Bule Hora Comprehensive Secondary School. He then joined Chiro Agriculture College in 2006 and obtained his diploma by Animal Sciences in June 2008. He was employed and served with bureau of agriculture, Melka Soda woreda as development agent from 2009 G.C up to 2013G.C. He Joined Adama Science and Technology University 2014; and graduated with Bachelor in Animal Sciences on June 2016. Then he work Melka Soda District as expert in livestock and fisheries office from 2016-2017.Then in September 2018, he has joined the postgraduate program of Hawassa University to study MSc degree in Agriculture (Animal Breeding and Genetics).