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EVALUATION OF MICROBIAL SAFETY AND PHYSICOCHEMICAL QUALITY OF CARCAS FROM BORENA AND CENTRAL HIGHLAND OF NORTH SHEWA GOATS

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Evaluation of Microbial Safety and Physicochemical Quality of Carcass from Borena and Central Highland of North Shewa Goats

By

Abebe Getachew

Submitted In Partial Fulfillment of the Requirements for the Degree of Master of Science (M.Sc.) in Food Safety and Quality

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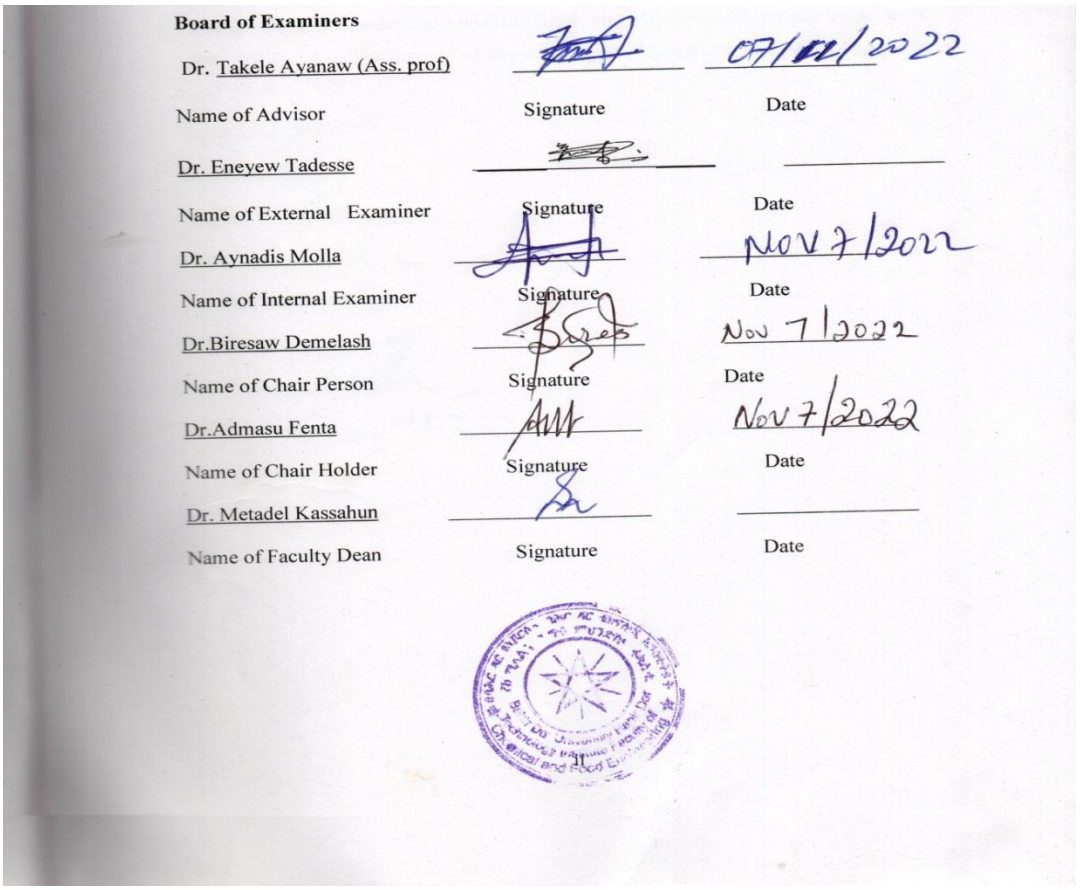

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This is to certify that the thesis entitled "Evaluation Microbial Safety and Physicochemical Quality of Carcass from Borena and Central Highland of North Shewa Goats submitted in partial fulfillment of the requirements for the degree of Master of Science in **Food Safety and Quality** under school of **Chemical and Food Engineering**,Bahire Dar Institute of Technology is record of original work carried out by me and has never been submitted to this or any other institution to get any other degree or certificates. The assistance and help I received during the course of this investigation have been duly acknowledged.

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DEDICATION

This work is dedicated to my uncle teacher Esayas Demessie and my mom Tesefanshe Demessie who taught me how to pass hurdles of life with patience and unreserved effort of hard working and grace of being faithful to almighty God.

ABSTRACT

The demand for goat meat has been increasing globally due to its ideal choice for health-conscious consumers. Goat meat has been generating foreign currency to Ethiopia. However, the highland goat is claimed for quick darkening and shortage of shelf-life. On the other hand customers prefer lowland goat including Borena goat with specific slaughter age. The objectives of the study were to evaluate microbial safety and physicochemical quality of carcass from Borena and central highland of north Shewa goats. A total of 12 intact kids of (6 Borena and 6 North Shewa) with the age of 0-teeth and 1-teeth old age were used for the study. The data were analyzed by 2x2 factorial arrangements of (2 location × 2 age group) with complete random block design using IBM SPSS version 22. The physicochemical meat quality attributes were evaluated on Longissimus dorsi muscle and microbial safety were determined using flank, neck and brisket samples. Borena goat had higher P<0.05 live weight, *hot carcass weight, dressing percentage, kidney, liver, feet+skin, lung+treachea, meat color of (lightness L*-value, yellowness b*-value and hue angle), cooking loss, and crude fat compared to North Shewa goats.* The none-carcass components (head, heart, viscera), meat color of (redness a*, Chroma) pH45, pH_{3h} carcass temperature *at (T_{45} and T_{3h}), moisture, protein, and ash were similar P>0.05 between Borena and north Shewa kids. North Shewa goat carcass pH_{24} and water holding capacity meat had significantly were significantly higher P<0.05 than Borena kids. The live weight and hot carcass weight were significantly increased P<0.05 with increasing slaughter age. The 0-teet old kids meat had significantly higher P<0.05 lightness (L*value) and moisture content. The load of total vial count, total coliform count and Escherichia coli were higher marginally higher P>0.05 in North Shewa goat meat. It can conclude that age and location had significant effect on carcass yield and physicochemical carcass and meat quality attributes. Borena goat had higher carcass yield and better meat quality whereas; North Shewa goat can be had lower carcass yield and dark meat color. It is advisable to use 0-teeth-old Borena kids to produce better quality meat for commercial purposes and reduce incidence of darkening highland goat meat.*

Keywords; Color, pH, hot carcass, Age, North Shewa, Borena, Quality, Microbial load

ABBREVIATION AND ACRONYM

AMSA	American meat science association
ISO	International Organization for Standardization
GDP	Gross Domestic Product
TVC	Total Viable Count
TCC	Total Coliform Count
E .coli	Escherichia coli
USD	United State Dollar
PH	Power of Hydrogen
H	Hour
CSA	Central Statistical Agency
CFU	Colony Forming Unite
Min	Minute
MT	Metric Tone
ECAE	Ethiopian Conformity Assessment Enterprise
SNNP	Southern Nation and Nationalities
FAO	Food and Agricultural Organization
DFD	Dark Firm Dray
EMDIDI	Ethiopian Meat and Dairy industry Development Institute
CIE	Commission International de Elcairage
MAS L	Meter above sea level
$	Dollar
US	United state
OECD	Organization for Economic Co-operation and Development

Table of Contents

LIST TABLE

LIST OF FIGURE

1 INTRODUCTION

1.1 Background of the Study

Agriculture is the backbone for Ethiopian economic development contributing about 35% to GDP, 68.2% to employment and 90% of export value (FDRE, 2016).Livestock production is an integral component of agriculture that has great potential of enhancing the economic development of the country. The sector is contributing 40% of agricultural GDP, 20% of total GDP, and 20% of national foreign exchange earnings (World Bank, 2017). Ethiopia has a huge livestock population ranked first in Africa and tenth in the world with 65 million cattle, 51 million goats, 40 million sheep, and 8 million camels (CSA, 2020/2021).

Goat/Capra hircus/ is the first domesticated livestock species (Monteiro et al., 2018).Goats are versatile animal species due to their strong adaptability to extreme environmental conditions (Aziz, 2010).Goats are popular in Asia and Africa where 57.7% of the world's goat population is found in Asia and 35.7% found in Africa (FAO, 2018).According to Guerrero et al. (2018) there are 570 different breeds of goat with genetic variation of species, morphology, productive performance, and an adaption of specific climate conditions.

Ethiopia has third largest goat population in Africa and seventh in the world (Mazhangara et al., 2019). Goats are found in all agro ecology of the country predominantly in pastoral, agro pastoral, and mixed-crop livestock production systems and 70% of goats and 35% of red meat are produced in lowland grazing pastoral and agro-pastorals livestock production systems (Shapiro et al., 2017). Therefore, goats are very important sources of meat and milk, cash income, and fulfilling cultural obligations for pastoralists and agro pastoralists (Fereja, 2016).

Based on physical description and management type Ethiopian goats are grouped into 12 breeds such as Afar, Abergelle, Arsi-Bale, Woito-Guji, Hararghe Highland, Short-eared Somali, Long-eared Somali Central highland and western highland, western low land and Keffa (FARM-Africa, 1996; Gizaw, 2009).

Borena goat is categorized under long eared Somali goat breed whereas north Shewa goat is classified under central highland goat breed (FARM-Africa, 1996; Peacock, 2005).Borena goat is found in south east and southern of arid and semi-arid ecology of Ethiopia. Borena goat produce good quality meat which has rapidly increasing demand both in domestic and export market (Zewdu Edea Bedada, Bikila Negasa Gilo, 2019).North Shewa goat classified under central highland breed and characterized by red brown coat color, curved or straight horn (Kasahun and Solomon, 2008). Central highland goat meat is claimed for quickly darkening of meat color and shortage of shelf-life (Abebe et al., 2010).

Even though, Ethiopia has largest goat populations in Africa the average carcass weight is 10 kg which is lower than the average carcass weight of 11kg in east Africa (Adane and Girma, 2008). The main constraint for the lower productive performance of goat is breed, disease, parasite incidence, shortage and poor quality of feed (Misbah & Belay, 2016).

Goats are primarily kept for their meat, milk, and fiber (Arguello, 2011; N.H. Casey, 2010). Meat is a flash of animal consumed as food including edible organs originating from mostly consumed animals species such as sheep, goats, cattle, pigs, rabbits, and poultry (Lawrie, 2006). Carcass is the body of animal after skinning and dressing (Boler & Woerner, 2018). Meat can be classified into red and white based on myoglobin concentration, mitochondrial densities, lipid profile, muscle fiber physiology, and physiological change during postmortem metabolism (Keeton & Dikeman, 2017).

Nutritionally meat is an important source of protein essential amino acids, healthy fatty acids, vitamins (A, B, and E), and minerals (zinc, iron, selenium, potassium, and magnesium) (Pereira & Vicente, 2013). However, red meat consumption is associated with chronic diseases such as obesity, diabetes, atherosclerosis, hypertension, and cancer due to high concentrations of cholesterol and saturated fatty acid (Boada et al., 2016; Klurfeld, 2015; Wang et al., 2016).Goat meat has also been

an emerging alternative source of red meat (Arguello et al., 2005). Because red meat consumers are demanding, nutritionally rich lower in health risks (Anaeto et al., 2010). Goat meat is healthier than any other red meat due to, its lower total fat, saturated fat, and cholesterol concentration (Anaeto et al., 2010; Horcada et al., 2012). Irrespective of age and breed type goat meat is a good source of high-quality protein and all essential amino acids (Addrizzo, 1992).

Goat meat consists of higher threonine than beef and pork, more valine than pork and lamb, and more methionine, arginine, and tryptophan than beef, pork, and lamb (Pellett, P. L. and Young, 1990). The fat content of goat meat is 42-59% less than lamb and 25% less than veal (Wulf et al., 2002). The saturated fat in goat meat is 85% less than poultry and 90% less than lamb (Muchenje et al., 2009). Hence, goat meat has been a healthier alternative and ideal choice for health-conscious consumers (Gitam Singh R. B. Sharma, 2017; S. Ivanovic & Pavlovic, 2016; M.S. Madruga, 2011). This point, goat meat has great potential to fill a special market niche in the global meat market (Ivanovic & Pavlovic, 2016b; Mazhangara et al., 2019).

Quality is the features of products that can meet customer needs and provide greater satisfaction (Juran & Godfrey, 1998). Quality is defined by differently by different people depending on personal needs and expectations from the use of a particular item. According to ISO (9000; 2005), quality is the ability consistently provide the product or service that can meet the need, expectations, and requirements of customers, consumers, and regulatory bodies.

Meat quality is defined on the basis of conformational and functional qualities(Warriss, 2000).Functional quality is desirable attribute in the product whilst the conformance quality is meeting consumer specification (Warriss, 2000).Function quality of meat related the intrinsic properties of t lower in saturated fat and lower intramuscular fat, high ratios of unsaturated fatty acid and hypocholesterolemic fatty acid goat (Pophiwa et al., 2020).

Meeting consumer needs of in terms of meat fat content cutting can be defined as conformational quality. On the other Madruga et al. 2009) define meat quality in combination of chemical and microbial quality.

Meat pH, color, water holding capacity, and cooking loss are meat quality attributes (Bauer, 1973; ElMasry & Sun, 2010; G. Januškevičienė, 2012; Hopkins & Geesink, 2009).Meat color and water holding capacity are main quality characteristics and concern of meat industries because its influence on consumer purchasing decision-making (Khliji et al., 2010)and economical value related to the weight of the product (Hughes et al., 2014).

Carcass yield is important quality criteria of producer and processor expressed by dressing percentage that varied between 40 to 56 % in young and old adult (N H Casey, 2003).Carcass composition is important feature of meat quality which assessed by physical dissection (muscle, fat, bone) or by proximate analysis of moisture, protein fat and ash (Moran, 1986).Meat composed of 75% water, 20% protein, 4% fat and 1% vitamins (Boler & Woerner, 2017). Goat meat consists of about 75.42% water, 3.55% fat, 19.95 % protein, and 1.06% mineral (Ivanovic et al., 2014a).Meat quality is affected by environmental factor slaughter, age, breed and stress (Albrecht & Dresch, 2016; Pophiwa et al., 2020).

1.2 Statement of the Problem

The demand for food quality has been increasing due to, deriving force increasing trade of agricultural products that enabled the consumer to wider access of choice to different origin products (Curzi & Pacca, 2015).

Color is the most important fresh quality attribute that influence consumer purchasing decision (Troy & Kerry, 2010).).Dark firm dry (DFD) is meat quality defect unpleasant to consumers that lead to financial loss for meat industries (Węglarz, 2019). Because dark meat is discriminated against to normal bright-cherry red fresh meat color that imposes for down grading loss of discounting (Ramanathan et al., 2020a).Australian meat export industries lost 15-177$ annually due to, downgrading cost of darkening (Warner et al., 2014).

Ethiopia has incurred about 272 million US dollars every year due to the quality problem of import and export of agricultural food commodities (Beshah et al., 2015). The country has 22 meat processing industries either already established or in the phase of construction however, only 15 industries are working either meat or offal processing under 34% of their capacities (Industry minister, 2015).Lacks of good quality meat producing animals that can meet the quality requirement customers has been hindering the potential of country generating foreign currency via limiting meat export performance the industries (Eshetie et al., 2018; Girmay & Yeserah, 2019).

Ethiopian meat export is restricted to certain slaughter age and origin of goat due to specification of imports in Middle market. Lowland goat carcass especially Borena, Somalia, and Afar with slaughter age of 12-15 month old kids is the most preferred in Middle East market (Yami et al., 2018).However highland goat carcass is unacceptable often claimed for quick darkening and shortage shelf life (Abebe et al., 2010; Yami et al., 2018).In general Ethiopian goat meat is perceived as poor quality consequently the price has been paid to Ethiopian meat is lower than other countries (Legese et al., 2014).Hence, evaluation of meat quality is important to deliver reliable information and guarantee the quality requirement of consumer (Damez & Clerjon, 2008).

The study conducted on physicochemical goat carcass quality with demand of customers is quite a few .Therefore the objective of the study was to evaluate the effect of age and location on physicochemical meat quality and carcass yield of North Shewa and Borena goat.

1.3 Objective of the Study

1.3.1 General objective

- To evaluate the physicochemical and microbial safety of meat and carcass from Borena and central highland of north Shewa goat

1.3.2 Specific objectives

- To evaluate physical quality and carcass yields from Borena and north Shewa goats
- To evaluate the microbial safety of Borena and north Shewa goat carcass
- To evaluate the proximate composition of Borena and north Shewa goat meat
- To determine the effect of slaughter age on proximate composition, physical meat quality and carcass yield of Borena and north Shewa goat

1.4 Significance of the Study

Per-capita meat consumption increased from 23 to 42.2 kg from 1961 to 2011 (Sans & Combris, 2015). The rapid population growth, increasing income, and urbanization were the driving forces for the increasing demand for meat (FAO, 2009). Since the base period of 2000, the global population is projected to increase to 9.5 billion by 2050 United Nations Department of Economics and Social Affairs (UNDESA, 2019).This huge population needs an additional large amount of animal-origin foods (Henchion et al., 2014; Thornton, 2010).

The demand for meat projected raised by 14% in 2030 (OECD, 2018).Goat meat consumption increased globally by 41.66% from 2000 to 2012 (Bampidis, 2018). Goat and sheep meat export is projected to be increased by 268%, from 1.5 million MTs in the base time of 2010 to 5.6 million MTs in 2050 (Enahoro et al., 2021).

Goats are the main raw material for Ethiopian meat exports, accounting for more than 90% of the country's total fresh meat export (Yami et al., 2018). Ethiopia is the second largest in fresh goat meat export next to Australia which has increased by 7.5% in the last five years from 2014-2019 (www.nationmaster.com).The value of goat meat export increased from 3.39 to 111 million US dollars from 1997 to 2019 (United Nations Statistical Office, 2019). Ethiopia gained 851million US dollars from 2006 to 2019 by exporting 154,166 Mt of meat (COMTRAD, 2019).

To intensively use the potential of livestock resources ministry of industry established an agro-industry strategic plan in the meat industry sub-sector to bring structural change in the livestock sector to increase the volume of meat export from 15,392 tons in the base period of 2015 to 697,000 tons by 2025 (MI, 2015). In addition of increasing volume the demand of the meat quality has been also increasing (ElMasry & Sun, 2010). Therefore addressing the consumer meat quality needs and expectation had positive impact for competitiveness of meat industries (Troy & Kerry, 2010). Evaluations of meat quality is helpful for quality-based grading and marketing system, strategic meat quality improvement and deliver appropriate information to consumers and customers.

2 LTERATURE REVIEW

2.1 Meat Quality

2.1.1 Carcass pH

Meat pH is the most important meat quality attributes that influence a consumer's purchasing decision (Brandy lynnk Knox, 2010; Pengli et al., 2014). Meat pH leads to an economic loss of saleable products due to drip loss and by imposing to regulatory penalties (Gardner et al., 2014). Meat quality can be defined in the combination of on chemical, microbial and sensory quality (Madruga et al., 2009).Meat pH is measured by conventional glass electrode at 24 to 48h post-mortem has been used as a benchmark for detecting dark firm and dry meat (Fletcher, D. L., Qiao, M., & Smith, 2000; Neethling et al., 2017).

After the animal slaughtered aerobic respiration ceased and mitochondrial ATP synthesis stopped and glycogen was aerobically broken to lactic acid as a result of the reduction of pH from pH 6.8-7.3 to 5.4-5.8 then the muscle changed to meat (Bender, 1992). In stressed animals, muscle glycogen is rapidly released into the blood and broken down to lactic resulting lowering of pH while the carcass is warm (Lomiwes, 2008). Animals are chronically stressed by starvation, improper transportation, and improper handling the muscle glycogen is depleted and resulting higher ultimate (Bender, 1992; Gardner et al., 2014; Lomiwes, 2008). The ultimate pH of greater than 6 is Dark and firm and dry (DFD) meat (Mounier et al., 2006; N H Casey, 2003; Nikola1 et al., 2019).

The rate of pH declines is associated with soft pale exudative (PSE) and high ultimate pH is related to dry firm and dry (DFD) condition. Dark Firm Dray meat (DFD) and Pale, Soft exudative (PSE) are among the most common meat quality defect (Karabasil et al., 2019). The rapid decline of pH leads to higher acidification of muscle that causes breaks down of muscle structure resulting in pale soft exudative meat (PSE) which is most common in pigs (Mushi., 2007).PSE meat occurred when the initial pH is rapidly reduced

to 6 at 45 minutes in post-mortem or ultimate pH of lower than 5.3 (Cobanović N, et al., 2019). Rapid declining of pH is caused by the exposure of the animal to acute stress such as fighting and hitting immediately long transportation, starvation, and overcrowding at lairage before slaughter (Warriss, 2000). Diffusionof Less oxygen in higher pH meat is related to rapid oxygen consumption and lower blooming (Ledward, 1985).

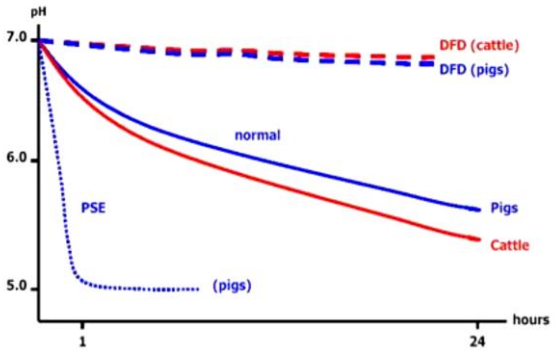


Figure 1. The rate of pH change and its impact on meat quality

Sources;(Hautzinger, 2007)

Glycogen is an energy store muscle and serves as the source of readily available glucose in the form of glucose -1- phosphate. Glycogen is metabolized to glucose and free fatty acid in response to high energy demand when animals are stressed and feared. Therefore, per-slaughter muscle glycogen concentration determines the ultimate pH of meat (Rosenvold et al., 2001; Young et al., 2004).

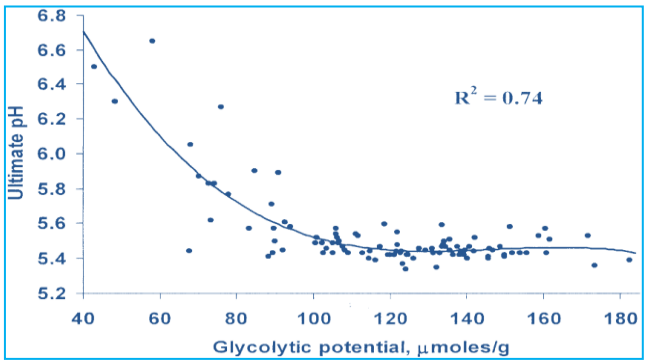


Figure 2: Relationship glycolytic potential and ultimate pH

Sources; (Wulf et al., 2002)

The ultimate pH ranging from 5.7 to 6.0 post-slaughter has been used as a threshold of DFD for beef (Jeremiah et al., 1991). According to June et al. (2014) the desirable pH ranges from 5.5 to 5.8 and is associated with light-colored, tender meat whereas the pH values above 5.8 adversely affected bacterial growth. Meat with low ultimate pH may be of poor eating quality because enzymes involved in postmortem tenderization are inhibited by acidification (EMushi, 2007). In addition, low ultimate pH is associated with increased drip loss resulting in meat with poor overall acceptability (Braggins, 1996).The ultimate pH of greater than equal to 5.87 is considered as Dark Firm dry meat (DFD) meat(Wulf , 2001)..The high ultimate 5.9-6.5 holds higher intracellular water so much light absorbed and meat appears dark and dry (Miller, 2007).

Meat pH is important during processing to achieve good taste and flavors. Meat with pH 5.6-6 is desirable for product to have good water binding for processed meat like frankfurter and cooked ham but, for preparing ripening and fabricated raw ham and dry fermented sausage lower pH of 5.6-5.2 is preferred because of its lower water-binding capacity (Hautzinger, 2007).Generally meat pH values above 6 are considered unsuitable for storage because high pH is favorable for the development of photolytic microorganisms (Bender, 1992).

2.1.2 Meat color

Fresh meat color is one of the most important quality criteria of consumer purchasing decisions and bright red color is the primary choice in the consumer preference (Killinger et al., 2004).Consumers tend to reject any deviation from normal bright cherry red color of fresh meat (Khliji et al., 2010; Ponnampalam et al., 2017). Many studies showed that meat color is affected by breed, slaughter age, and muscle type (Simela, 2005; W. Ding et al., 2010).Color is the reflection of different wavelengths of light emanating from an object, either absorbed pass-through or reflected. Evaluation of meat color is important for grading, measuring color change and meeting customer requirements, and determining the cause of discoloration (Owen A. Young and John West, 2001).

Fresh meat color is a very important physical quality that has a very significant role in consumer purchasing decisions because consumers consider color as an indicator of freshness and quality (Font-i-Furnols & Guerrero, 2014; Ponnampalam et al., 2013). The color of the meat is affected by more factors such as species, stress sex, slaughter age, rate of pH declining, and the level of ultimate pH (Seideman et al., 1984). Consumers prefer bright cherry-red meat for purchasing decisions (Carpenter et al., 2001; Prill et al., 2019). The color of the meat is determined by the extent of light scattered, absorbed, or back reflected light to the eye, which determines, the acceptability and perception of the consumer (Purslow, 2020). Meat with a higher lightness L* is a brighter red and is acceptable to consumers (Arguello, 2005).Meat color is affected by numerous multifaceted factors that could be categorized into pre-mortem and post-mortem factors (Bekhit et al., 2018) as showed in figure 3 below.

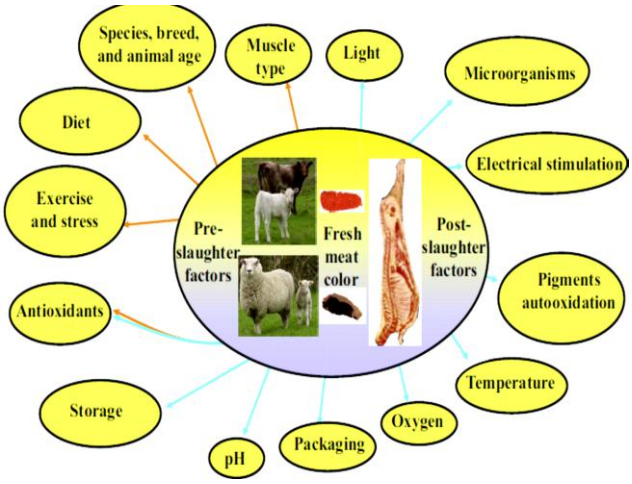


Figure 3: Factors affecting meat color

Sources; Bekhit et al., 2018

Meat color can be measured either by subjective or objective methods using different models of instruments. The objective meat color can be measured with different types of spectrophotometer instruments using the colorimeter of CIEL* a* b* system. Where L* represents lightness, indicating the meat's blackness to whiteness; its values range from 0 black to 100 light; a*represents reddness ranges from -60 green to +60 (red); and b*represented yellownessad the value ranges from -60 blue to +60 yellow (AMSA, 2012).

The hue angle and Chroma are calculated using for these basic three a* and b*color scale. The light scattering property of meat influences the color of meat (Ledward, 1985). The light scattering property of meat is determined by the rate and ultimate pH value of meat. Meat with a high pH had more space between and within muscle fibers, so much water was retained and the muscle swallowed. As a result, much light absorbed rather than reflected finally, the meat looks dark (Hughes et al., 2014).

Age had a significant effect on meat color. Kawęcka & Pasternak, (2022) investigated the effect of slaughter age on meat quality and showed that 9-month old kids had lower pH and higher L* and (b^*) than 12-month old kids' meat. However, the redness value (a*) was not significantly different P >0.05 between slaughter age groups of 9-month old kids and 12-month-old kids. Belhaj et al. (2021) reported that the L* and b* were decreased with slaughter age while redness value (a*-value) increased with slaughter age.
Feed/diet is an important factor that affects meat color. According to Priolo, (2001) meat from animals finished on pasture was darker than meat from animals finished on concentrate. The study showed that meat from animals pasture fed for 150 days had a 5% lower L* than meat from animals finished on concentrate.

Breed had significant effects on meat color of CIEL*, a*b* (Guerrero et al., 2017).The variation in meat quality in goat breeds is due to the variation of stress susceptibility between breeds. Kadim et al. (2003) reported that Batina goat meat had significantly higher $P<0.05$ pH_{24} than Dhofari and Jabal Khaddar goat breeds in all muscle types of biceps, femoris, semitendinosus, semimembranosus, and longissimus dorsi muscle. In the later study of Kadim et al. (2006) reported that the reason for higher pH in the Batina goat breed was due to higher susceptibility response to stress since higher concentrations of cortical, dopamine, and adrenaline were found in the Batina goat. Stressed animals deplete muscle glycogen before slaughter and post-mortem acidification meat becomes low, resulting higher pH meat that is associated with lower L* and higher water holding capacity of meat (Kadim et al., 2014).

Myoglobin is the iron-containing, water-soluble protein that gives meat its red color (AMSA, 2012; Ramanathan et al., 2020a). The color of meat is determined by the chemical state of myoglobin such as oxymyoglobin (OxyMb), deoxymyoglobin (DMb), metmyoglobin MetMb and carboxymyoglobin COMB upon exposure to fresh meat cut with oxygen and carbon monoxide (AMSA, 2012). When oxygen and carbon monoxide are combined, oxymyoglobin (OxyMb) and carboxymyoglobin (COMb) are formed, and the color of meat changes from purple to a bright cherry red developed which is mostly preferred by consumers (Suman & Joseph, 2013).

Further oxidation of oxymyoglobin forms metmyoglobin (MetMb) and the color of meat turns brown (Ramanathan et al., 2020) as shown in figure (3) below.

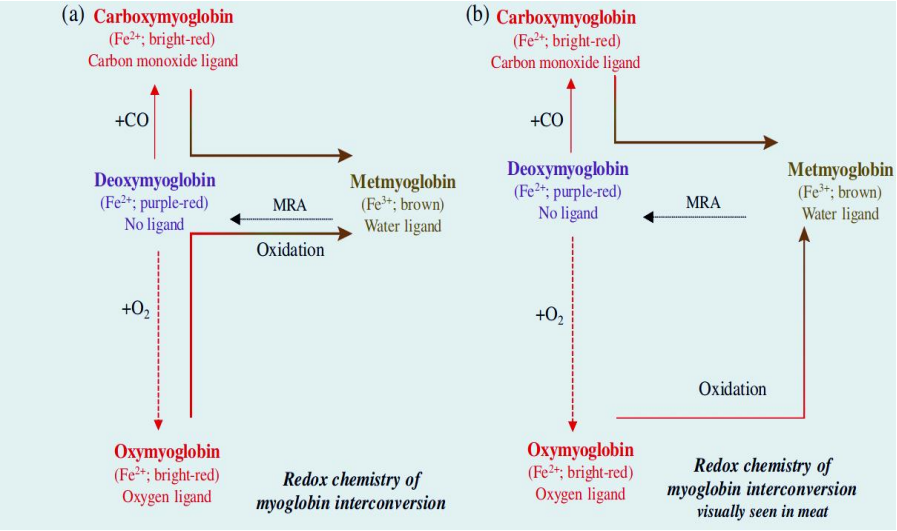


Figure 3: Inter-conversionmyoglobin, in fresh meat

Sources;(Ramanathan et al., 2020)

The concentration of myoglobin is varied in species, age ,breed and muscle type (Neethling et al., 2017).The concentration of (Mb) is higher in beef meat lowers in poultry, lamb, and intermediate in pork. The concentration of myoglobin increased with increasing of slaughter age. Hence, older animal meat is darker than younger animal. The amount of myoglobin is also affected by on-use muscle. Heavy use of muscle requires more oxygen generally has high amount of myoglobin.In deoxymyoglobin (deoxyMb) state the color of meat is purple-red. The treating meat with carbon monoxide (COMb)

converts the meat color to bright red. The meat color is influenced by storage time and muscle type. Jeong et al., (2009) reported the lightness value (L*) of longissimus dorssi (LD) muscle was significantly higher P<0.05 than Psoas major (PM) and semimembranosus (SM) muscle. The concentration of myoglobin was significantly higher P<0.05 in Psoas muscle (PM) than LD and (SM) muscles. The concentration (OxyMb) in PM muscle was rapidly decreased and accumulated of significantly higher P<0.05 MetMb than LD and SM muscles as showed in the figure 4 below. Consequently, Psoas muscle more rapid discolored during storage than LD and SM muscles.

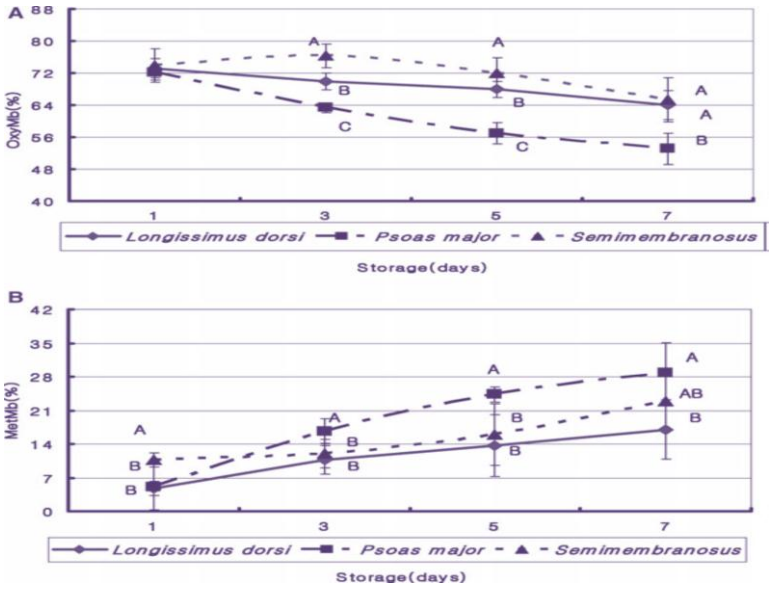


Figure 4: Changes in OxyMb percent (A) and MetMb percent (B) of for cattle muscles 7 days of cold storage.

Sources; (Jeong et al., 2009)

Light sources in the retail meat display can cause variation for meat color. Under higher UV fluorescent light (HFLO), meat steaks exhibited a higher P < 0.05 redness a* than light-emitting diode LED displayed steaks (Cooper et al., 2018). Meat steaks displayed in HFLO and FLO had higher P <0.05 oxymyoglobin percentages than those displayed under LED. This indicates meat retail display LED light sources rapidly discolored as compared to HFLO and FLO lights. Because the concentration of MetMb in LED-exposed steaks have higher P < 0.05 percentages than those displayed in HFLO and FLO.

In 7 days of retail display, HFLO-exposed steaks had lower $P < 0.05$ MetMb percentages than the steaks displayed in both FLO and LED. As a result, the light source affected the color stability of meat during retail display, and higher fluorescent light can reduce surface discoloration.

Electrical simulation had a positive effect on meat quality. It is important to improve initial pH and reduce the occurrence of cold shortening. The initial pH electrically stimulated carcass decreased from 6.37 for to 5.90±0.14, but redness (a*-vallue) and tenderization significantly increased (Simela, 2005). Palo et al. (2013) investigated the effects of packaging materials on veal meat quality and shelf life. The study showed that meat color (CIL*, a*, b*, and chroma) significantly influenced by packaging materials $P < 0.001$.The samples packaged with CRY (Cryovac LID 2050, Passirana di Rho, Milano, Italy) showed that the a*-values was increased with storage time. The yellowness b* measured from the 2^{nd} to the 14^{th} storage day was higher $P < 0.01$ than that measured at one the day of packaging $P < 0.01$. Sample packaged with WEE (Weegal PEBAR film Vignola materials) in the 14^{th} storage time had significantly higher yellowness (b*) $P < 0.05$.

2.1.3 Water holding capacity

The water holding capacity (WHC) is defined as the ability of meat to hold all or part of its own water during the application of external forces, such as cutting, grinding, and pressing (Huff-Lonergan, 2019). It is one of the most important meat quality attribute that influences consumer acceptance and the final of the weight of the product.

Water exists in three forms: bound water, immobilized or entrapped water, and free water forms. Bound water accounts for less than 10% of total water and has little effect on post-rigor muscle (Honikel, J.L, 1998). Bound water directly held by chemical bonds to the meat proteins. It is tightly bound to proteins and is not freely move be frozen. Myofibril proteins are the most important proteins in the binding of water in the meat. Immobilized water is indirectly held by electrically charged reactive groups of meat proteins. For meat

processors, a more water immobilized state has benefits by making the product retain moisture and thus have increased yields. The amount of immobilized water in meat can range from approximately 35-75%. In early post-mortem tissue, this water does not flow freely from the tissue, yet it can be removed by drying, or can be easily converted to ice during freezing. Free water can flow from the muscle freely. Free water is not easily seen in pre-rigor meat, but can develop as conditions change that allow the entrapped water to move from the structure where it is found. The flow of free water is affected by the rate and extent of pH decline, proteolysis and protein oxidation, animal genotype, and post-slaughter carcass handling.

Water holding capacity is determined by filter press method, centrifugation, and the honikel bag method (Honikel, 1998; Afar & Rustdlmansyah, 2017).

2.1.5. Cooking loss

Cooking is a process of heating to denature proteins and to make them easy to consume (Corlett et al., 2021). Muchenje et al., (2009) reported that cooking loss is a decrease of the weight of meat due to evaporation during cooking. It is an important quality parameter considered by meat processors and consumers. High temperatures cause denaturation of myofibrillar proteins complex and loss of meat liquid due to muscle fiber shrinkage (Khastrad et al., 2017). The meat cooked at a high temperature had a lower meat yield, more cooking loss, less moisture, and protein content (Romany. 2013 & Nithyalakshmi, Preetha, R.2015). Cooking loss is affected by breed, age, cooking temperature, and duration (Birmaduma, G., and Y; Mohammad, 2019).

2.1.4 Meat and carcass composition

Carcass is the slaughtered body of an animal obtained after dressing and removing the hide, head, and skin testicle visceral and internal organs consisting of muscle, connective tissue, fat, and bone. The body of animal is composed of 55-60 % of water, 35-40% protein, and 3-4% carbohydrates (Warriss, 2000).Moisture is the greatest component of all food that constitute75% the lean meat (Honikel, 2009). Devendera, (1988) reported

that goat meat is composed of 74.2–76% moisture, 20.6-22.3% protein, (0.6-2.6%) fat, and (1.1%) ash.

The moisture content of meat has high economic importance due to its greatest contribution to product weight. In addition the moisture content of meat is also influence the sensory qualities of tenderness and juiciness. Water in food exists in the form of bound water, immobilized or entrapped water, and free water. Bound water accounts less than 10% of total water and has little effect on post-mortem muscle (Honikel, J.L, 1998). Bound water found in muscle is directly held by chemical bonds to the meat proteins.

Meat proteins had high biological value that contains sufficient amount of all the essential amino acids required for the growth and maintenance of body (Todera, 2010). Muscle proteins are categorized into three types: myofibrillar, sarcoplasmic, and stromal proteins. Myofibrillar proteins consist primarily of myosin, actin, accounting for 65% of the total muscle protein. Sarcoplasmic proteins constitute 30–35% of the total muscle proteins and consist of oxymyoglobin, hemoglobin, cytochrome, and a wide variety of endogenous enzymes. It is soluble in low salt concentrations but not in water.

Myoglobin is the most important protein for the meat color development of fresh meat. Myoglobin consists of a globular protein and a non-protein portion called a heme ring. The heme portion of the pigment plays a special role in meat color development that is determined by the oxidation state of iron within the heme ring. Stromal proteins primarily consist of collagen and elastin. Collagen is the single most abundant protein found in mammalian species and is present in bone, skin, tendons, cartilage, and muscle. The crude protein is determined on the basis of nitrogen, with the Kjeldahl method being universally applied to determine nitrogen content, N = 6.25 (1/0.16).

Fat is an important factor in meat and carcass quality determinants. Fat has three sites of deposit in the in-animal body. These are subcutaneous, visceral, or flare fat and intramuscular marbling. Subcutaneous fat and visceral fat constitute the visible fat in pieces of meat that consists 40–50% of the total weight of fatty meat. Intramuscular fat or marbling constitutes 4–8% of the weight of lean meat. Phospholipids and, to some extent,

long-chain fatty acids belong to intramuscular fat or marbling. Marbling is most important in influencing the sensory attributes of flavor and juiciness and the limited extent of tenderness of the product. These attributes of, the flavor may be the characteristic that is most dependent on marbling. The meat flavor is compounds of lipid fraction of the muscle tissue, with higher amounts of marbling.

2.2 Microbiological Quality and Safety of Meat

Food safety is defined as the absence or presence of an acceptable level of harmful substances in food when prepared, handled, and stored in accordance with regulations under controlled sanitary conditions.

Food safety is a major concern for producers, consumers, and public health officials in both developing and developed countries. Food borne illness is caused by excessive contamination of food with pathogenic and spoilage microorganisms (Hernández-Cortez et al., 2017). Animal-origin food is a major vehicle of food-borne disease and one of the most perishable foods favorable for microbial growth (García, 2018).

Meat is nutritionally rich and contains high moisture content, making it available for the proliferation of pathogenic bacteria (Albrecht & Dresch, 2016). According to Ahmad et al. (2018), food containing more than 70% moisture can be classified as first perishable, 50-60% moisture is less perishable, and 15% moisture is classified as stable.

Meat pH is another important factor affecting the survival and growth of microorganisms in food. High pH meat is favorable to bacterial deterioration and most microorganisms grow more rapidly on meat at pH >6.0 (Bender, 1992).Therefore, goat meat is categorized as a highly perishable food, favorable for microbial growth that can pose a health risk of food borne disease (Lianou et al., 2017).

The most frequently identified bacterial pathogens in meat products are associated with illness and include Salmonella ssp., E.coli, Listeria monocytogenes, Clostridium perfringens, Yersinia enterocolitis, Bacillus, Cerus, and Vibro parahaemolyticus, L. monocytogenes. Salmonella and E.coli are the most pathogenic disease-causing agents (Bhandare et al., 2007). Food borne illness is caused by excessive contamination with pathogenic and spoilage microorganisms (Lynch, 2009).According to Wattanachant (2015), meat from healthy animals is sterile but it will deteriorate it will contaminated with pathogens originated from animal faces, hooves, hair, hide, intestinal content and processing equipment.

2.2.1 Total and fecal Coliform count

A total coliform is a specific group of bacteria in the Enterobacteriaceae family of non-sporulated, germ-negative, aerobic or facultative anaerobic bacteria species. The optimal growth temperature ranged from 35 to 40 degrees Celsius. The presence of coliform bacteria is an indicator of bad hygienic practices and insufficient control of storage temperature. The main difference between total and fecal Coliform is that the total fecal Coliform ferments lactose at temperatures between 44 and 45°C (Ray B, 2004).

2.2.2 Escherichia coli

Escherichia coli are a facultative anaerobe, a gram-negative, non-spore-forming, rod-shaped bacterium. The Escherichia coli (E. coli) bacteria live in the intestines of people and animals. None of the pathogenic E. coli in the human intestinal tract has health benefits. However, E. coli O157: H7 is the most common food-borne pathogen in humans, causing colitis and hemolytic-uremic syndrome (CDC, 2012). It is transmitted through contaminated water, food, or contact with an animal. Escherichia coli bacteria are most common in the face, skin, and carcass. In Ethiopia's export abattoir, the load of E. coli O157:H7 was 4.7% in the feces and 8.7% on the skin (Zelalem et al., 2019).

2.3 Factors Affecting Meat and Carcass Quality

Meat quality and carcass quality are affected by numerous factors that can be categorized into intrinsic and extrinsic factors (Guerrero et al., 2013). The intrinsic is related to the animal itself, such as species, sex, and breeds or cross-breeds, slaughter age, and weight. Extrinsic factors include nutrition, pre-slaughter animal handling, and post-mortem chilling and freezing factors.

2.3.1 Age at slaughter

Age at slaughter is a very essential criterion for carcass classification and grading systems in the meat industry (Strydom, 2011). The chemical composition of meat is affected by slaughter age (Arain Khaskheli, et al., 2010). Kumar et al.(2019) studied the effect of age on meat quality of black Bengal goat meat in three age categories: 6-8 months, 9-12 months, and above 12 months, and showed that kids 6-8 month and 9-12 month old had lower moisture, but lower fat and protein compare to 12-month old kids meat.

Age at slaughter affected carcass yield (Toplu et al., 2013). Basinger, (2016) studied the effects of slaughter age on carcass measurement and tenderness using kids at 135, 180, 225, 270, 315, 360, 405, and 450 days of age showed that the hot carcass weight and dressing percentage were significantly increased ($P \leq 0.05$ with an increase in slaughter age. The average dressing percentage ranged between 40 and 50%, with the 315-month-old kides having the highest value $P < 0.001$. The color of meat is affected by slaughter age (Webb et al., 2005). The lightness (L*) of the semimembranosus (SM), biceps femoris (BF), longissimus muscle (LM), and rectus femoris (RF) was significantly decreased $P \leq 0.004$ with an increasing of slaughter (Basinger, 2016).

Mohammad Asif Arain Khaskheli, et al. (2010) reported that protein content old kids 20.3% in > 11-month was higher $P < 0.05$ compared the protein content of 18.43% than in 8–10 month old month old and the protein 15.31%. of 7–month old goats .The moisture content of 76.60% of ≤7 month old kids was higher than the average moisture of 75.70 % in goat age groups of 8–10 month old and the moisture 73.80 % in groups of greater of > 11 month old goats. The crud fat content 11-month old kids meat had higher percentage of fat 3.07 % than the fat 2.71 % of 8–9 months old kid meat and 1.77 % in < 7 month old kid meat. The ash content of greater 11-month old kids had higher $P < 0.05$ than 8–9-month old and 7-month old goat meat. The concentration of myoglobin is higher in older goat hence; the color of meat is darker than younger animals (Lawrie RA, 1991). Ilavarasan et al. (2015) studied the effect of age on the physicochemical and nutritional composition of indigenous kodiadu goats and observed significantly higher $P<0.05$ L*, and lower a* $P<0.01$, b* $P<0.05$ and pH $P<0.05$ in younger goat meat than in

adult goat. Similarly Simela et al. (2004) reported that milk-teeth goat meat had a higher L* than the 8-teeth goat meat However, flavor of meat increased with increasing of slaughter age age (Spanier et al., 1997). This is because intramuscular lipid content increases with age (Warriss,2000).The demand for slaughter age and weight varied based on economic factors, individual preference, beliefs, culture, tradition, and geographical region (Grunert, 2005). In Europe and Latin America, kids between 8 and 10 weeks of age and 6–8 kg live weight have been used to produce the best quality meat. Middle meat consumers prefer goats slaughter age ranged 12–24 months with body weights of 13–25 kg for kids and (Guerrero et al., 2018). However, African and most Asian countries consume goat meat with a live weight ranging from 20–30 kg with slaughter age of 2 to 6 years (M.S. Madruga, 2011).

2.3.2. Effect of breed on meat quality

The quality of the meat is significantly influenced by the breed (Guerrero et al., 2013; Moawad, R.K., G.F. Mohamed, and M.M.S. Ashour, 2013). Sebsibe (2006) studied the growth and carcass characteristics of three Ethiopian goat breeds of Afar, Central Highland, and Long-eared Somali, and reported that the central highland goat breed had a higher ultimate pHu 5.94wich darker in meat color ($P<0.01$). The study of Kadim et al., (2003) on the evaluation of the growth, carcass, and meat quality characteristics of Omani, Batina, Dhofari and Jabal Akhdar goat breed indicate that the muscles from Batina goat had higher pH than Dhofari goat.

Kadim et al., 2006 studied on the effect of transportation at high ambient temperature on physiological response showed that Batina had significantly higher ultimate pH caused by high susceptibility of goat to stress. High susceptibility of goat to stress leads to depletion of muscle glycogen and high ultimate pH of meat (Claudia Tallow et al., 2021; Kadim et al., 2014; Tarrant, 1989). Depletion of muscle glycogen leads to lower lactic acid during post-mortem metabolism, resulting in a high ultimate pH (Terlouw et al., 2021). The breed affects carcass quality traits of slaughter weight, hot carcass weight, and dressing percentage (Almu et al., 2020). Dhanda et al. (1999) reported that the Boer crossed with the feral genotype had greater subcutaneous fat than the Saanen crossed feral goat.

3 METHODOLOGY

3.1 Description of the Study Site

The meat samples were collected from Borena and the central highlands of North Shewa intact kids. North Shewa is one of the 11 administrative zones in the Amhara National Regional State of Ethiopia. The zone is located between 90-110 N latitude and 38o-400 E longitude, covers approximately 15,936 km^2, and has an annual rainfall range of 790 to 1765mm (Abegaz, 2020). The zone is bordered on the northeast by Oromia Zone, on the south and west by the Oromia region, on the north partly by South Wollo and on the east by the Afar region. Debra Berhan is the capital city of the zone, located 130 km on the north-east of Addis Ababa. The topography of the zone ranges from 927–2450 m.a.s.l. and the highest point is 4012 m.a.s.l (Eremew, 2018). The main rainy season is June-September (Romilly, T. G. and Gebremichael, 2011).

Borena is found in the Oromia regional state in the southern part of Ethiopia. It is bordered by to the north by the SNNP, on the west by the Guji zone, on the east by the East Somalia regional state, and on the south by Kenya. The zone is located 570 kilometers from the country's capital, Addis Ababa, at 3°36′-6°38′ N latitude and 3°43′-39°30′ E longitude. The altitude of the zone ranges from 1000 to 1500 meters above sea level (m.a.s.l) and the highest point is 2000 m.a.sl. The ecosystem of Borena is erratic and semiarid, receiving rain of between 300 mm and 900 mm annually. The main rainy seasons are March-May and October-November (Hulunim Gatew, 2014).

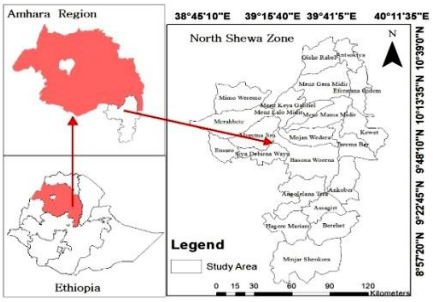


Figure 5: Map North Shewa zone, Amhara region, Ethiopia.

Source: ethioGis, 1997 North Shewa administrative Zone

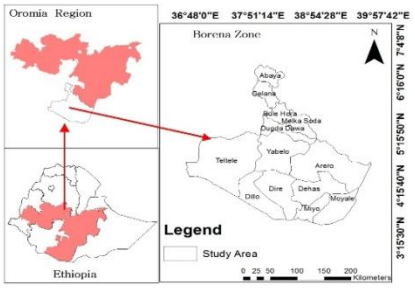


Figure 6: Map Borena zone, Oromia region, Ethiopia.

Source:ethioGis,1997 Borena zone town administrative

3.2 Study Animal and Slaughtering Procedure

A total of 12 intact male kids of 6 Borena and 6 North Shewa, with a slaughter age of 0-teeth (full milk incisor) and 1-teeth or one permanent incisor were used in the study. North Shewa goats were purchased from Tarmaber cattle market. Borena goats were purchased at Mojo, supplied from Yabbelo Borena area. Borena goat was identified based on supplier information and phenotypic characterization of the white coat color and plain coat pattern reported by (Bedada et al., 2019). Slaughter age of goats was determined based on the irruption pattern of permanent incisor teeth using the method described by (Awgichew, 2009). The animals were kept with grass hay and free access to drinking water. The live weight is measured after the withdrawal of feed and free access of water over night.

3.3 Determination of Carcass Yield

The study animals were slaughtered at the Luna export abattoir in Mojo, Shewa Ethiopia. The slaughtering activity was performed based on the company slaughtering procedures by severing the carotid arteries and jugular vein in a single cut using a sharp knife. The hot carcass weight was determined as described after removing of skin, head, feet at (carpal-metacarpal joint), hind feet (at the tarsal-metatarsal joint), testicles, viscera, liver, kidneys, lung, heart, pancreases, spleen, and pancreas were removed (Sebsibe, 2006). The skin+feet, head, viscera, lung, trachea, liver, heart, and kidney were recorded. The dressed carcass was weighed within 1h after kids slaughtered. The dressing percentage (DP) was calculated as proportion of hot carcass weight (HCW) to live weight using the formula; $DP\% = \frac{HCW}{LW} \times 100$ (Manaye, 2019; Worku et al., 2020). The dressed carcass was weighed and chilled at $\leq 4\ ^{0}C$ for 24h

3.4 Sample Collection for Physicochemical and Microbial Analysis

Longissimus dorsi muscle of chilled carcass were dissected between 8^{th} to 12^{th} ribs site for analysis of proximate composition and physical quality meat quality characteristics while brisket, flank, and neck were collected and mixed for microbial analysis. The samples were vacuum-packed and frozen at -20^{o}C until analysis. The samples were transported to Ethiopian conformity assessment, Ethiopian food and drug authority, Haramaya University, Ethiopian meat and dairy development institute laboratories with ice box based on the method described by (ES/ISO17604, 2012).

3.5 Determination of Proximate Composition

The moisture, protein, ash, and fat content were determined based on the method recommended by the international organization for standardization (ES/ISO; 2005).
The moisture was determined based on the method described by(ES/ISO1442, 2005)5g of sample was dried by using the dry oven at 103 ±2 ^{o}C overnight and cooled in desiccators containing silica gel. The percentage of moisture content was calculated with the formula: Moisture % $=\frac{w1-w2}{w1}\times 100$ where w_1= initial weight of sample $w_{2=}$ weight of dried sample.

The ash content was determined by the gravimetric method described by (ES/ISO936, 2005). Pre-weighed of 3gminced sample was placed in the crucible and transferred to a muffle furnace. The sample was incinerated at 550±25 ^{o}C for 5–6 h until the sample had a grey-white appearance. The percentage of ash was calculated using the following formula; Ash % $=\frac{W2-W3}{W1}\times 100$, w_1 = sample weight w_2 = sample weight + weight of crucible; w_3 = weight of ashed sample + crucible

The crude fat content was extracted using Soxhlet apparatus with diethyl ether according to the method described by (ES/ISO1443, 2012).

The crude protein was determined by micro Kjeldahl as described by (ES ISO 937: 2005). 1g of sample was digested by 25 ml sulfuric acid for 2h with 0.5 g copper sulfate

as a catalyst for the reaction. The flask was heated in an inclined position until float ceased then allowed cooled at 40 ^{0}C and 50 ml of water was added for father cooling.The digested sample was distilled by pouring 100ml of sodium hydroxide solution at an inclined position and boiled for 20 minutes for acid neutralization. The condenser was fitted with a distillation tube and 150ml of distillate was collected. The distillate was titrated with 0.1 HCL equivalents to 0.0014 N. Five drops of methyl indicator were added and titrated with 1ml 0.1N HCL. The crude protein was determined by multiplying the nitrogen content by conversion factor. Crude protein CP = N× 6.25

3.6 Determination pH and Temperature

The carcass pH was determined directly on longissimus dorsi (LD) muscle of hanging position of carcass between 12th and 13th ribs using meat pH meter (Model HI99163, FC 2323, Romania) combined with sharp penetrating electrode based on method described by (Ark& Karaca, 2017).The initial pH was measured at 45 minute and 3h while the ultimate pH measured on carcass chilled carcass at ≤ 4 ^{O}C for 24h. The probe was washed by distilled water and calibrated with pH of 4.1 and 7.1 standard buffer solution between and each measurement.

3.7 Determination of Meat Color

The meat color was determined on (LD) muscle according to CIEL* a* b* color system using meat colorimeter (Hunter Lab, EZ, MiniScan, 1547, USA) 45/0 illuminations, D_{65} light source, 10^0 observer angle (AMSA, 2012). Before measurement of color sample was exposed to air on a flat surface of white background and allowed to bloom for about 30 to 45 minutes at room temperature. The instrument was calibrated with black and white standard plate before and between each measurement. The average values triplicate measurement was taken as the value of L*,a*and b*.The Chroma and hue angle was determined sing a* and b* using the formula: Chroma $C= (a^2 + b^2)^{½}$ and hue angle (H°) arc tan (b*/a*) based on the method described by (Węglarz, 2019) .

3.8 Determination of Water holding Capacity

Water holding capacity was determined by press method using filter paper and 1kg load following the method described by (Ernández-Castellano, 2015). Mean values of replicates values were taken as average value water holding capacity.

The percentage of WHC was determined calculated as; WHC% = $\frac{W1-W2}{W1} \times 100$ where w_1= weight of sample before compressing, w_2= weight of sample after compressing.

3.9 Determination Cooking Loss

Meat sample of 50 g sample of was weighed and tightly sealed in polyethylene bag oven bag and heated on in a water bath at 82°C until the internal temperature reached at71˚C. The cooked out dried, cooled dried using filter paper and reweighed .The cooked loss was expressed in percentage using the formula: Cooking loss (CL) %= $\frac{w1-w2}{w1} \times 100$ (Moawad, R.K., G.F. Mohamed, M.M.S. Ashour, 2013). w_1=Initial weight of sample, w_2= Cooked sample weight.

3.10 Microbiological Analysis

3.10.1 Sample preparation producers

A total of 25g of minced meat has been weighed in a sterilized jar. The sample was transferred into a sterile polythene bag and mixed with 225 ml of sterilized 0.1 percent sterilized buffered peptone water (BPW). The sample was homogenized with a stomacher bag mixer at 230 revolutions per minute for 60 seconds. The first dilution, 10^{-1}, was obtained at this stage. The second dilution, 10^{-2}, was made by transferring 1 ml of suspension to the test tube containing 9 ml of BPW. Similarly, subsequent serial dilution of up to 10^{-3} was prepared. The prepared sample was subjected to microbial analysis for total viable count (TVC), total coliform count (TCC), and E. coli.

3.10.2 Determination of total viable count

The total viable count (TVC) was determined according to the method described by (ES/ISO4833-1:2015). 1ml of suspension of each dilution was pipetted on to a duplicated

petridish. The suspension received approximately 15-20 ml of cooled plate count agar (PCA) at 45 ^{0}C ±1. The sample and the nutrient were mixed by rotating the petridish. The petridish were turned over and the media incubated for 24 to 48 hours at 34 to 36 °C. The normal plate containing 30-300 colonies was counted using a digital colony counter. The result was obtained by multiplying the average number of colonies by the dilution factor described by (Arain, Rajput, Khaskheli, et al., 2010).Using the formula; $N = \frac{\sum C}{(n1+0.1n2)d}$, $\sum C$= Sum of colonies counted on all petridish retained; N= total colony n_1; number of dish retained in first dilution; n_2; number of second dilution d = dilution factor corresponding on the first dilution.

3.10.3 Detection of total Coliform and Escherichia coli

The total of coliform and Escherichia coli were detected according to the methods described by (ES-ISO 4331:2015) and (ES-ISO 7251:2012) respectively. Total coliform was detected by inoculating 1ml of initial suspension up to 10^{-3} serial dilutions in a Lauryl Sulfate Tryptose broth (LST) with an inverted durum tube. The inoculums were incubated at 37 °C for 24h. The tube forming the gas is considered positive for coliform. A loop suspension of the gas positive tube was inoculated in 10ml of Brilliant Green Bile Broth (BGLB).

The inoculums were incubated at 35°C for 24–48h for coliform and at 37 °C for 24 ± 2h for E. coli. The formation of gas in each tube confirms the presence of coliform and E. coli. A confirmation test for E. coli was carried out by transferring a loopful of gas-forming E. coli broth to tryptone water and incubating for 48±2h.

Five drops of Kovacs reagent were added and the formation of a red ring color was considered a positive indole reaction (MacWilliams, 2009). The number of colonies forming units was determined by the method described by (ISO 7218: 2012).

3.11 Statistical Analysis

The data was analyzed by 2x2 factorial arrangement of random complete block design(RCBD) using IBM SPSS version 22.The effect of slaughter age and location on carcass yield, offal component, proximate composition, water holding capacity, cooking loss pH, instrumental color of lightness(L*), redness (a*) yellowness (b*), Chroma and hue angle were analyzed using ANOVA. The relationship physicochemical meat qualities were determined by Pearson correlations. The mean difference were considered significant at $P<0.05$.

Model; $Y_{ij}= \mu+\alpha_i + \beta j+ (\alpha_i\times \beta)_{ij}+\varepsilon_{ij}$,

Y_{ij}= Physicochemical meat quality attributes and carcass yield,

μ = Population mean common to all observations

α_i = Effect of location (a_{i1} =Borena and $a_{i2=}$ North Shewa goat), β_j = Age (βj_1 = 0-teethβ_{j2}=1-teeth,

εij= random error,

$(\alpha_i\times \beta)_{ij=}$ interaction effect of age and location

Model (2); $Yij = \mu+\alpha_i+\varepsilon_{ij}$ $Y_{ij\ =}$ Microbiological quality (TVC, TCC and E.coli)

μ = Population mean common to all observations, αi= Location ($a_{i1\ =}$ Borena, $a_{i2=}$ North Shewa), εij= random error

4 RESULT

4.1 Carcass Yield and None Carcass Component

The live weight (LW), hot carcass weight (HCW), dressing percentage (DP), kidney, liver, heart, lung + trachea, skin + feet, viscera and head were determined for Borena and North Shewa goats as showed in theTable1. Borena goat had significantly higher P<0.05 DP, LW, HCW, kidney, liver, lung+treachea, and feet+skin compared to north Shewa goat due to significant effect of P<0.05 location. However, heart, viscera and head were similar P<0.05 in Borena and north Shewa goat. 1-teeth old kids had significantly higher P<0.05 LW and HCW and liver compared with 0-teeth old kids with significant effect of slaughter age. The dressing percentage, heart, lung+treachea, viscera, head and feet+skin were not significantly affected P>0.05 by slaughter age.

Table 1. Carcass yield and offal component (Mean± Standard deviation) from Borena and North Shewa goats. N=6

Parameters	Location		Age		P-values		
	BG	NSG	0-teeth	1-teeth	L	A	A×L
LW	19.96±1.02[a]	16.08±1.32[b]	17.00±2.88[a]	19.05±2.00[b]	0.001	0.034	0.342
HCW	9.20±0.93[a]	6.43±1.38[b]	7.3±1.99[a]	8.5±1.51[b]	0.001	0.037	0.332
DP	46.73±2.70[a]	42.32±2.30[b]	43.81±4.06[a]	45.23±2.54[a]	0.016	0.355	0.351
Kidney	0.08±0.01[a]	0.05±0.01[b]	0.06±0.02[a]	0.07±0.01[a]	<0.001	0.169	0.471
Liver	0.34±0.01[a]	0.24±0.05[b]	0.28±0.05[a]	0.31±0.04[a]	<0.001	0.098	0.098
Heart	0.07±0.01[a]	0.06±0.01[a]	0.07±0.01[a]	0.68±0.01[a]	0.242	0.545	0.545
Lung+trachea	0.23±0.02[a]	0.14±0.03[b]	0.18±0.05[a]	0.18±0.06[a]	0.001	0.773	0.506
Viscera	3.47±0.52[a]	4.02±0.45[a]	3.58±0.60[a]	3.9±0.48[a]	0.096	0.309	0.700
Head	1.51±0.18[a]	1.35±0.29[a]	1.35±0.25[a]	1.56±0.25[b]	0.209	0.07	0.44
Feet+ Skin	2.37±0.47[a]	1.79±0.38[b]	1.83±0.56[a]	2.33±0.33 [b]	0.024	0.045	0.702

[ab] Mean bearing different letters of superscript in the same row significantly different P <0.05, N= Number of sample, NSG= North Shewa goat, BG= Borena goat A= Age, L= location, , A×L= interaction effect of slaughter age and location,

4.2 Proximate Compositions of Meat

The average moisture, protein, crud fat and ash content of longissimus dorssi (LD) muscle from Borena and north Shewa goat with effect of age and location was determined and as presented in Table 2 below. The moisture, protein and ash of LD muscle of Borena and North Shewa kid meat were not significantly different $P < 0.05$. However, crude fat content of in Borena kid meat was significantly higher $P>0.05$ compared to north Shewa meat due to significant effect of location $P<0.05$. 0-teeth old kids had significantly higher $P<0.05$ moisture content compared to1-teeth old kid meat due to significant effect of slaughter age $P<0.05$.

Table 2.Proximate composition (%) (Mean± Standard deviation) of LD muscle of Borena and North Shewa goat. N=6

Parameter	Location		Slaughter Age		P-values		
	BG	NSG	0-teeth	1-teeth	L	A	A×L
Moisture	74.87± 1.85[a]	75.87±2.16a	76.64±0.98[a]	74.13±1.99[b]	0.328	0.029	0.681
Protein	21.14±0.46[a]	21.18±0.57[a]	21.27±0.55[a]	21.05±0.49[a]	0.902	0.515	0.409
fat	2.43±0.13[a]	2.22±0.10[b]	2.26±0.12[a]	2.39±0.17[b]	0.008	0.080	0.638
Ash	1.32±0.11[a]	1.34±0.07[b]	1.30±0.06[a]	1.36±0.01[a]	0.835	0.169	0.471

[ab] Mean bearing different letters of superscript in the same row significantly different $P<0.05$, N= Number of sample, NSG= North Shewa goat, BG= Borena goat A= Age, L= location A×L= interaction effect of slaughter age and location

4.3 Physical Meat Quality Characteristics

The pH and temperature (T) at 45m, 3h and 24h,instrumental meat color lightness (L^*), redness (a*) yellowness (b*), Chroma (C) and hue angle (h),cooking lose (CL) and water holding capacity (WHC) for Borena and North Shewa goat meat were determined as presented in the Table 3. Borena goat meat had significantly higher $P<0.05$ L^*, CL, but significantly lower $P<0.05$ in the ultimate pH_{24} and WHC compared to north Shewa kid meat. Slaughter age and location had no significant effect $P<0.05$ on pH_{45}, pH_{3h} and temperature T_{45}, $T_{3h,}$ T24h, color of a* and C. The $pH_{24,}$ $b^*$and h were significantly affected $P<0.05$ by location .However, T3h was significantly affected $P<0.05$ by slaughter age. The $L^*$and WHC were significantly decreased $P<0.05$ with increasing of slaughter age.

Table 3: Physical meat quality characteristics of (mean± standard deviation) of LD muscle of Borena and North Shewa goat. N=6

Parameters	Location		Age at slaughter		P-value		
	BG	NG	0-teeth	1 -teeth	L	A	A×L
pH_{45}	6.68±0.11[a]	6.65±0.08[a]	6.67±0.13[a]	6.66±0.07[a]	0.584	0.783	0.208
pH_{3h}	6.57±0.11[a]	6.54±0.08[a]	6.56±0.13[a]	6.55±0.06[a]	0.489	0.927	0.082
pH_{24}	5.80±0.11[a]	6.27±0.17[b]	6.08±0.29[a]	6.01±0.32[a]	<0.001	0.471	1.00
L*	34.55±1.31[a]	31.65±2.56[b]	34.72±1.11[a]	31.48±2.40[b]	<0.001	<0.001	0.270
a*	10.22±0.69[a]	10.07±0.48[a]	9.96±0.36[a]	10.32±0.71[a]	0.674	0.340	0.497
b*	10.4±0.56[a]	8.55±1.09[b]	9.8±1.55[a]	9.15±0.95[a]	0.006	0.231	0.648
C	14.54±0.70[a]	13.00±1.60[a]	44.85±4.68[a]	40.61±4.32[a]	0.086	0.663	0.902
h	46.05±2.61[a]	39.85±4.27[b]	44.85±4.68[a]	40.61±4.32	0.005	0.037	0.682
T_{45}	20.57±0.41[a]	20.73±0.7[a]	20.71±0.25[a]	20.58±0.25[b]	0.209	0.070	0.44
T_{3h}	20.11±0.27[a]	19.53±0.89[b]	19.48±0.56[a]	19.98±0.33	0.025	0.110	0.702
T_{24}	5.50±0.85[a]	5.92±1.04[a]	5.47±0.66[a]	5.95±1.15	0.482	0.418	0.449
WHC	71.01 ±5.13[a]	76.32±2.74[b]	76.20±1.51[a]	71.14±5.53[b]	0.003	0.005	0.020
CL	32.56±5.00[a]	23.29± 1.03[b]	26.75±5.84[a]	28.91±5.85[a]	0.002	0.336	0.398

[ab] Mean bearing different letters of superscript in the same row significantly different $P < 0.05$, N= Number of sample, NSG= North Shewa goat, BG= Borena goat A= Age L= location, LD = Longissimus dorssi muscle, Chroma, A×L= interaction effect

4.4 Pearson Correlation Coefficient of Physical Meat Quality Attributes

The correlation between physical meat qualities attributes of color, pH and water holding capacity (WHC), cooking loss (CL) and hot carcass weight (HCW) were determined and presented in the Table 4. The pH_{24} is negatively correlated with CL, ($P < 0.01$, r=-0.78, HCW $P<0.05$, r= -0.72* meat color of lightness L*- values $P>0.05$, r=-0.33, redness a* $P>0.05$, r=-0.26), hue angle ($P<0.05$, r=-0.59 yellowness b* $P<0.01$,r=0.716. However WHC, positively was correlated with pH_{24}at $P<0.05$, r=0.709**.

Table 4: Pearson correlation coefficient of physical meat quality attributes

	pH_{45}	pH_{3h}	pH_{24}	L^*	a^*	b^*	C	H	CL	WHC	HCW
pH_{45}											
pH_{3h}	.921**										
pH_{24}	.448	.450									
Lightness (L*)	-209	-.234	-.332								
Redness (a*)	-037	-228	-206	-262							
Yellowness (b*)	-456	-638	-716	.623*	.239						
Chroma (C)	-319	-500	-552	.332	.589*	.773**					
Hue angle (H)	-527	-603*	-591*	.826**	-070	.872**	.595*				
Cooking loss	-404	-394	-778**	.469	107	.583*	.389	.553			
WHC	.226	.174	.709**	-.130	-169	-248	-175	-221	-768**		
HCW	-050	-130	-702*	.139	.312	.434	. 248	.221	.641	-601	

** = Significant difference at $P<0.001$ *= Significant difference at $P<0.05$

4.5 Microbiological Quality and Safety

The bacterial loads of total viable count (TVC), total Coliform count (TCC) and Escherichia coli were determined as presented in the Figure 6. The loads TVC, TCC and E.coli were marginally higher P > 0.05 in north Shewa goat meat due to higher ultimate pH and water holding capacity attribute of meat.

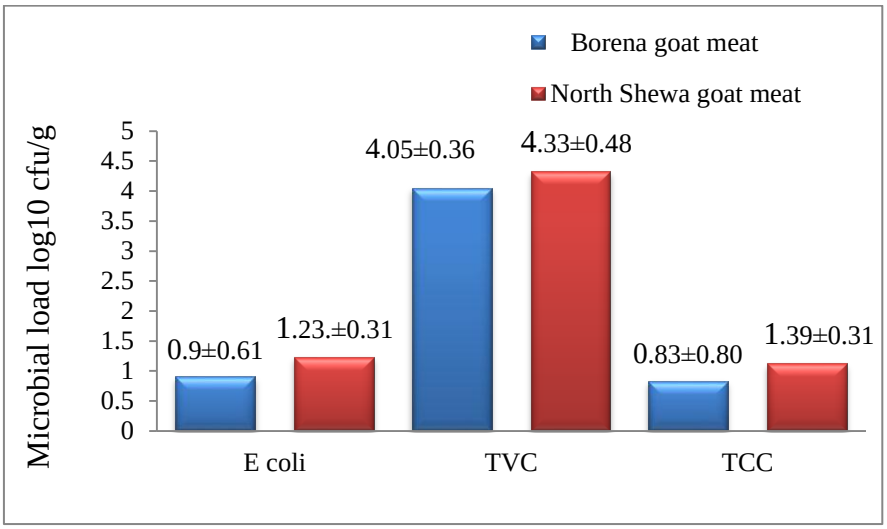


Figure 7: Microbial loads in Borena and north Shewa goat meat (mean ±Standard deviation

5 DISCUSSION

5.1 Carcass Yield and Offal Component

Carcass yield is important determinant of economic return and used as index for evaluating performance of meat producing animals (Yusuf et al.,2019).Comparison of carcass and meat quality characteristics is important to inform producer and processor about the productivity and suitability of goat (Sebsibe, 2006).The mean live weights (LW) of 19.96 kg, hot carcass weight (HCW) of 9.20 kg and the dressing percentage (DP) 46.73 % of Borena kids in the current study result were significantly higher $P<0.05$ than the mean (LW) of 16.08 kg, (HCW) of 6.43kg and Dp 42.23% of North Shewa goat. The higher (HCW) and (Dp) of Borena goat is due to significantly heavier $P<0.05$ slaughter live weight of Borena goats.Pophiwa1, (2017) reported that the higher $P<0.05$ hot carcass weight of 19.9 kg for 39.8 kg live weight of south African Boer goat than lighter of live weight of weight 33.7 kg that had lighter carcass weight of 16.7 kg .similarly Marichal et al. (2003) reported heavier LW of 25 kg had significantly heavier $P<0.001$ hot carcass weight 9.81kg than the lighter HCW of weight of 4.91 kg for and 10 kg LW that produce 2.83 carcass from 6 kg LW.The mean, hot carcass weight and dressing percentage for 0-teeth and 1 teeth old kids in the current study was 7.3 kg and 43.81% 8.5 kg HCW and dressing percentage 45%

The LW of19kg and HCW of 8.5 kg of the current study result for 1-teeth old kids were significantly higher $P<0.05$ than live weight of 7.5kg for 0-teeth old kids with significant effect of slaughter age $P<0.05$.Similarly Yalcintan et al. (2018) reported 120 days old kids had significant higher slaughter weight $P<0.05$and HCW $P<0.01$ than 80 days old kids. The dressing percentage (DP) determine slaughter values of small ruminates and influenced by live weight, growth rate and age Kawęcka & Pasternak, 2022; McGreAttwood, (2007).The dressing percentage of Borena goat 47.73% and north Shewa goat 42.32% were found in the range of 40-47% reported by (Marichal et al., 2003). The HCW of Borena goat in the current result were similar with HCW of 9.15 kg higher than the dressing percentage of 45.11% recorded for 20kg LW of Borena goat previously reported by (Yusuf et al., 2019). However, the DP of 47.72% of the current result for

Borena goat was similar with the average DP of 47.5 Borena indigenous South African goats reported by (Pophiwa, 2017). Slaughter age in the current study result had significant effect P<0.05 on live weight (LW) and hot carcass weight (HCW). The result was similar with the finding of (Abhijith et al., 2021; Assan et al., 2011; D. E.Mushi., 2007; Purnami & Purbowati, 2021; Toplu1 et al., 2013; Webb et al., 2005). However, DP of the present study result was not significantly affected P>0.05 by slaughter age with argument of (Peña et al., 2011; Simela, 2005).The weight of liver, kidney, feet+skin, digestive tract and head of current result was similar with the study finding reported by (Tadesse et al., 2016)for highland of Hararghe, short- eared Somali and Bati goat.

5.2 Chemical Composition of Meat

Evolution of chemical composition of meat is important to predict the nutrient and quality of processed meat product (Aksoy, Y., 2019). Goat meat is a source of high quality protein lower total intercellular fat (Horcada et al., 2012; Moawad, et al., 2013).The moisture 74.89 %,v75.87 %, protein 21.41% v 21.18% and ash (1.32% v1.34%, crud fat (2.43%v2.22%) for Borena and north shewa kid meat were found in the rage of moisture, (74.6-76.2),protein, (21.2-21.9%) fat,(2.2-4.4%) and ash (1.2%-1.34%), previously reported by (Sebsibe, 2006) for indigenous Ethiopian goats. Generally the present study result were within range of 74.2-76% 20.6-22.3% protein, 0.6-2.6% fat and comparable 1.1% ash content reported for goats by (Devendra,1988).the crud fat content, the current result protein and ash of the present study result were agreed less than the study finding reported by with (Arain et al., 2010; S. Ivanovic et al., 2020; Ivanovic et al., 2014b; Migdał, et al., 2021). The variation in chemical composition of meat might be effect of breed (Horcada et al., 2012; Ivanovi & Pavlovi, 2020; W. Ding et al.,2010).

The moisture, protein, ash and fat in present study were not affected by P>0.05 slaughter Similarly Arain et al. (2010) reported none significant difference P>0.05of moisture, protein, ash and crud fat among ≤ 7 month old kids and 8-10 month old kids however, the protein, fat, and ash were significantly higher P≤ 0.05 in meat goat ≥11 month old age kids.

5.3 pH and Instrumental Meat Color

Determination of pH is very important for accurate meat quality decision making and storage shelf-life (Young et al., 2004).The rate of pH declining and the ultimate pH determine the meat color (Simela, 2005).The values pH_{45} and pH_{3h} ranged 6.5-6.65 and 6.54-6.57 of the present study result comparable pH_{45} 6.54 and pH_{3h} of 6.24 reported by (Shija et al., 2013). The result not indicated the pale soft and exudative condition of meat quality defect caused by immediate stress. The pH_{24} values ranged 5.8-6.27 of the current study result was similar with finding of pH_{24} value ranged 5.8 -6.27 reported by (Chala Merera and Rama Prasad, 2017; Simela, 2005) an H_{24} value that ranged 5.91-6.29 reported by (Abebe et al., 2010; Arain, Rajput, Sciences, et al., 2010).The ultimate pH_{24} values 5.8 of Borena goat was found in the normal range of 5.49-5.86 previously reported by (Arguello et al., 2005; Pratiwi et al., 2007; Sebsibe, 2006).However, the pH_{24} of North Shewa goat meat in the present was higher than the normal ultimate pH_{24} for good meat quality. The higher up pH_{24} in north Shewa goat meat might be due to pre-slaughter depletion of muscle glycogen caused by high stress susceptibility (Abhijith et al., 2021; Kannan et al., 2014; Pophiwa, 2017).

The pH_{24} values of 6.08 for 0 -teeth old kids and 6.01 for 1-teeth old goat meat of the current study result was not significantly affected $P>0.05$ by slaughter age. Similarly (Muhammad Asif Arain et al., 2010) non-significant difference of $P>0.05$ pH values between age groups $\leq$ 7 month, 8-10 month and 11$\geq$ month old kids.

High ultimate pH of meat retain higher intercellular water that leads to decreased inter-fiber space and surface water resulting dark color of meat (Hughes et al., 2014). High pH meat initiates oxygen consuming enzyme activities that decrease light reflectance meat (Ramanathan et al., 2020). The pH meat greater than 5.85 seriously comprises microbial quality and reduces shelf life that corresponds to darkening and toughness (Lawrie, 2006; warriss, 2000).High pH meat has dark color so, it is disliked by retailer and customer (Zotte et al., 2017).

The lightness (L*) of meat is an indicator of the degree of brightness and condition of darkening (Ponnampalam et al., 2013).The lightness L*values 34.5 for Borena goat meat significantly higher the value L* 31 for north Shewa go but, found the L* values ranged

34- 36 reported by (Abebe et al., 2010) and L*values of 34.8 reported by (Babiker et al., 1990 for Sudanese desert goat.The L* value of 31.56 for north shewa goat the current result was found between the L* that ranged 31.66 to 32.41 reported by Ivanovic et al., 2014) for Balkan goat Alpine goat Saanen goat. The redness a* 10.07-to 10.22 in the current result were in range 8.19-10.78 reported by Peña et al.(2011) Criollo Cordobes and Anglonubian kids.

The L^* and a*of current study was lower than the study finding reported by (Migdał et al., 2021; Sañudo et al., 2012).The meat color is influenced by slaughter age (Kadim et al., 2003; Kopuzlu et al., 2018).The L*-value of the current result was significantly decreased $P<0.05$ with increasing of slaughter age and highest value was observed in 0-teeth teeth old kids. Old animal had darker meat color than young animal (Arshad et al., 2018; Toplu, 2014).Kannan et al. (2003), reported significantly higher $P < 0.01$ a* and Chroma and lower L*-value in age groups 30 month old goat meat but, more L* and lower a* were observed in age groups of 6-12 month old goat meat. Because the concentration myglobin is higher in older animal meat than in younger (Dugas, 2019).The a*and b* are associated with myoglobin concentration, whereas L* is associated with muscle structure of light reflectance (Hughes et al.,2014).The meat color affected by muscle pH (Neethling et al., 2017). Meat of $pH \leq 6$ undertake higher protein denaturation lower light reflectance resulting higher L* values but, meat with $pH \geq 6$ indicates less protein denaturation that leads to more light to be absorbed and dark meat (Lawrie RA, 1991).The current study result of pH_{24} was negatively correlated with L*$P>0.05$, $r=-0.33$),a* $P>0.05$, $r=-0.206$,b*$P<0.05$,$r=-0.638$ and hue angle $P<0.01$, $r=-0.603$)agreed with the study finding reported by (Kawęcka & Pasternak, 2022).The instrumental meat color of L*a* and b* compared with visional acceptability to determine the consumer acceptability. The values a* and L* are important for consumer color acceptability. The a* values of 10.22 and L* 34.5 for Borena goat were agreed with (Khliji et al., 2010) reported for consumer acceptability thresholds values of $a^* \geq 9.5$ and $L^* \geq 34$ .The value of a* and L* 31.61 for North Shewa goat in the present study result is debating from consumer acceptability threshold value reported by (Khliji et al., 2010).

5.4 Cooking Loss

The cooking loss (CL) of23.29% for north Shewa goat meat was significantly lower P<0.05 compared with the cooking of 32.56% for Borena goat meat. The result of cooking loss in present study found the ranges of 21.27–33.36% reported by Kadim et al.(2006) for Omani goats. The lower cooking loss of north Shewa goat meat of the current study could be due to higher ultimate pH. Similarly Fazlani, (2019) reported higher cooking loss of 34.82 % and ultimate pH 6.01 than the cooking loss of 28.02% and higher pH of 6.48 . The cooking loss of the present study was not significantly affected P<0.05 by slaughter age. Similarly (Fazlani et al., 2019) reported non-significant differences of cooking loss P<0.05 between age groups of 13- 18 month and 6-12 month old age goats. This is due to non-significant differences of P>0.05 pH value 6.12 and 6.05 between age groups of 12-13 month and 13-18 month. Similarly Kadim et al.(2003) reported significantly lower cooking loss of in higher ultimate pH of Batina goat meat.

5.5 Water holding Capacity

The water holding capacity (WHC) of the current study result ranged 71-76% compared with the mean WHC of 62.7% reported by (Arain Khaskheli, et al., 2010).The higher WHC of meat of the current study result is due to ultimate pH. The person correlation of the current study result showed that WHC had positive significant correlation with pH_{24} ($P<0.01$ $r= .708$). Similarly Bouton et al. (1971) reported significant positive corelation of pH_{24} with water holding capacity,$P< 0.001$, $r = 0.80^{**}$.High ultimate pH had more negative charges so, water molecules strongly attached to protein as the result much water is retained in meat. The WHC of the present the current was significantly affected by slaughter age $P<0.05$. the study finding of Arain, Khaskheli, et al., (2010)who reported lower water holding capacity for <7 month old kids than 8-10 month old kids and > 11 month old kids.

5.6 Microbiological Quality Carcass

The total viable count (TVC), total Coliform (TCC) and Escherichia coli has been used to indicates the microbial quality of food, predicting storage of shelf-life and possibility presence pathogenic micro-organism(Kim, J., Yim, 2016; Valero et al., 2016).The contamination of carcass during evisceration and trimming is responsible for presence of indicator organism in meat (Gill & Baker,1998). Detection of E.coli typically indicated fecal contamination (Berri et al., 2019).The current study result of TVC,TCCand E.coli was lower than the study finding reported by (Mohammad Asif Arain Rajput et al., 2010; Moawad R.K., G.F. Mohamed M.M.S. Ashour, 2013) for Egyptian goat breed.

Meat with higher pH is favorable for fast microbial growth and shortage of shelf-life (Lawrie, 2006; Nakyinsige et al., 2014).The level TVC E.coli of the present meat were found in acceptable level European union microbial criteria of defined by the limit (m) and maximum (M) number of microorganisms per gram as follows: $M = 5 \times 106$ CFU/g (6.7 log CFU/g) for $m = 5 \times 105$ CFU/g (5.7 log CFU/g),for TVC; and M = 500 CFU/g m = 50 CFU/g, for E. coli per 25 gram of minced meat (Eureapoan commision, 2005).

6 CONCLUSION

Location and age had significant effect on hot carcass weight and color of lightness L*, value water holding capacity. Dressing percentage, crude fat, $pH_{24,}$ meat color yellowness b* and hue angle and edible offal (liver and kidney) affected by location. Comparative to north Shewa goats, Borena goat had higher carcass yield, edible offal of (liver and kidney), meat color of lightness L*-values, cooking loss, crude fat but, lower in pH_{24} and water holding capacity. The L*-value fresh meat decreased with increasing slaughter age and the highest value of L* was recorded in 0-teeth old kids. The LW, HCW and liver increased with increasing slaughter age. North Shewa goat could be characterized by lower carcass yield, crude fat and lower dark color. I can conclude that meat higher in ultimate pH and water holding capacity had dark color, high bacterial load and unsafe for storage. It is would be better using 0-teeth/ full milk teeth kids to produce higher lightness L*- value of meat desirable for commercial purpose and reducing incidence darkening

7 RECOMMNDATION

- Further studies should be conducted the effect stress susceptibility on Physicochemical meat quality characteristics.
- Further comprehensive investigation is need on effect of breed, location with wider ranges age on physicochemical meat quality.
- Meat quality and productivity improvement strategies and policy on the slaughter established and implemented along supply chain to troubleshoot existing problem of meat quality and carcass yield.
- Further study is need on evaluation meat yield, and storage stability of meat color.

8 REFERANCE

A. Argu¨ello , N. Castro, J. Capote, M. S., & A. (2005). *MEAT Effects of diet and live weight at slaughter on kid meat quality*. *70*, 173–179. https://doi.org/10.1016/j.meatsci.2004.12.009

Abebe, G., Kannan, G., & Goetsch, A. L. (2010). Effects of small ruminant species and origin (highland and lowland) and length of rest and feeding period on harvest measurements in Ethiopia Rest experiment. *Afr. J. Agric. Res.*, *5*(9), 834–847. https://doi.org/10.5897/AJAR09.274

Abhijith, A., Warner, R. D., Ha, M., Dunshea, F. R., Leury, B. J., Zhang, M., Joy, A., Osei-Amponsah, R., & Chauhan, S. S. (2021). Effect of slaughter age and post-mortem days on meat quality of longissimus and semimembranosus muscles of Boer goats. *Meat Science*, *175*(January), 108466. https://doi.org/10.1016/j.meatsci.2021.108466

Albrecht, A., & Dresch, L. C. (2016). *Identification of influence factors on the quality and shelf life of fresh meat throughout the supply chain*. 1−12.

AMSA. (2012). *Meat Color Measurement* (Issue December).

Arain, M. A., Khaskheli, M., Rajput, I. R., Faraz, S., Rao, S., Umer, M., & Devrajani, K. (2010). *Effect of Slaughtering Age on Chemical Composition of Goat Meat*. *9*(4), 404–408.

Arain, M. A., Rajput, I. R., Khaskheli, M., Faraz, S., Devrajani, K., & Fazlani, S. A. (2010). Evaluation of microbial quality of goat meat at local market of Tando jam. *Pakistan Journal of Nutrition*, *9*(3), 287–290. https://doi.org/10.3923/pjn.2010.287.290

Arain, M. A., Rajput, I. R., Sciences, M., & Fazlani, S. A. (2010). *Examination of Physical Properties of Goat Meat*. accessed *May 2014*.

https://doi.org/10.3923/pjn.2010.422.425

Arik, E., & Karaca, S. (2017). The effect of some pre-slaughter factors on meat quality of bulls slaughtered in a commercial abattoir in Turkey. *Indian Journal of Animal Research*, *51*(3), 557–563. https://doi.org/10.18805/ijar.v0iOF.4563

Arshad, M. S., Sohaib, M., Ahmad, R. S., Nadeem, M. T., Imran, A., Arshad, M. U., Kwon, J. H., & Amjad, Z. (2018). Ruminant meat flavor influenced by different factors with special reference to fatty acids. *Lipids in Health and Disease*, *17*(1), 1–13. https://doi.org/10.1186/s12944-018-0860-z

Assan, N., Sikosana, J. N. L., Matika, O., Maphosa, V., Nyoni, S., & Musasira, M. (2011). *Evaluation of Carcass Performance of Matebele Goats Managed Extensively Based on The Eruption of Permanent Incisors Teeth*. *17*(2), 141–147.

Aziz, M. A. (2010). Present status of the world goat populations and their productivity. *Lohmann Information*, *45*(2), 42–52.

Babiker, S. A., El Khider, I. A., & Shafie, S. A. (1990). Chemical composition and quality attributes of goat meat and lamb. *Meat Science*, *28*(4), 273–277. https://doi.org/10.1016/0309-1740(90)90041-4

Bauer, A. (1973). *Meat Quality – standard methods and new approaches*. 117–120.

Berri, C., Picard, B., Andueza, D., Lef, F., Bihan-duval, E. Le, Chartrin, P., Vautier, A., Legrand, I., & Hocquette, J. (2019). *Predicting the Quality of Meat : Myth or Reality ?8*, 1–22.

Boler, D. D., & Woerner, D. R. (2017). What is meat? A perspective from the American Meat Science Association. *Animal Frontiers*, *7*(4), 8–11. https://doi.org/10.2527/af.2017.0436

Browning, J., Phelps, O., Chisley, C., Getz, W. R., Hollis, T., & Leite-Browning, M. L. (2012). Carcass yield traits of kids from a complete diallel of boer, kiko, and spanish meat goat breeds semi-intensively managed on humid subtropical pasture. *Journal of*

Animal Science, *90*(3), 709–722. https://doi.org/10.2527/jas.2011-3999

Chala Merera and Rama Prasad. (2017). Meat pH and color of Western Highland goats managed under different feeding diets. *International Journal of Agriculture*, *3*(2), 43–46.

Cobanović N, Jamnikar-Ciglenečki U, Kirbiš A, Križman M, Š. M. and K. N. (2019). *Impact of various housing conditions on the occurrence of pathological lesions in slaughtered pigs Vet.*

CSA. (n.d.). *Federal democratic republic of Ethiopia. Central statistical agency. Agricultural sample survey, Volume II, Report on livestock and livestock*. Central Statistical Agency (CSA), Addis Ababa, Ethiopi. https://www.scirp.org/journal/articles.aspx?searchcode=CSA+(Central+Statistics+Agency)+(2015)+Agricultural+Sample+Survey+2014%252F15.+Volume+II+Report+on+Livestock+and+Livestock+Characteristics+(Private+Peasant+Holdings)%252C+Central+Statistical+Agency+(C

D. E.Mushi., L. A. M. and L. O. E. (2007). Some factors affecting the quality of meat from ruminants and their relevance to the Tanzanian meat industry - review. *Tanzania Journal of Agricultural Sciences*, *8*(2), 173–192.

Devendra, C. (1988). *The nutritional value of goat meat*.

Dugas, T. D. (2019). *Productivity and Meat Quality with Meat Goat Management*. *March*.

El-Din Ahmed Bekhit, A., Morton, J. D., Bhat, Z. F., & Kong, L. (2018). Meat color: Factors affecting color stability. *Encyclopedia of Food Chemistry*, *May 2021*, 202–210. https://doi.org/10.1016/B978-0-08-100596-5.21665-X

ElMasry, G., & Sun, D. W. (2010). Meat Quality Assessment Using a Hyperspectral Imaging System. In *Hyperspectral Imaging for Food Quality Analysis and Control*. https://doi.org/10.1016/B978-0-12-374753-2.10006-1

Ernández-Castellano, L. (2015). *water holding capacity determination in meat samples by the press method*. ttps://www.researchgate.net/post/water-holding-capacity-determination-in-meat-samples-by-the-press-method/5501410ccf57d70b7c8b46b3/citation/download.

ES/ISO1442. (2005). *Meat and meat products - Determination of moisture content*. Ethiopian standard agnecy.

ES/ISO1443. (2012). *Determination of total fat*.

ES/ISO936. (2005). *Meat and meat products – Determination of total ash*. EThiopian Estadard agency.

ethioGis. (1997a). *Shape files and satellite imagery file from Borena zone town Administrative.*

ethioGis. (1997b). *shape files and satellite imagery shape file from North Shewa zone town Administrative shape file*.

Eureapoan commision. (2005). Commission Regulation (EC) No 2073/2005 of 15 Nov 2005 on microbiological criteria for foodstuffs. Off. *J. Eur. Union. 2005, L 338/1*.

FAO. (2009). Food and Agriculture Organization of the United Nations (FAO). In *The SAGE Encyclopedia of Food Issues*. https://doi.org/10.4135/9781483346304.n170

FAO. (2018). *FAOSTAT. Live Animals – Production of Goats by Country.* https://www.fao.org/faostat/en/?#compare

FARM-Africa. (1996). *Goat Types of Ethiopia and Eritrea: Physical description and management systems*. https://cgspace.cgiar.org/bitstream/handle/10568/5372/Goat_types_ethiopia.pdf?sequence=4&isAllowed=y

Fazlani, S. (2019). Influence of glycogen level on physical characteristics of goat meat. *Pure and Applied Biology*, *8*(4), 2409–2419. https://doi.org/10.19045/bspab.2019.80186

Fazlani, S., Khaskheli, A. A., Magsi, A. S., Khaskheli, G. B., Barham, G. S., & Fazlani, H. N. (2019). Sensory Attributes of Goat Meat Under the Influence of Glycogen. *Journal of Asian Scientific Research*, *9*(12), 217–226. https://doi.org/10.18488/journal.2.2019.912.217.226

FDRE. (2016). *Growth and Transformation Plan II (GTP II) (2015/16-2019/20)* (No. 81). Ministry of Finance and Economic Development, I(GTP II), 236. https://www.fao.org/faolex/results/details/en/c/LEX-FAOC169444/

Fereja, G. B. (2016). *Characterization of African Goat Production and Productivites: The Case of Ethiopia: A Review*. *16*(5).

G. Januškevičienė, G. Z. A. K. (2012). *Evaluation of meat quality*. Kaunas University of Technology, Food institute.

Gill, C. O., & Baker, L. P. (1998). *Assessment of the Hygienic Performance of a Sheep Carcass Dressing Process t*. *61*(3), 329–333.

Gizaw, S. (2009). *TECHNICAL BULLETIN No.27 Goat breeds of Ethiopia: A guide for identification and utilization, ethiopian sheep and goat productivity improvemnt program ESAGPIP* (Issue 27).

Hautzinger, G. H. P. (2007). Meat Processing Technology For Small- To Medium- Scale Producers. In *Food And Agriculture Organization of The United Nations Regional office For Asia and the Pacific*. Food And Agriculture Organization Of The United Nations Regional Office For Asia And The Pacific. https://doi.org/10.1007/978-1-4684-6876-2_6

Hopkins, D. L., & Geesink, G. H. (2009). Protein degradation postmortem and tenderization. *Applied Muscle Biology and Meat Science, Thompson 2002*, 149–174. https://doi.org/10.1201/b15797-12

Horcada, A., Ripoll, G., Alcalde, M. J., Sañudo, C., Teixeira, A., & Panea, B. (2012). Fatty acid pro fi le of three adipose depots in seven Spanish breeds of suckling kids.

MESC, *92*(2), 89–96. https://doi.org/10.1016/j.meatsci.2012.04.018

Huff-Lonergan, E. (2019). Water-holding capacity of fresh meat contents. *Food Engineering*, 1–19. https://swine.extension.org/water-holding-capacity-of-fresh-meat/

I.T. Kadim , O. Mahgoub, A. Al-Kindi, W. Al-Marzooqi, N. M. A.-S. (2006). Effects of transportation at high ambient temperatures on physiological responses, carcass and meat quality characteristics of three breeds of Omani goats. *Meat Science*, *73*, 624–634.

Industry minister. (2015). *Ethiopian Agro-Industry Strategy Meat Industry Sub- Sector Strategic Plan (2015- 2025) theEthiopian Agro-Industry Strategy Meat Industry Sub- Sector Strategic Plan*.

Ivanovi, S., & Pavlovi, M. (2020). *Influence of breed on selected quality parameters of fresh goat meat*. 219–229.

Ivanovic, S. D., Stojanovic, Z. M., Nesic, K. D., Pisinov, B. P., Baltic, M., Popov-Raljic, J. V., & Đurić, J. M. (2014). Uticaj rase koza na kvalitet mesa. *Hemijska Industrija*, *68*(6), 801–807. https://doi.org/10.2298/HEMIND131201006I

Ivanovic, S., Pavlović, M., Pavlović, I., Tasić, A., Janjić, J., & Å1/2. Baltić, M. (2020). Influence of breed on selected quality parameters of fresh goat meat. *Archives Animal Breeding*, *63*(2), 219–229. https://doi.org/10.5194/aab-63-219-2020

J. Hughes, Sofia Oiseth, P. Purslow, R. D. Warner. (2014). A structural approach to understanding the interactions between colour, water-holding capacity and tenderness. *Meat Science*, *98*(3), 520–532. https://doi.org/10.1016/j.meatsci.2014.05.022

JA. Węglarz. (2019). *Meat quality defined based on pH and colour depending on cattle category and slaughter season*. *November*. https://doi.org/10.17221/2520-CJAS

Jeong, J. Y., Hur, S. J., Yang, H. S., Moon, S. H., Hwang, Y. H., Park, G. B., & Joo, S. T.

(2009). Discoloration characteristics of 3 major muscles from cattle during cold storage. *Journal of Food Science*, *74*(1). https://doi.org/10.1111/j.1750-3841.2008.00983.x

Juminten Saimin1,? , Hartati2 , Yenti Purnamasari2 , Sufiah Asri Mulyawati2 , Tien2, P. A. (2020). *Microbiological and Biochemical Contamination Analysis of Refilled Drinking-water in Abeli, Kendari, Southeast Sulawesi*. *12*(2). https://doi.org/10.18585/inabj.v12i2.871

Juran, J., & Godfrey, A. (1998). Juran's quality handbook, 5th edition. in *juran's quality handbook, 5th edition*.

Kadim, I. T., Mahgoub, O., Al-Kindi, A., Al-Marzooqi, W., & Al-Saqri, N. M. (2006). Effects of transportation at high ambient temperatures on physiological responses, carcass and meat quality characteristics of three breeds of Omani goats. *Meat Science*, *73*(4), 626–634. https://doi.org/10.1016/j.meatsci.2006.03.003

Kadim, I. T., Mahgoub, O., & Khalaf, S. (2014). Effects of the transportation during hot season and electrical stimulation on meat quality characteristics of goat longissimus dorsi muscle. *Small Ruminant Research*, *121*(1), 120–124. https://doi.org/10.1016/j.smallrumres.2014.01.010

Kadim, I. T., Mahgoub, O., & Ritchie, A. (2003). *An evaluation of the growth , carcass and meat quality characteristics of Omani goat breeds*. *66*, 203–210. https://doi.org/10.1016/S0309-1740(03)00092-5

Kannan, G., Kouakou, B., Terrill, T. H., & Gelaye, S. (2003). Endocrine, blood metabolite, and meat quality changes in goats as influenced by short-term, preslaughter stress. *Journal of Animal Science*, *81*(6), 1499–1507. https://doi.org/10.2527/2003.8161499x

Kannan, G., Lee, J. H., & Kouakou, B. (2014). Chevon quality enhancement: Trends in pre- and post-slaughter techniques. *Small Ruminant Research*, *121*(1), 80–88. https://doi.org/10.1016/j.smallrumres.2014.03.009

Kasahun and Solomon. (2008). Breeds of sheep and goats. In B. of sheep and Goats (Ed.), *Sheepand goat production manual for Ethiopia* (p. 349).

Kawęcka, A., & Pasternak, M. (2022). The Effect of Slaughter Age on Meat Quality of Male Kids of the Polish Carpathian Native Goat Breed. *Animals*, *12*(6). https://doi.org/10.3390/ani12060702

Khliji, S., van de Ven, R., Lamb, T. A., Lanza, M., & Hopkins, D. L. (2010). Relationship between consumer ranking of lamb colour and objective measures of colour. *Meat Science*, *85*(2), 224–229. https://doi.org/10.1016/j.meatsci.2010.01.002

Killinger, K. M., Calkins, C. R., & Eskridge, K. M. (2004). *Consumer Visual Preference and Value for Beef Steaks Differing in Marbling Level and Color*.

Kim, J., Yim, D.-G. (2016). Assessment of the microbial level for livestock products in retail meat shops implementing HACCP system. *Korean J. Food Sci. Anim. Resour.*, *36*, 594.

Kopuzlu, S., Esenbuga, N., Onenc, A., Macit, M., Yanar, M., & Yuksel, S. (2018). *Effects of slaughter age and muscle type on meat quality characteristics of Eastern Anatolian Red bulls*. 497–504.

Kumar, S., Patra, G., Roy, A., & Sarkar, H. (2019). Effect of age on meat quality of black Bengal goat meat in different agro-climatic zones in west Bengal. *Journal of Entomology and Zoology Studies*, *7*(5), 47–50.

Kumsa, S., Amha, N., & Urge, M. (2019). *International Journal of Advanced Research in Biological Sciences Carcass characteristics of yearling male borana goats supplemented with protein and energy feed resources .6*, 91–97. https://doi.org/10.22192/ijarbs

Lawrie, R. A. D. A. (2006). *Lawrie's meat science* (SEVENTH ED). Published by Woodhead Publishing Limited, d. www.woodheadpublishing.com%0APublished

Lawrie RA. (1991). *Meat scince* (5th edn). Pergamon Press.

Legese, G., Haile, A., Duncan, A. J., Dessie, T., Gizaw, S., & Rischkowsky, B. (2014). Sheep and goat value chains in Ethiopia : A synthesis of opportunities and constraints. *International Livestock Research Institute (ILRI), ICARDA/ILRI Project Report. Nairobi, Kenya: International Center for Agricultural Research in the Dry Areas/International Livestock Research Institute.* https://www.ilri.org

Madruga, M. S., Janine, E., Medeiros, L. De, Sousa, W. H. De, Gomes, G., Morais, J., Filho, P., & Cássia, R. De. (2009). *Revista Brasileira de Zootecnia Chemical composition and fat profile of meat from crossbred goats reared under feedlot systems Composição química e perfil lipídico da carne caprina de grupos genéticos terminados em confinamento*. *3598*.

Manaye, T. (2019). *Effective, influence of transportation and use of microorganisms treated feeds on growth, carcass yield and meat quality of arsi-bale and afar sheep phd* (Issue 047).

Marichal, A., Castro, N., Capote, J., Zamorano, M. J., & Argüello, A. (2003). Marichal, A., Castro, N., Capote, J., Zamorano, M. J., & Argüello, A. (2003). Effects of live weight at slaughter (6, 10 and 25 kg) on kid carcass and meat quality. Livestock Production Science, 83(2–3), 247–256. https://doi.org/10.1016/S0301-6226(03)0011. *Livestock Production Science*, *83*(2–3), 247–256. https://doi.org/10.1016/S0301-6226(03)00113-1

Mazhangara, I. R., Chivandi, E., & Mupangwa, J. F. (2019). *The Potential of Goat Meat in the Red Meat Industry*. 1–12.

McGregor.Attwood, B. (2007). *Meat and Offal Yiled of Goat*. https://apo.org.au/sites/default/files/resource-files/2007-01/apo-nid57100_0.pdf

Migdał, W.; Kawęcka, A.; Sikora, J.; Migdał, Ł. M. (2021). Meat Quality of the Native Carpathian Goat Breed in Comparison with the Saanen Breed Władysław. *Animal*.

Moawad, R.K., G.F. Mohamed, M.M.S. Ashour, E. M. A. E.-H. (2013). *Chemical Composition , Quality Characteristics and Nutritive Value of Goat Kids Meat*. *9*(8),

5048–5059.

Monteiro, A., Costa, J. M., & Lima, M. J. (2018). Goat System Productions: Advantages and Disadvantages to the Animal, Environment and Farmer. In *Goat Science*. InTech. https://doi.org/10.5772/intechopen.70002

Moran, J. B. and J. T. W. (1986). Comparative performance of 5 genotypes of Indonesian large ruminants. 3. Growth and development of carcass tissues. *Aust. J. Agric. Res*, *37*, 435–447.

N H Casey, W. A. N. and E. C. W. (2003). *Goat Meat*. 423–425.

Nakyinsige, K., Fatimah, A. B., Aghwan, Z. A., Zulkifli, I., Goh, Y. M., & Sazili, A. Q. (2014). Bleeding efficiency and meat oxidative stability and microbiological quality of New Zealand white rabbits subjected to halal slaughter without stunning and gas stun-killing. *Asian-Australasian Journal of Animal Sciences*, *27*(3), 406–413. https://doi.org/10.5713/ajas.2013.13437

Neethling, N. E., Suman, S. P., Sigge, G. O., Hoffman, L. C., & Hunt, M. C. (2017). *Exogenous and Endogenous Factors Influencing Color of Fresh Meat from Ungulates*. Meat and Muscle Biology. https://doi.org/10.22175/mmb2017.06.0032

P. Pophiwa1, E. C. W. & L. F. (2017). *Carcass and meat quality of Boer and indigenous goats of South Africa under delayed chilling conditions*. *47*(6).

Page JK, Wulf DM, S. T. (2001). A survey of beef muscle color and pH No Title. *J Anim Sci*, *79*, 678.687.

Peacock, C. (2005). *Peacock*, (Vol. 60, pp. 179–186).

Peña, F., Bonvillani, A., Morandini, M., Freire, V., Domenech, V., & García, A. (2011). Carcass quality of Criollo Cordobes and Anglo Nubian suckling kids: Effects of age at slaughter. *Archivos de Zootecnia*, *60*(230), 225–235. https://doi.org/10.4321/s0004-05922011000200007

Ponnampalam, E. N., Hopkins, D. L., Bruce, H., Li, D., Baldi, G., & Bekhit, A. E. din.

(2017). Causes and Contributing Factors to “Dark Cutting” Meat: Current Trends and Future Directions: A Review. *Comprehensive Reviews in Food Science and Food Safety*, *16*(3), 400–430. https://doi.org/10.1111/1541-4337.12258

Pophiwa, P., Webb, E. C., & Frylinck, L. (2020). A review of factors affecting goat meat quality and mitigating strategies. *Small Ruminant Research*, *183*, 1–25. https://doi.org/10.1016/j.smallrumres.2019.106035

Pratiwi, N. M. W., Murray, P. J., & Taylor, D. G. (2007). *MEAT Feral goats in Australia : A study on the quality and nutritive value of their meat*. *75*, 168–177. https://doi.org/10.1016/j.meatsci.2006.06.026

Purnami, N. A., & Purbowati, E. (2021). *Meat production of young and adult Kejobong goats fed diets with different protein concentration*. *31*(1), 52–59. https://doi.org/10.21776/ub.jiip.2021.031.01.07

Ramanathan, R., Hunt, M. C., Mancini, R. A., Nair, M. N., Denzer, M. L., Suman, S. P., & Mafi, G. G. (2020a). *Meat and Muscle Biology* ^{TM} *Recent Updates in Meat Color Research : Integrating Traditional and High-Throughput Approaches Effect of pH on Muscle Structure and Meat Color*. https://doi.org/10.22175/mmb.9598

Ramanathan, R., Hunt, M. C., Mancini, R. A., Nair, M. N., Denzer, M. L., Suman, S. P., & Mafi, G. G. (2020b). Recent Updates in Meat Color Research: Integrating Traditional and High-Throughput Approaches. *Meat and Muscle Biology*, *4*(2). https://doi.org/10.22175/mmb.9598

Sañudo, C., Campo, M. M., Muela, E., Olleta, J. L., Delfa, R., Jiménez-Badillo, R., Alcalde, M. J., Horcada, A., Oliveira, I., & Cilla, I. (2012). Características de la canal y calidad instrumental de la carne en cabritos y corderos lechales. *Spanish Journal of Agricultural Research*, *10*(3), 690–700. https://doi.org/10.5424/sjar/2012103-670-11

Sebsibe, A. (2006). *Meat quality of selected Ethiopian goat genotypes under varying nutritional conditions . By* (Issue June). Pretoria, South Africa:University of Pretoria.

Shapiro, B.I., Gebru, G., Desta, S., Negassa, A., Nigussie, K., A. G. and M. H. (2017). *Ethiopia livestock sector analysis*.

Shija, D. S., Mtenga, L. A., Kimambo, A. E., Laswai, G. H., Mushi, D. E., Mgheni, D. M., Mwilawa, A. J., Shirima, E. J. M., & Safari, J. G. (2013). Chemical composition and meat quality attributes of indigenous sheep and goats from traditional production system in Tanzania. *Asian-Australasian Journal of Animal Sciences*, *26*(2), 295–302. https://doi.org/10.5713/ajas.2012.12432

SiHonikel, J.L., 1998. (2004). *Effect of sex , age , and pre-slaughter conditioning on pH , temperature , tenderness and colour of indigenous South African goats*. *34*(Supplement 1), 208–211.

Simela, L. (2005). *Meat characteristics and acceptability of chevon from South African indigenous goats by Thesis submitted in partial fulfilment of the requirements for the degree PhD (Animal Science) in the Faculty of Natural & Agricultural Sciences University of Pretor*. *June*.

Tadesse, D., Urge, M., Animut, G., & Mekasha, Y. (2016). Growth and carcass characteristics of three Ethiopian indigenous goats fed concentrate at different supplementation levels. *SpringerPlus*. https://doi.org/10.1186/s40064-016-2055-2

Todera, F. (Ed.). (2010). *Handbook of Meat Processing* (First). Blackwell Publishing. www.wiley.com/ wiley-blackwell

Toplu, H. D. O. (2014). *Factors Affecting Carcass and Meat Quality Characteristics in Goats 1*. *3*, 248–252.

Effects of slaughter age and gender on carcass characteristics of Turkish indigeneous Hair goat kids reared under an extensive production system, 56 Archives Animal Breeding 75 (2013). https://doi.org/10.7482/0003-9438-56-008

Toplu1, H. D. O., Goksoy2, E. O., & Nazligul1, and A. (2013). Effects of slaughter age and gender on carcass characteristics of Turkish indigeneous Hair goat kids reared

under an extensive production system. *ArchivTierzucht, 56,* 8,75-88.

Troy, D. J., & Kerry, J. P. (2010). Consumer perception and the role of science in the meat industry. *Meat Science*, *86*(1), 214–226. https://doi.org/10.1016/j.meatsci.2010.05.009

UNDESA. (2019). World population prospects 2019. In *Department of Economic and Social Affairs. World Population Prospects 2019.* (Issue 141). http://www.ncbi.nlm.nih.gov/pubmed/12283219

Valero, A., Rodríguez, M.-Y., Posada-Izquierdo, G. D., Pérez-Rodríguez, F., Carrasco, E., & García-Gimeno, R. M. (2016). Risk Factors Influencing Microbial Contamination in Food Service Centers. *Significance, Prevention and Control of Food Related Diseases*. https://doi.org/10.5772/63029

W. Ding , L.Kou a, B. Cao, Y. W. (2010). Meat quality parameters of descendants by grading hybridization of Boer goat and Guanzhong Dairy goat. *Meat Science*, *84*(3), 323–328. https://doi.org/10.1016/j.meatsci.2009.04.015

WARRISS, P. D. (2000). *Meat Science An Introductory Text*.

Webb, E. C., Casey, N. H., & Simela, L. (2005). *Goat meat quality*. https://doi.org/10.1016/j.smallrumres.2005.06.009

Worku, A., Urge, M., Animut, G., & Asefa, G. (2020). *Comparative Slaughter Performance and Meat Quality of Rutana , Gumuz and Washera Sheep of Ethiopia Supplemented with Different Levels of Concentrate*. 48–63. https://doi.org/10.4236/ojas.2020.101005

World Bank. (2017). *The World Bank Livestock and Fisheries Sector Development Project (P159382: International Development Association Project Appraisal Document on a Proposed Credit to The Federal Democratic Republic of Ethiopia for a Livestock and Fisheries Sector Developme*.

Wulf, D. M., Emnett, R. S., Leheska, J. M., & Moeller, S. J. (2002). Relationships among glycolytic potential, dark cutting (dark, firm, and dry) beef, and cooked beef palatability. *Journal of Animal Science*, *80*(7), 1895–1903. https://doi.org/10.2527/2002.8071895x

Yalcintan, H., Akin, P. D., Ozturk, N., Ekiz, B., Kocak, O., & Yilmaz, A. (2018). Carcass and meat quality traits of saanen goat kids reared under natural and artificial systems and slaughtered at different ages. *Acta Veterinaria Brno*, *87*(3), 293–300. https://doi.org/10.2754/avb201887030293

Young, O. A., West, J., Hart, A. L., & Van Otterdijk, F. F. H. (2004). A method for early determination of meat ultimate pH. *Meat Science*, *66*(2), 493–498. https://doi.org/10.1016/S0309-1740(03)00140-2

Yusuf, A., Abera, B., & Eticha, E. (2019). *Evaluation of Carcass Yield Characteristic of Sheep and Goat at ELFORA Export Abattoir , Bishoftu town , Ethiopia Arsi Zone Livestock and Fishery Resource Office , Asella , Ethiopia*. *13*(2), 46–51. https://doi.org/10.5829/idosi.abr.2019.46.51

Zewdu Edea Bedada, Bikila Negasa Gilo, G. T. D. (2019). Morphometric and Physical Characterization of Borana Indigenous Goats in Southern Morphometric and Physical Characterization of Borana Ethiopoa. *Universal Journal of Agricultural Research*, *1*, 25–31. https://doi.org/10.13189/ujar.2019.070104

Zotte, A. D., Brugiapaglia, A., & Cullere, M. (2017). What is meat in Italy? *Animal Frontiers*, *7*(4), 63–70. https://doi.org/10.2527/af.2017.0448

9 Appendix

9.1 Study animal and slaughtering procurers

Figure 8. Study Goats

Figure 9. Slaughtered goats

9.2 Determination of pH

Figure 10. Calibration of pH

Figure 11. Measuring pH

9.3 Determination of instrumental color

Figure 12. Colorimeter calibrating plates

Figure 13. Color measurement

9.4 Microbial determination procedures

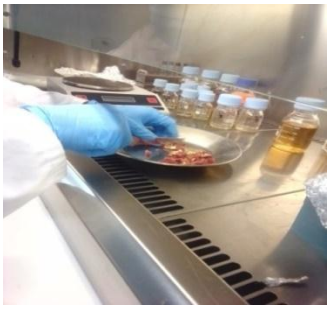


Figure 14. Mincing of sample

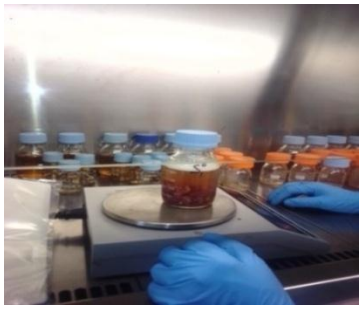


Figure 15. Dilution of sample

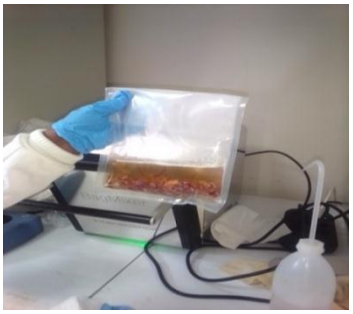


Figure 16. Sample homogenization

Figure 17. Bag mixer inter science

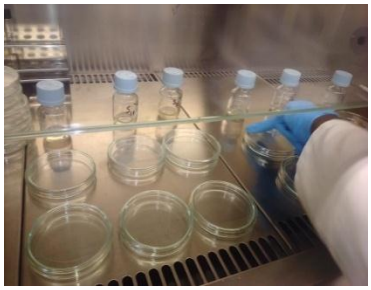
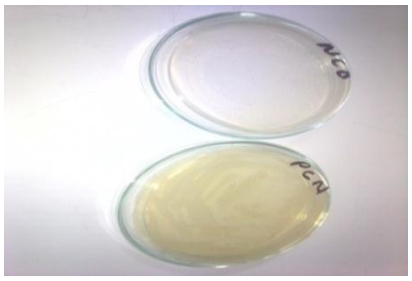


Figure 18.SterilizedpetridishFigure 17.PCA in water bath

Figure 19.Pouring PCA peteridish igure 20. Pipetting suspensions



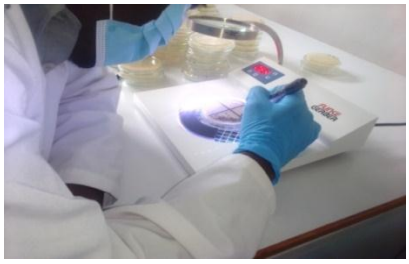


Figure 21. Negative control Figure 22. Microbial count

Figure 23..Microbial suspension

9.5 ANOVA Table

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
pH 45min	Between Groups	.030	1	.030	.435	.525
	Within Groups	.690	10	.069		
	Total	.720	11			
pH3hr	Between Groups	.163	1	.163	3.952	.075
	Within Groups	.413	10	.041		
	Total	.577	11			
pH 24 hr	Between Groups	.653	1	.653	22.273	.001
	Within Groups	.293	10	.029		
	Total	.947	11			
L*	Between Groups	25.056	1	25.056	6.039	.034
	Within Groups	41.491	10	4.149		
	Total	66.548	11			
a*	Between Groups	.071	1	.071	.200	.664
	Within Groups	3.529	10	.353		
	Total	3.600	11			
b*	Between Groups	10.323	1	10.323	13.725	.004
	Within Groups	7.521	10	.752		
	Total	17.844	11			
Chroma	Between Groups	7.115	1	7.115	4.652	.056
	Within Groups	15.295	10	1.529		
	Total	22.409	11			
Hue angle	Between Groups	132.003	1	132.003	10.552	.009
	Within Groups	125.097	10	12.510		
	Total	257.100	11			

Carcass Yield and none component

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
LW/Kg	Between Groups	45.202	1	45.202	15.638	.003
	Within Groups	28.905	10	2.891		
	Total	74.107	11			
HCW/kg	Between Groups	22.963	1	22.963	16.648	.002
	Within Groups	13.793	10	1.379		
	Total	36.757	11			
DP%	Between Groups	58.080	1	58.080	9.245	.012
	Within Groups	62.825	10	6.283		
	Total	120.905	11			
kidney g	Between Groups	.002	1	.002	33.684	.000
	Within Groups	.001	10	.000		
	Total	.003	11			
Heart g	Between Groups	.000	1	.000	2.276	.162
	Within Groups	.001	10	.000		
	Total	.001	11			
Liver g	Between Groups	.029	1	.029	22.516	.001
	Within Groups	.013	10	.001		
	Total	.042	11			
lung with trachea, g	Between Groups	.026	1	.026	35.143	.000
	Within Groups	.007	10	.001		
	Total	.033	11			
Viscera kg	Between Groups	.907	1	.907	3.810	.079
	Within Groups	2.382	10	.238		
	Total	3.289	11			
head kg	Between Groups	.083	1	.083	1.411	.262
	Within Groups	.591	10	.059		
	Total	.674	11			
feet and skin kg	Between Groups	1.021	1	1.021	5.576	.040
	Within Groups	1.831	10	.183		
	Total	2.852	11			

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Moisture	Between Groups	2.891	1	2.891	.712	.418
	Within Groups	40.600	10	4.060		
	Total	43.491	11			
Protein	Between Groups	.099	1	.099	.275	.611
	Within Groups	3.594	10	.359		
	Total	3.693	11			
Fat	Between Groups	1.688	1	1.688	6.382	.030
	Within Groups	2.644	10	.264		
	Total	4.332	11			
Ash	Between Groups	.001	1	.001	.138	.718
	Within Groups	.060	10	.006		
	Total	.061	11			