FATTENING PRACTICE, INSTRUMENTAL TENDERNESS AND WATER HOLDING CAPACITY OF BEEF SUPPLIED TO ABATTOIRS IN SOURHERN ETHIOPOIA

MSc THESIS

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This is to certify that the thesis entitled "**Fattening practice, instrumental tenderness and water holding capacity of beef supplied to abattoirs in Southern Ethiopia"** submitted in partial fulfillment of the requirements for the degree of Master with specialization in Animal Production, the Graduate Program of School of Animal and Range Science, and has been carried out by Solomon MarkosSamago, ID No SGSK/207/08 under our supervision, and no part of the thesis has been submitted for any other degree or diploma. Therefore, we recommended that the student has fulfilled the requirements and hence hereby can submit the thesis to the thesis to the department.

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DEDICATION

I dedicate this thesis manuscript to my beloved parents, **Ato MARKOS SAMAGO** and late mother **W/ro WELETE SELASAE SIDAMO**, and my wife **W/ro SHETO TSEGAYE**for their warmest affection, love and dedicated partnership for the success of my life.

STATEMENT OF THE AUTHOR

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ACRONYMS AND ABBREVIATIONS

AMSA	American Meat Science Association
ANOVA	Analysis of Variance
ASF	Animal Source Food
CL	Cooking loss
CSA	Central Statistical Agency
DFD	Dark, Firm and Dry
EARO	Ethiopian Agricultural Research Organization
EIAR	Ethiopian Institute of Agricultural Research
FAO	Food and Agriculture Organization
FDI	Foreign Direct Investment
GDP	Gross Domestic Product
NGO'S	Non-Governmental Organizations
QDA	Quantitative Descriptive Analysis
SF	Shear Force
SNNPRS	Southern Nation and Nationalities People Regional Government
SPSS	Statistical Package for Social Sciences
TLU	Tropical Livestock Unit
USDA	United States Department of Agriculture
WBSF	Warner Bratzler Shear Force

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Fattening practice, instrumental tenderness and water holding capacity of beef supplied to abattoirs in Southern Ethiopia

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ABSTRACT

This study assessed the fattening practice, instrumental tenderness and water holding capacity of beef supplied to abattoirs in Southern Ethiopia. The study had two components: survey and lab experiment. The survey study was conducted at Hawassa city (Tula), Wolayita zone (Dimtu) in SNNPRG and Arsi Negelle in Oromia region. The locations were purposively selected because they were the main suppliers of beef cattle to Hawassa City. The key informants were selected based on the information of their fattening experiences. Therefore, 45 traditional fatteners at farmer level, 30 fatteners in sub-urban areas were interviewed. 30 consumers were interviewed in Hawassa city concerning their preference of beef in relation to the origins of the cattle. The results showed thatthe 95.1%, of the respondent farmers used their oxen to plough their farm lands and either fattened or sold the old aged oxen.The farmers trekked their animals to the local market places and the average distance was 13.23 ±2.748Km. Using oxen for draught power, selling the animals at old age and trekking the animals long distance to market areas were the identified practices which adversely affect the beef quality.36.7% of the consumers preferred beef of the animals from Arsi Negelle, 26.7% from Hawassa, 26.7% from Wolayita and 10% from other locations. 90% of the consumers' preferred the beef mainly based on good tenderness and only 10% of the consumers preferred by the presence of white fat layer.The Lab analysis was conducted to assess the instrumental beef tenderness (WBSF) and beef cooking loss of the beef slaughtered at Hawassa City abattoir. 227 beef samples were collected from randomly selected cattle in two different seasons: dry season (December, January and February) and wet season (March, April and May). The beef samples were taken from Longissimus muscle (longissimus dorsy), aged at -4 ^{0}C for 14 days and analyzed by WBSF instrument according WBSF-Ethiopian protocol procedure at Hawassa. The CL was obtained by calculating the percentage of the weight difference of the beef samples weighed before and after cooking in the laboratory. The results showed that the overall WBSF value and the CL of the beef were 3.9±0.1kgf and 25.42±0.54 (%), respectively. The WBSF value of the beef in wet season and dry season were4.16±0.15 & 3.69±0.16 Kgf,respectively. The difference of beef tenderness between wet and dry season was significant at p≤0.05. CL was 23.49±0.84% at dry season and 27.08±0.66% at wet season. The CL percentage was higher at wet season than the dry season, and the difference was significant at p≤0.05. The WBSF was 3.97± 0.15, 3.70±0.22 and 4.03±0.28 in Hawassa, Wolayita and Arsi Negelle locations respectively. The CL was 26.12± 0.84, 23.81± 0.92 and 25.20± 1.14 in Hawassa, Wolayita and Arsi Negelle locations respectively. Both WBSF and CL were not significantly different between the locations.Therefore, the WBSF value of the beef in wet and dryseason can be graded as intermediate and tender beef respectively.The overall WBSF value can be graded as Tender beef. In order to produce more tender beef younger animals which were not used for traction power should be provided to the beef market and trekking theanimals long distance before slaughter should be minimized to minimize the stress.

Key words: Cooking Loss, Beef Tenderness, Shear force.

1. INTRODUCTION

Human population of Ethiopia is increasing figuratively going beyond 100 million in number (CSA, 2018), and similarly, urbanization is increasing now a days more than ever. As the consequence of fast urbanization, availability of job opportunities and increased income (GDP per capita= $549.8)of the people (CSA, 2018)are basic reasons for the increasing demand for food of animal origin, mainly meat.

According to the Central Statistics Authority of Ethiopia (2017) the population of livestock is 59.5 million cattle, 30.70 million sheep, 30.20 million goats, 8.44 million donkeys, 2.16 million horses, 1.21 million camels, and 0.41 million mules. Out of these resources nationally the estimated numbers of annually slaughtered beef cattle and dairy cattle is 499,841.

Ethiopians usually consume 8.5kg per capita meatof which approximately 4.3 kg is beef. Beef consumption has been growing at a rate of 2.25 percent per year. (FAOSTAT, 2004 and FAO, 2009) of limited types of animals because of the existence of the taboos associated diverse cultural practices and beliefs (Semeneh, 2014). Moreover, the consumption of meat and meat products has a very tidy association with religious beliefs, and are influenced by religions (Kebede, 2010,Semeneh, 2014).However; consumption of meat is also very essential cultural practice in Ethiopia. Ethiopians prepare food items from meat in holidays, initiation rites and visitations by important guests (Kifleyesus, 2007). Similarly meat and meat products are preferable during feasting days and social ceremonies. Meat and meat products are eaten and the stews are also made mainly from chicken, beef, lamb and mutton.

Based on the data provided by CSA (2017) national beef cattle population is 402,614 heads. when we see regional beef cattle population distribution there are 262,623 heads of

beef cattle inOromia region (within Oromia region there are 20,286 heads of beef cattle in ArsiNegelle area), and there are 65,825heads of beef cattle in SNNP region (within SNNP Regionthere are 12,999 heads in Sidama zone, 1,964 heads in Wolayita zone million and 9,715 heads of beef cattleGamoGofa zone).

In Ethiopia, some occasions and holidays such as the celebration ceremony of the finding of the 'Holly Cross' called 'Meskel', a cow or an ox can be butchered for the purpose of dividing, sharingand sellingwithin the communityand that specific ceremony is called 'Kircha' (Semeneh, 2014). This shows us that meat and meat product consumption ceremonies have social significance in family gatherings, making friendships, prestige by offering dinners (Semeneh, 2014, MAPP, 1994).

Existence of large number of livestock population in Ethiopia provides opportunities to insure national food security in short period of time by supplying animal source food. However, these potentials are not utilized properly because of the problems related to low production and the low productivity of the animals, poor standardization of the qualities of livestock products (especially unknown standard of beef quality), poor animal health facilities, low availability of animal feed and poor finishing (fattening practices), and continuously increasing human population of the country (FAO, 2005; and UN, 2005). In addition to the reasons mentioned above, currently poor meat quality is the largest limiting factor to both domestic and export market accesses for Ethiopian beef(Alemayehu, 2012). Previously some works have been done in western Ethiopia to assess beef tenderness and retail life by Abdisa(2009) on Horro cattle.

However, only few studies are availableconcerning beef tenderness in Ethiopia this is one of the limitations to standardize beef nad beef products for bothe domestic and export markets. Thus, this study was initiated with the following objective of this study was To assess fattening practice, instrumental tenderness and water holding capacity of beef supplied to abattoirs in Southern Ethiopia.

The specific objectives were:

- To assess and describe the fattening practices that may affect the beef qualities (beef tenderness and cooking loss) of the animals fattened at the farmers' level and at urban and peri urban fattnerslevel;
- To assess the tenderness, and cooking loss of the beef currently produced in the Hawassa city abattoir.

2. **LiteratureReview**

2.1.The Livestock Production Systems

The beef cattle production systems of Ethiopia are predominantly categorized as agro-pastoral system in the lowlands, and the mixed crop–livestock system in altitudes ranging between 1500 and 3200 m.a.s.l(Alemayehu, 2003 and 2012).

Livestock production is integrated into crop production system for the purpose of, threshing, manure production, tillage, milk production, meat production and cart pulling. The Arsi breed is the dominant local/indigenous cattle breed in Arsi Negelle and in southern Ethiopia (Hawassa and Wolayita), which is near to Arsi Negelle. This local breed is characterized by low milk production, thus, its major contribution is provision of draught power and manure production and meat. On average, 85% of households keep two draught oxen for tillage, threshing and manure production. When the capabilities of the draught oxen begin to decline, the oxen are sold for slaughter after a short period of fattening. Sheep, goats and chicken are also kept by households for sale and household consumption (Addisu, 2012).

The unpublished annual report documents of the municipality of the city administration (2018) show that sources of the beef animals are mixed crop-livestock production system in areas such as Arsi Negelle (Western Arsi zone of the Oromia regional state), Sidama zone, Wolayita zones of SNNP governmental state, andto some extent from Boran zone which is known as pastoral and Agro-pastoral production fromHarar which is known for Crop- livestock mixed production system in Eastern part of the Oromia regional state.

2.2.Livestock Marketing in Ethiopia

There was no strategic production of livestock for marketing except some sales targeted to traditional Ethiopian festivals. However there are some traditional fattening practices dispersed all over Ethiopia, and there are very few feed lots around cities (Mojo, Adama, and Addis Ababa).

Table 1: Five year data of slaughtered animals at Hawassa City Abattoir (2012-2017)

Budget Year	**Number of slaughtered cattle**
2012/13	16,516.00
2013/14	18,124.00
2004/15	20,117.00
2015/16	22,538.00
2016/17	23,114.00

Source: Yearly Report of Hawassa Municipality annual report of June, 2017

The price of meat in the study areas (Hawassa, and Arsi Negelle) showed variation depending not only on the quality of the meat but on the other reasons such as favorable coat color for the local buyers, sex, age, body condition, approaching of holidies and seasonal unsatisfactory supply for the increasing demnd. According to Lijalem, *et al*., (2015) the price of the livestock were significantly higher just prior to the festivals and also during the holiday season. The price of the roasted chevon and beef are higher than the raw one.

There is increasing deman for beef in Hawassa city as we can see from table 2 which shows the number of beef cattle slaughtered for five years at Hawassa city administration abattoire and number of animals slaughtered increased from year to year.

Lijalem, *et al*. (2015) also stated that the pattern of consumption of meat was highest during the festivals and holidays (89.1%), followed by times of social obligations (79.2%).

Hawwas city administration also gaines large amount of income by giving slaughter service at we can observe the income trend on table 2. According to the annual report of Hawassa city administration municipality the abattoir makes average the annual income ETB 6,495,462 /six million, four hundred ninety five thousand, four hundred sixty two Ethiopian birr/ by providing slaughtering services to the butcheries in the city (Annual report,. 2017/18).

Table 2: Six year's from (2012 to 2018) income trend showin the economic importance of this sector for Hawassa city adminstration

Income from service	Ethiopian fiscal yearly income the abattoir					
	Year 2012/13	Year 2013/14	Year 2014/15	Year 2015/16	Year 2016/17	Year 2017/18
Slaughtering & Delivering	3,325,000	4,531,000	5,029,250	5,577,250	8,331,900	8,430,000
Treatment of Hide	127,105.40	30,000	415,560.37	1,748,073	821,530.60	606103
Total income	3,452,105.4	4,561,000	5,444,810	7,325,323	9,153,430.6	9,036,103

Source: Yearly Report of Hawassa Municipality annual report of June, 2017

2.3.Livestock Export Markets of Ethiopia

Of the various breeds of cattle found in Ethiopia, the Boran breed (found in Borena Zone in the Oromiya Region of Ethiopia) is one of the most prized in the Middle East markets and the country has exported approximately 200,000 livestock annually in the illegal markets. This is significantly higher than the annual official exports of cattle (12,934 head), sheep (13,554 head) and goats (1,247 head) between 1998 and 2003Ethiopia has the

comparative advantage of geographical proximity, currently meat is exported mainly by air and live animals through three main routes, trough Somalia and Somaliland to the Gulf States, the southern border to Kenya and the northwestern border to Sudan (Alemayehu & Ayalew 2013).

However, the country's high air cargo costs and the high rate of carcass rejection upon arrival in the Gulf States decreases its cost competitiveness, while the low quality of meat (dark cutting due to poor animal handling, etc.) lowers Ethiopia's quality competitiveness as well.

Low productivity of the animals and the smallholder subsistent non market-oriented production systems are described as the main constraints of livestock production in the country. In Ethiopian, for the demand of live animal and meat, there are different opportunities like domestic consumption, official exports and high demand of animals by the export abattoirs. However, various internal and external factors are described under the challenges of live animal and meat marketing system in Ethiopia and it includes: absence of effective grading system, absence of market information system, absence of promotional activities, supply problems, prevalence of diseases, traditional production system, and illegal export trade, inadequacy of infrastructure, competition, repeated bans and inadequate port facilities (Eshetu and Abraham, 2016).

2.4.Beef and Beef Quality

As we can see from liratures meat is the flesh of adult animals which used as food by human beings and it consists protein, water, adipose tissue, carbohydrate and other soluble non-protein chemicals and this makes meat to consist the essentials and adequate diet for human being (Warriss, 2000).

Beef is meat from cattle; particularly skeletal muscle of full-grown cattle, about 2& above year's old and good quality beef is red in color and also may be very dark red in mature carcass. A live steer weighs about 1,000 pounds (lb) and yields about 450 pounds (lb) of edible meat (USDA, 2015), and Veal is meat from a calf which weighs about 150 pounds. Those that are mainly milk-fed usually are less than 3 months old. The difference between "veal" and "calf" is based on the color of their meat, which is determined almost entirely by diet. Veal is pale pink and contains more cholesterol than beef (Gregory and Welfare, 1998).

There are at least 50 breeds of beef cattle in the world, but fewer than 10 make up most cattle produced. Some major breeds are Angus (Aberdeen Angus), Hereford, Charolais, and Brahman (UDSA, 2015).

Angus cattle, known as Aberdeen Angus in most parts of the world, are a breed of cattle commonly used in beef production. They were developed from cattle native to the counties of Aberdeenshire and Angus in Scotland (Warriss, 2000).

2.4.1. Beef Quality

Characteristics of meat which satisfy consumers taste can be defined as assessment of meat quality. Meat quality assessment can be conducted by studying either the intrinsic quality traits of the meat and/or the extrinsic quality traits of the meat which are associated to the price, brand or quality labels. The relative importance of different meat quality traits can vary with different human cultures, through time and also due to contribution of the meat to the healthiness and food safety for man (Jean*et al*, 2012).Hpwever, the major components of meat quality are yield, technological properties and palatability, as elaborated in Table 2 according to Warriss(2000).

Table 3: Major components of meat quality

Yield and gross composition	Quality of saleable product
	Ratio of fat to lean
	Muscle size and shape
Appearance and technological characteristics	Fat texture and color
	Amount of marbling in lean (intramuscular fat)
	Color and WHC of lean
	Chemical composition of lean
Palatability:	Texture and Tenderness
	Juiciness
	Flavour
Wholesomeness:	Nutritional quality
	Chemical safety
	Microbiological safety
Ethical quality:	Acceptable husbandry of animals

Source: Warriss, 1996C

2.4.2. Yield and Gross Composition of Beef

The yield and gross composition refers to the quantity of meat, the ratio of fat to lean and shape and size of muscles. The yield of product is important because it determines how much you have to sell and higher yields mean more product and potentially greater profit.Average carcass weight at the local abattoirs of Ethiopia is reported as 135.9kg. Whereas, the average live weight, carcass weight and dressing percentage at the export abattoirs, such as ElforaBishoftu, Elforacombolcha and ElforaMelgawendo, was reported as 241.41 kg, 106.96kg and 44.21 %, respectively (Mummed, 2015).

2.4.3. Appearance and Technological Characteristics of Beef

Technological qualities of meat are more concerned with appearance, water holding capacity (WHC), and chemical composition. Since most consumers observe and judge the acceptability of most meat at purchase appearance of meat is important quality component.

2.4.3.1.Beef Water Holding Capacity

Water holding capacity is one of appearance and technological characteristics of meat and it can be stated as the ability of meat to hold its own or added water during the application of any force (Hamm, 1986). The capacity of meat to hold internal water from loss in drip is desirable meat quality, and more drip is formed when water holding capacity is poor and less drip is formed when the water holding capacityhigh.Moreloss of drip leads to weight loss in fresh meat, and in processed meats(Warriss, 2000).

Water holding capacity (WHC) of beef is important characteristic of beef because it determines weight loss of meat (meat met products yield loss), juiciness and cooking loss and also the water-soluble constituents of beef determine flavour beef (Warriss, 2000)

2.4.4. Beef Palatability

Palatability or eating quality encompasses three main characteristics. These characteristics are texture, tenderness, juiciness and flavour/odour. In many developed countries, people prefer their meat to be tender (Warriss, 2000, Parrish, 1974).

2.4.4.1.BeafTenderness

Tenderness is one of the palatability characteristics of meat and it refers to the ease of chewing of meat which is contributed by many factors such as age, stress, feed etc. The fibrous nature of muscle contributes to chewing resistance (Warriss, 2000, Gerrard, 2003). Consumers prefers and willing to pay higher for high tender beef (Nandode, 2013), and we can say beef tenderness is the most important palatability factor impacting consumer eating satisfaction (Savell*et al.,* 1987; Miller *et al*., 1995; Savell*et al.,* 1999). To the date, there is scarcity of information concerning beef tenderness of Ethiopian beef except some works

has been done on Horro cattle breeds (Abdisa, 2009) and Harar, Arsi, Bale (BirmadumaGadisa*et al.,* 2019).

According to some studies there is positive relationship between the price of a cut of meat and its relative tenderness (Savell and Shackelford, 1992). It has been demonstrated that consumers will pay more for steaks that are known to be tender (Boleman*et al.*, 1995), thus, there is an economic incentive for predicting meat tenderness.

Low tenderness, which means toughness and not easy to chew, and excessive external fatness are part of the top quality concerns of the beef industry (Smith, 1992), and in addition to that inconsistency in meat tenderness has been identified as one of the major problems facing the beef industry worldwide (Morgan et al., 1991; Morgan, 1992; Smith, 1992; and Savell and Shackelford, 1992).However, increased intramuscular fat is associated with improved tenderness (Hopkins *et al*.,2006).

The inconsistency in meat tenderness is due to a combination of our inability to identify animals producing tender meat or tough meat, and routinely produce tender meat.

Three tenderness grades can be used to improve the prediction of consistency of meat quality from day-1 shear value: highest grade, middle grade and lowest grade carcasses. Better meat tenderness is associated with higher intramuscular fat (IMF) (Wolcott *et al*. 2009), and higher IMF is also associated with good flavour of meat (Hopkins *et al*. 2006). According to the criteria established by Bellew and others, beef cattle carcass muscles may be classified by their shear force as: very tender, SF values less than 3.2 Kgf; tender, SF values between 3.2 Kgf and 3.9 Kgf; intermediate, SF values between 3.9 Kgf and 4.6 Kgf; and hard, SF values above 4.6 Kgf (Bellew*et al*., 2003).

Shear force test standards have been established to determine the best meat tenderness for various type of meat. According to Destefanis*et al*., (2008), most frequently meat tenderness has been assessed by instrumental procedureWarnerBratzlershear force (WBSF) test, since 1930s.

Warner-Bratzler Fixtures measure the force required to cut through a piece of meat. The fixture consists of a steel frame supporting a triangular shear blade. To test a meat sample such as steak, the steak is cooked, cooled and then cut into core samples.

Previous work experiences concerning testing beef tenderness by using Warner-Bratzler shear force testing procedure in Ethiopia(Abdisa et al., 2009) and in brazil(Abdisa *et al.*, 2009) show that the results from the procedure will be compared to the values of the quantitative descriptive analysis (QDA) of the sensory evaluation of the sensory panel(Ishihara, *et al.*, 2013).

2.4.4.2.Beef Flavor

The test and the aroma/smell of meat are sensedbytongue and nose respectively the information from integrated and interpreted by the brain and gives us the Flavor of the meat (Warriss, 2000). Flavor is the most influential factor in food choice of mankind. The source of differences in meat flavor is fat content and the fat content depends on species and breed of animals (Tran and Thu, 2006). As stated by Warriss (2000) species-specific flavor of different meat slices comes from heating the fats present in meat, especially the phospholipids and to a lesser degree the triglycerides.

Beef flavor can be identified as meaty, buttery, bloody, or livery, increased marbling levels maybe associated with Meaty/brothy and buttery beef flavors rather than bloody/serumy and livery/organy flavors (Tran and Thu, 2006).

2.4.4.3.Beef Juiciness

Juiciness is the moisture released by meat during chewing, and moisture from saliva(Li, 2013).Meat juiciness is associated with levels of intramuscular fat, which is called marbling (Warriss, 2000).Meat juiciness can be affected by higher fat content and the amount of moisture left in the meat after it has been cooked (Gregory and Welfare, 1998).

2.4.5. Beef Wholesomeness

The wholesomeness of meat is concerned with safety of the consumers. The meat should be safe to eat, both in terms of freedom from parasites that may also infect humans, and microbiological pathogens and hazardous chemicals. The consumers should not get food poisoned from eating meat and also should not be exposed to high levels of residues from previous veterinary medication of the animal, or from growth-promoting agents (Heitzman, 1996), or from adventitious contaminants such as pesticides (Warriss, 2000, Jean*et al.*, 2012, Grunet, 2006).

The wholesomeness of meat is also concerned dietary importance of meat. The consumers would prefer that meat was positively beneficial to their health in contributing minerals, vitamins and high value protein, and possibly essential fatty acids, such as eicosapentaenoic (EPA) and docosahexaenoic (DHA) acids, to their diet.

2.4.5.1.Nutritional Quality

Meat nutritional quality refers the wholesomeness of meat as stated above.Meat in general and beef in this case, is nutritionally rich provides adequate levels of proteins (20%), fat (5%), Energy (517 KJ/100g), vitamins and minerals to human beings. The amount of energy in beef can vary depending on the amount of fat the beef contains (as the amount of

fat increases the amount of energy increases).The protein in beef has a high biological value because its composition matches closely the proteins of human body.

Beef is source of B vitamins, particularly B1 (thiamine), niacin (nicotinic acid), B2 (riboflavin), B6 and B12 (cyanocobalamin), and vitamin A (retinol) and also known as amajorsourceof minerals such as iron, copper, zinc and selenium (Warriss, 2000).

2.4.5.2.Beef Fat

Fat is lately developing tissue in cattle because fat growth accelerates as animal approach maturity after formation of muscle and bone (Tran & Thu, 2006).

Fat can exist in beef between muscles or within the muscles. Marbling is intramuscular fat that is deposited within muscle in loose network of perimysial connective tissues, between the muscle bundles. The fat component in meat is important because many of the volatile compounds produced on heating are fat-soluble. (Warriss, 2000)

Marbling can differ from animal to anima by its quantity, fineness and distribution. Marbling has much stronger and more predictable effects on juiciness flavor than tenderness (Tran & Thu, 2006).

2.4.6. Ethical Quality of Beef

The ethical quality concerned with the welfare of the animals and environmental sustainability. Therefore, meat should come from animals which have been bred, reared, handled and slaughtered in ways that promote their welfare and in systems which are sustainable and environmentally friendly (Warriss, 2000;Verbeke & Viaene, 1999).

2.5.Factors Affecting Beef Quality

There are ante-mortem (on-factors)and post-mortem factors affecting beef quality. The ante-mortem factors can be stated as breed ,rearing system,season related to feed availability andheat stress at that specific season, feeding and nutrition, sex, ageand maturity at slaughter, live weight, transportation system to lairage,lairagecondition and resting time at lairage, stunning system and complete bleeding are most determining factors of beef quality. The post-mortem factors can be rigor, chilling and aging also determine beef quality after slaughter(Warriss, 2000).

2.5.1. Stress Prior to Slaughter

Stress before slaughter depletes muscle glycogen and when animals have lower than normal (100µM-lactate/g) muscle glycogen level at slaughter the lactate production will be low. As the result the ultimate pH will be higher (often >6.5) and these condition may cause dark, firm and dry (DFD) which is undesirable meat characteristics (Van Laack*et al.,* 2001).This shows stresses on the animals before slaughtering have negative effect on met tenderness.

Stressed animals are more likely to be easily upset/fractious and may fall or bruise themselves, and they can also cause danger to the personnel handling them (Warriss, 2000).

Previous studies on local as well as export abattoirs in Ethiopia showed that the meat animals suffer from stress following transportation. Therefore, Lairage should provide comfortable environment and to relief from stress (Yesihak, 2015).

2.5.2. Age of the Animals

The age of a beef animal has a direct effect on tenderness of the meat it produces. As cattle mature, their meat becomes progressively tougher(Hopkins, *et. al*, 2006).Tenderness cooked was meat negatively and significantly correlated with age, carcass weight, back fat thickness as well as muscle score in HanwoosteersTheevaluations of carcass maturity are used in determining USDA Quality Grades. There are five maturity groupings, designated as A through E. Approximate ages corresponding to each maturity classification are:- A = 9 to 30 months of age; B = 30 to 42 months of age; C = 42 to 72 months of age; D = 72 to 96 months of age; E = more than 96 months of age(Tatum, 2007).Sensory traits (tenderness, flavour, juiciness and overall liking) declined as shear force and age increased, and as intramuscular fat percentage decreased.

The pH was not significantly correlated with tenderness in both raw and boiled meatHanwoosteers

2.5.3. Fattening of Finishing with High Energy Feed

Subjecting and animal, which had not been well fed, to high energy feeds for short period of time, most of the time for around 90 days, is known as fattening. The cattle physical appearance, which are recommended for fattening should be tall and long in body, healthy and weigh proper weight for their age.Subjecting and animal, which had not been well fed, to high energy feeds for short period of time, most of the time for around 90 days, is known as fattening. The cattle physical appearance, which are recommended for fattening should be tall and long in body, healthy and weigh proper weight for their age.Fattening can be called ‘finishing’ in the seasons when the availability of new, highly nutritious pasture allows rapid ‘compensatory’ growth to occur and hence improve meat qualities such as tenderness, meat fat content and marbling.

2.5.4. Breed, Sex and Castration and Beef Quality

Meat tenderness is influenced by the genetic makeup (breeds) of cattle (Šárka*et al*., 2010). Jersey, Pinzgauer, South Devon, and Piedmontese were reported by Koohmaraie*et al.*, (1995) to produce more tender meat than other breeds. However, meat cooking loss was not affected by breed Jama*et al*. 2008)

The relation of beef tenderness to sex has been studied and meat from bulls was less tender than from heifers (Šárka, *et al*. 2010, Hedrick *et al*. 1969; Prost *et al*,.1975; Wulf*et al*.,1996, Pipek*et al*.,2003; Jeleníková*et al*.,2008).

Bull is intact (uncastrated) mature male cattle. It exhibits unproportionately heavy development of round and pronounced crests. Thick fleshed chucks and prominently large pizzile eye (a cut of proximal portion of the bull penis). Its scrotal fat is irregular in shape and typically rough.

Steers are castrated mature male cattle. The carcass of steer may be characterized as containing irregularly rough and irregular shaped fat in the code area. The lean is less dark and less coarse than that of bulls'(Gregory and Welfare, 1998).

Steers with higher intramuscular fat percentage exhibited reduced WBSF (i.e. more tender beef) and cook-loss% in comparison to the bulls (Jamie*et al., 2019).* Sales (2014) also stated that meat from intact (un-castrated) animals tend to have higher cooking losses and more tough meat than physically castrated animals.

Meat from intact (un-castrated) animals tend to have higher cooking losses and more tough meat than physically castrated animals(Sales,2014).

Carcasses from calves appears a grayish red to moderately red color of lean and the fat type is flakier. The ribs are wider with a less pronounced evidence of red color. Bullock is a young bull that has been castrated and it lean color may be darker and coarser texture than that of steers'.

Heifer is a young cow that has not yet given birth to calf. Beef from calf can be characterized as smooth, uniform fat deposition in the udder region. Calf is less heavily muscled and the carcass has less fat cover than steers, and bulls(Gregory & Welfare 1998). A cow is large and mature female cattle which most of the time is kept for milk production in farms. Therefore most of the cows are subjected to finishing after they are used for milk production for long period. They may exhibit hard and white bones and tougher beef(Drake, 2004).

The live weight of animals increases slowly at first, the rate of increase reaches a maximum and then decreases so the increase in live weight with age in old animals is small. This shape of growth curve can be derived for most animals. The point of inflexion, where the curve changes from concave to convex, occurs at the maximum growth rate and is therefore referred to as the maximum point of growth (Warriss, 2000).

2.5.5. Post-mortem Conditions and Beef Quality

2.5.5.1.Rigor and Aging

Post-mortem ageing ofmeat improves its tenderness (Young *et al.*, 2006).The muscle cells continue to function for a period of times immediately after slaughtering. Thus, the conversion of muscle to meat is a process that involves proteolysis and oxidation. After four to 24 hours post mortem muscles use all of the oxygen to burn the glycogen and since the blood circulation is stopped no additional oxygen is provided anaerobic reaction will

take place and produces lactic acid which results in drop of PH of the meat. The drop of the PH causes release of calcium which alters the normal relaxing and contracting movements (the smooth sliding movement muscle filaments, actins and myocin, on one another) by causing permanent contraction and hardening of the muscle which is called rigor. However, photolytic enzymes will act on the muscle fibers after 24 hours post mortem causing the muscle to relax and this process is known as aging of meat, and it is very important process to improve meat tenderness (Pearce *et al*.2011).

3. Materials and Methods

3.1. Description of the Study Area

The study was conducted in three locations namely Hawassa city, Wolayita zone (Bitana district)and Arsi Negelle area. The three location were selected purposely because Hawassa, Dimtu /Wolayita zone Bitana district/ and Arsi Negelle areas are known as the places of traditional fattening of beef animals, and sources beef animals to the abattoir of Hawassa city.

3.1.1. **Hawassa**

Hawassa is located at 7’3’N latitude and 38’28’E longitude with the elevation is 1,708m above sea level at a distance 275 Km to the south of Addis Ababa. The Ethiopian Central Statistical Agency (CSA, 2015), gives the estimated population of Hawassa for year 2015 as 351,469, with an annual population growth rate of just over 4%. The city administration is divided into 8 sub-cities and 32 Kebeles (20 urban and 12 rural kebeles). The administrative land area of Hawassa is 15,720ha, with the municipal boundary (i.e. the area of the 20 urban Kebeles) covering 6,465ha.

In addition to the inhabitants so many business people, tourists and diplomats come to the city because of the availability of various business opportunities, cultural and natural attractiveness in addition to the diplomatic activities.

The city is well known place to host many economic, ritual, social as well as governmental activities. There are large economic transactions, industry parks, and international as well and national conferences which provide job opportunities and positively affect the purchasing power of the city inhabitants.

Hawassa city is also well known as the place where best quality meat is provided by well known butchers, restaurants and hotels, and is the preferred destination of best quality meat consumers and meat animal traders in the region, and the city abattoir provides 20,082 animals slaughtering service annually on average and this number increases by 8% per year (annual report of the City municipality, 2009EC).

According to the unpublished annual report of the municipality of the Hawassa City administration, and the research findings of the daily average number of beef cattle slaughtered ranges from 120 to 150 animals, and the average carcass weight ranges from 100 to 150 kg, although there are some exceptional animals of more than 150 kg carcass weight (Mummed, 2014). The well known livestock market places in the city at Tula sub-city and there is also other big cattle market called BishanGurracha, in Oromia region, 5 km north of the city.

3.1.2. Wolayita zone -Dimtu area

Wolayita zone is located 350-400 km southwest of Addis Ababa, with an altitudinal range from 700–2900 metres. DigunaFango is one of the weredas in Wolayita zone. The wereda is 65 km far to the south west of Hawassa and Dimtu is the market place of tye beef animals supplied to Hawassa City. The altitude of Dimtu is 1500 m.a.s.l.

Livestock production in Wolayita is divided between cattle (oxen, milking cows and young stock), goats and sheep, equines (horses and donkeys), poultry (mostly local chickens, but also some improved breeds) and bees. Cattle, kept for milk, draught, cash and manure, dominate livestock numerically (FARMAFRICA, 2006).

3.1.3. ArsiNegelle Area

Arsi Negelle is one of the 180 woredas in the Oromia Region of Ethiopia and it is located at $7^0$21'N $38^0$42'E/ 7.350^{0}N 38.700^{o}E. It is part of the west Arsi Zone located in the Great Rift Valley, and it is bordered on the south by Shashamene, on the southwest by Lake Shala which separates it from Siraro woreda, on the west from the Southern Nations, Nationalities and Peoples Region, on the north by AdamiTullu and JidoKombolcha woredas with which it shares the shores of Lakes Abijatta and Langano, and on the east by the Arsi Zone. The district is located 230Km far to the south of Addis Ababa, and 45 Km far to the north of the region police, Hawassa. The altitude of Arsi Negelle is 1500-2300 m.asl.

The livestock production system around Arsi Negelle is mixed crop-livestock production system. Arsi Negelle is known as a place of traditional fattening and source of beef cattle for Hawassa city and other local markets.

3.2.Survey Study

3.2.1. Selecting the Informants

The survey incompassed the fatnes both at farmers level and als at urban and peri urban ares of Wolayita-Dimtu, Hawassa and Arsi Negelle. The informants for the survey were selected by consulting the Agricultural Development Office agricultural extentionexperts and the development agents of that respective study locations. Therefore, fifteen farmers at

Tula, fifteen farmers at Wolayita-Dimtu, and fifteen farmers at Arsi Negelle and totally fourty five farmers were interviewed. Ten fatteners at Tula, ten fatteners at Wolayita-Dimtu, and ten fatteners at ArsiNegelle and totally thirty fatteners were interviewed. Thirteen butchery house, five Hotel and Restaurant managers andthirty consumers were interviewed in Hawassa city concerning their preference of beef in relation to the origion of the cattle.

Structured questionnaire was implemented to interview the informants which have experience in fattening beef animals at farmers' level and at urban and peri urban level in the study locations.

The sequence of interview is stated as follow:

The local Government Agriculture and Livestock development office and the development agent for that specific area were contacted. The development agents helped the selection of specific informants (farmers and fatteners). Only when fatteners respond that they usually buy most of the animals they fatten from the local farmers at their local markets, interviewing the local farmers was proceeded. The selected farmer or fattener was interviewed and at the same time the fattening premises were visited.

The traders were selected and interviewed at the local markets of Wolayita-Dimtu, Hawassa- Tula ans Arsi Negellelocations.

The consumers were interviewed while they were buying the meat at the butcheries or while they were being served at the restaurants/Hotels

Assistant data collectors and translators of Afan Oromo were used at Arsi Negelle and other locations whenever it was necessary.

3.3.Selecting the Seasons

The long dry season ‘Bega’(Winter):ie. December, January, February, andthe short rainy season ‘Belg’ (Spring)ie. March, April, May, were selected for this study. These two seasons were selected purposely for this study because there is the difference of feed availability between dry season and wet season. Since wet season is rainy season the natural grass and fodder will be available for animals. In the case of dry season the is no rain and the avalilability natural grass and fodder will be relatively lower. The seasonal variation of beef quality was assessed to know if there were relation between seasonal feed availability and the beef quality attributes such as instrumentalbeef tenderness (WBSF) and beef cooking loss (%).

3.4.Beef Sampling and Lab Analysis methods

3.4.1. Ante-mortem Examination and Pre-slaughter Resting Time

The animals were carefully examined by the veterinary personnel on the entrance gate of the holding area. The examination procedures were conducted by direct observation of the animals and registration of the relevant data takes place at this time. The healthy animals were admitted to the holding area and the observation and further pre-slaughter examination of the veterinarian takes place for more than 12 hours (from 11.30 am to 12.00 pm) until the slaughter time. The resting time was good enough for the animals to relief from stress. However, the Lairage was muddy and not comfortable; also the animals were over crowded. The Lairage should provide comfortable environment and to relief from stress (Mummed, 2015).

3.4.2. Determining Samples Size

Anite-mortem inspection of the ani,als was conducted by veterinarians 6 to 12 hours prior to slaughteras shpwn in figer 1, and only healthy animals were sampled. The total population size (N) was 20082 based on the annual report of the City municipality (2017). The sample size was determined by the simplified formula of (Yemaneh, 1967) to 202and the Systematic random sampling of the animals (Selection of the animals at regular intervals) while they were passing through long ante mortem examination crash of the abattoir was implemented.

$$n = \frac{N}{1 + N(e)^2}$$

Where: N is population size = 20,082, e is sampling error = 0.07, n is sample size.

n= 20082/1+20082(0.07)^2 Therefore, n= 202

Figure 1: Figure : Ante mortem examination of the animals by veterinary personnel 6 to 12 hours prior to slaughter at Hawassa city abattoir.

3.4.3. Determining Age and Live weight of the cattle

After the animals were selected for beef sampling the researcher determined the age of the animal by using dentition method which was demonstrated by Workneh (1992) and applied by Zewdu (2004). The Live weight of the animals was estimated by using Heart girth meter.(see figure 11 and 12 in the appendix).

3.4.4. Post-mortem Examination

The veterinary examination of carcass took place according to Ethiopian meat examination procedure. Carcasses with any clinical defects were discarded and condemned according to Ethiopian regulation of Ministry of Agriculture Animal and Plant Health Regulatory Directorate, Meat Inspection Guideline for public meat inspectors (2010). It was only after the carcasses passed this examination procedures that the samples were collected according the procedures set for sampling.

Taking beef samples

The animlas were selectedby systematic random system at Hawassa abattoir and the samples were taken from the selected animals. 105 beef samples were collected in dry season, 122 beef samples were collected in short wet season and totally 227 beef samples were collected from longissimus muscle (*longissimus dorsy*).

The samples were coded, transported and refrigerated at -4 ^{0}C for 14 days for aging purpose andtawed at room temperature for 12 hours prior to the lab analysis at Hawassa University, College of Agriculture, Animal Nutrition laboratory as shown in figure 2.

3.4.5. Lab-analysis of Beef Samples

Instrumental meat tenderness analysis was conducted for 227 samples according to Ethiopian Warnner-Bratzler Shear force (WBSF) procedures, at Hawassa University, College of Agriculture, Animal nutrition laboratory. The Ethiopian Warnner-Bratzler Shear force (WBSF) procedures were used in the following order:

Tehe beef samples were taken out of the refragirator where they were been aged at -4^{0}C for 14 days and late to stay over night at room temperature in the laboratory and this procedure is tawingas shown in fig 2.

The cooking skillet was heated to a constant 204^{o}C. Also, a small amount of cooking oil was added in order to prevent the steak from sticking during cooking. Each sample beef steaks were cut 1 inch (2.5cm) in thickness perpendicular to the long axis of the longissimus dorsi (LD). This produced steaks that were cut across the grain of the muscle fibers. The external heavy connective tissue was removed. The steaks were weighed their initial weight was recorded by using sensitive balance. The thermocouple was inserted into the geometric center of the each sample steak by following the AMSA guidelines and instructional videos and the initial steak temperature was recorded by using the thermocouple.

Each sample steak was placed in the pre-heated 204^{o}C skillet. The steak was flipped when the internal temperature reached 45^{o}C and remove from the skillet when the steak reached 70^{o}C (as showen in figure3). The thermocouple output was watched and the peak cooking temperature was recorded before removing the thermocouple from the steak. The final cooked weight of each steak was recorded and the steak was let to cool to room temperature for about an hour prior to WBSF analysis (as shoen in figure 4). After cooling, the sample steak was cut across the long axis of the steak (knife tip on heavy connective

tissue side (dorsal) and knife handle on ventral side) to expose the fiber direction. After exposing the fiber direction 6 cores were removed parallel with the muscle fibers (as shown in figure 5). The WBSF device was used to shear each core. The shear was across the middle (center) on each core. The peak WBSF value of each core was recorded in kgf. The values for each core were averaged for the determination of a single value for each steak. One kgfis equal to 9.098 N.

The weight of the steak before cooking and after cooking was used to estimate the cooking loss.

The same procedures of sample collection and instrumental shear force analysis were repeated in both wet and dry seasons.

Figure 2: Thawing the samples for overnight prior WBSF analysis

Figure 3: Cooing the samples according to the procedure

Figure 4: Monitoring the internal temperature of the sample until 70^{o}C

Figure 5: Coring the cooked beef samples along the beef fiber

4. Results and Discussion

4.1. Livestock Production Systerms and Supply of Slaughter Animals

Beef quality varies dipending on variables such as historical data about the cattle slaughtered (age, time-on feed, dietary energy density), live animal performance data (average daily weight gain and per day of age). In this survey the isues such as livestock production system, using oxen for fram power at farmers' level and fattening practices wrereassedsed to relate to the quality of beef produced and the results of the survey are discussed below.

4.1.1. The LivestockProductionSystem

Table 4: Crop-Livestock production system in the study area

Farm activity	Percent
Farmers practicing crop farming and keep livestock simultaneously	97.5
Only keep livestock	2.5

Among 45 farmers interviewed 97.5 percent of the informant farmers responded that they practice crop farming and keep livestock simultaneously (table 4).

The farmers responded that they kept multiple livestock speciesbecause they use them for different purposes, such as source of farm power to plough farm lands, carrying baggage , as saving,for income source and the like.

Number of animals per household was converted into common unit TLU, as stated in Harvest Choice(2015).The conversion factors were: cattle = 0.7, sheep = 0.1, goats = 0.1, donkey = 0.5 and horse =0.8.

Table 5The number of livestock (in TLU) per household in the study areas

Type of livestock	**Cumulative**	**Hawassa**	**Wolayita**	**Arsi Negelle**
Cattle	6.53 ±0.623	5.83±0.223	3.15±0.458	9.47±1.243
Sheep	0.41±0.0712	0.26±0.0434	0.12±0.042	0.75±0.145
Goats	0.2±0.0741	0.107±0.0431	0.09±0.419	0.36±0.187
Donkey	0.36±0.08	0	0.3±0.082	0.77±0.153
Horse	0.15±0.063	0	0.08±0.08	0.32±0.152
Total TLU per House hold	7.64±0.784	6.2±0.233	3.74±0.615	11.67±1.521

According to the responses of the farmers the average number of cattle was 6.53 ±0.623 TLU, sheep 0.41±0.0712 TLU, goats 0.2±0.0741TLU, donkeys 0.36±0.08TLU and horses 0.15±0.063 TLU. The average herd size was 7.64±0.784 TLU pear house hold. The average male cattle number was 3.58±0.27 males and 5.78± 0.071females, the average number of localcattle number per house hold was 8.58±0.848 and the average number of crossbred cattle with Holstein Frisian per house hold was 0.73±0.16. the exotic blood level of the cross bred cattle was not knownand there were no information which confirm existence of pure exotic pure cattle breeds(as shown in table 5).

Farmers rear oxen to use for traction power to till their farm land and sale the oxen after using for the traction purpose. These results show us that the livestock production system around Hawassa, Wolayita and Arsi Negelle areas can be characterized as mixed crop–livestock system and this result is in line with the discriptopn of Alemayehu (2012).

Farmers usually trekked their animals to the local market areas (fig 6 and 9).

Figure 6: Cattle market at BishanGurracha 3 km from Hawassa city

4.1.2. Traditional Fattening at Farmer Level

Most of the farmers practice traditional fattening practices, feed less concentrates and fatten their animals for long time, more than 90 days and this result goes in line with the work of Addis (2012) which stated that the fattening of beef cattle in Arsi Negelle area areas is mainly dependent upon crop residues and local liquor by-products. They mixed 'Atela' with wheat bran,cro residues and other feed resources.

Among the respondent farmers 95.1% responded that they used their oxen as a source of power68.3% of them soled them after fattenning.

The average age of animals at fattening at the farmer level was was 5.6 ±0.205years this age not recommended because the beef animals will be less tender as the age of the animal increases.

The beef animals were brought to market at older age and after they were used for traction power and these practices would resultin poor beef eating quality especiall the beef would

be tougher and the cooking loss wuld be higher. The findings were supported by the works of (Yesihak, 2015) and Warris (2000).

Among the farmers interviewed 90.2%of farmers responded they used wheat bran in line with other feed resources to fatten their animals and 24.4% of farmers supplemented their animals with Lean seed cake. 82.9% of the farmers responded that they fatten only once in a year and 14.6% of the farmers fatten twice in a year. According to the farmers the average number of days of fattening at farmers level was 105.03 ± 3.84 days, the term of fattening per year was 1.15 ±0.057 and the number of animal per fattening was 1.73±0.129. All of the farmers responded that they trekked their animals to all market places and the average distance was 13.23±2.748 (showntabelesin the annex4).

4.1.3. Small Holder Fatening Practices in Urban and Sub-Urban Areas

Thirty fatteners in urban and sub-urban areas were selected as key informants based on their experience on cattle fattening and the average number of fattening days was 90.57± 5.88. 96.67% of the fatteners responded that they bought the animals from local markets/ from farmers.

Number of animals fattened at a time was 2.6±1.04. Average distance the animals trek to the market place was 4.23 ±3.53Km).

Table 6: Time length of Fattening Beef Cattle in the urban and sub-urban study area (%)

Fatening days	Percent of Respondents by Locations			Over all
	Hawssa	Wolayita	Arsi negele	
70	-	10	-	3.3
85	10	-	-	3.3
90	70	70	80	73.3
100	20	20	10	16.7
105	-	-	10	3.4

According to the survey result 73.3 % of the respondents responded that it took them 90 days to fatten , and 16% responded 100days (see tabele 6) this result has show resemblance with the work of Addis (2012).

Among 30 fatteners80% of them responded that the usually fattened oxen which were used and sold out by farmers for farm draught power (See appendix 17)

4.1.4. Feeds Resources used for traditional fatening

Table 7: Basal Feed recourses used bytraditional fatteners in the study area

Basal Feed recourses	Affirmative response (%)	Negative response (%)
Local grass and indigenous fodder	97.6	2.4
Crop residues	97.5	2.5

Thirty traditional fatteners wer interviewed concerning the feed resources they supplied to fatten the beef cattle and 97.6 % of them responded that they used local grasses and indigenous fodder, and also 97.5 % of them responded that they also used crop residues such as Maize, Wheat, Haricot bean, Barley, 'Enset' (table 7).

Table 8: Supplementary feeds used by traditional fatteners

Supplementary Feed Resources	**Affirmative response (%)**	**Negative response (%)**
Wheat bran	90.2	7.5
Lean seed Cake	53.3	46.7
Local mineral Block 'Bole'	100	0
Local brewery by-products 'Atela' and Industrial beer by-product of BGI Beer factory	66.7	33.3

Concerning supplementation among 30 informants 90.2% fatteners responded that they used wheat-bran as a supplementary feed, 53.3% of the fatteners resonded that they supplemented their animals with lean seed cake, and 66.7% of the informants used different brewery byproducts (such as 'Atela' in Arsi Negelle and St. George's beer by-product in Hawassa and BishanGurracha) and these brewery by- products wer mixed with wheat bran and/or with crop residues such as chopped stover of maize, barley, teff or wheat. All of the fatteners used either table salt or local mineral source called 'Bole (table 8).Farmers mix atela (local brewing by-product) with wheat straw, tef straw, chopped maize stalks, and over matured dry grasses to fatten animals which they purchase from local brewers , and these results resemble with the findings of Addisu, et al., (2012) and this kind of feed is rich in both energy and protein, is a good basis for a fattening diet.

4.1.5. ConsumerPreferences of beef inrelation to the origin of the animals

Table 9: The preference of the consumers based on the origin of the cattle

Consumers' responses	Percent of Respondent
Hawassa – Tula	20.0
Wolayita	33.3
Arsi Negelle	36.7

Among 30/thirty/ consumers were interviewed at different butcheries in Hawassa city and 40% of them responded that they frequently visited the same butchery and 60% consumers paid seldom visited to the same butchery depending on the quality of meat that the butcheries provided.

Among the consumers 13.3% of them regularity asked from which location the butchery bought the animals, 60%of them asked only sometimes and 26.7% of them did not care about the origin of the animals but care about the good quality of the meat.20 % of the consumer preferred meat of the animals from around Hawassa areas such as Tula, Hawssazuriya , 33.3% preferred Wolayita area such as Dimtu, 36.7% preferred Arsi Negellenad10% of the preferred other locations (shown in table 9).

Table 10: The percent of consumers who preferred the beef because it was easy to chew (good tenderness)

Consumers' responses	Percent
Yes	90.0
No	10.0

Among thirty consumers interviewed 90% of the consumers' preference was mainly based good tenderness (ease of chewing) and the rest 10% based on the other meat qualities as shown in table 10. Deep dark red colored meat and beef with white external fatattractedconsumers because the consumers thought that such animals were fattened at better feeding condition and their meat can also be more tender than the meat with less fat.

4.2. WBSF - Instrumental Beef Tenderness (kgf) and Cooking loss (%)

The overall WBSF value of the beef at Hawassa city abattoirwas 3.9 ± 0.11kgf. The WBSF value of the beef at dry season was 4.16 ± 0.15kgf which can be graded as intermediate tender beef, while the shear-force value at wet season was3.7±0.16kgf which can be graded as tender beef. Therefore, we can say that the beef was within the tender to intermediate tenderness grade which according to Belle*wet al*., (2003).

4.2.1. Seasonal Effects on Beef quality

Table 11: Instrumental beef tenderness (WBSF) and beef cooking loss (%) between dry and wet seasons

Beef quality	Seasons		SL
	Dry	Wet	
CL (%)	23.49±0.84[b]	27.08±0.66[a]	*
WBSF	3.69±0.16[b]	4.16±0.15[a]	*
N	105	122	

[a,b,c] *Mean values with different letters of superscript within the rows of are significantly different at 5% probability level, WBSF = Warner Bratzler Shear Force, SL = significance level, N= number of animals per group,CL=cooking loss*

The over allmean WBSF of both dry and wet season was 3.95±0.11kgf. The WBSF at Dry season (December, January and February) was 3.69±0.16kgf *and* 4.16±0.15kgf at wetshort

rainy, season (March, April and May), the difference is significant at p≤0.05 value (table 10).The beef of wet season is less tender than that of dry season.Wet season is usually associated with availability of more natural grass and fodder than dry season. However, the age of the animals slaughtered at dry season was younger than that of the wet season and this might be the reason for better WBSF- instrumental beef tenderness in dry season rhanwetr season (tabele11).

The over allmean cooking los of both dry and wet season was 25.42±0.54 (%). The cooking loss (%) of the dry and wet season was 23.49±0.84 and 27.08±0.66 respectively and the difference is significant at p≤0.05 value (table 11).

Both the WBSF (beef tenderness) and the cooking loss(%) of beef at Hawassa abattoir were significantly different between dry and wet seasonsat p≤0.05, as shown in table 11.

In Ethiopian cases there is better forage availability at wet seasons and the vice versa at the dry season and the beef was expected to be more tender at wetseason than the dry season.However, the dry season coexists at the same time to the main fasting period "AbyTsom" of the Ethiopian Orthodox church which prohibits the consumption of all animal source food. Because of this, the number of meat consumers and butchers reduce reasonably. Because of these reasons the farmers and traders think it was more economical to sell younger and smaller bulls at this season instead of fattening older and bigger oxen. Therefore, the meat was more tender at the dry season than the wet season. On the contrary the wet season provides better feed resources and very good market opportunity for fattening men to fatten older and bigger oxen and supply the well finishedanimals, withhighenery feeds,were available at the markes.Thereware also minimum fasting days of Ethiopian Orthodox church at this time and there were more consumers at the markets.

4.2.2. Efect of Transportationof animals on beef quality

The longest distances of transportation of the animals to the abattoir were from Wolayita and from Arsi Negelle areas, and the short distances (about 5km) were from Tula and from BishanGurracha areas. From 227 animals sampled 53.3 % of them were trekked 5km from respective market origins (Tula) and 46.7% of them were transported by caras show in (Figure 7, 8 and 9). All of the animals from Tula market are transported on their foot /trekking around 5km distance from the abattoir/12 hours before slaughter. The animals from both Wolayita and Arsi Negelle were transported by car to the abattoir. However, there was no significant difference on beef tenderness based on transportation (Trekking vs. Car) maybe because the distance of trekking was short(5KM) and the resting period of the animals before slaughter was around 12 hours.

Out of 227 animals randomly selected for sampling 49.34 percent of them were from Tula market, 22.47 percent from Wolayita area (Dimtu market place), 21.15 percent from Arsi Negelle and only 6.61 percent of the animals from other market areas.

As some of the traders information Tula market area has got large number of catchment areas from Oromiya region (Dodola, Kofole, Wendoweredaareas) and SNNP regions, (such as Melga, Shebedino - Leku, Hawassa zurea – Shamena and Dore, Wendogenet andArbegonawereda areas).

4.2.3. Body Conformation Grading Effects on Beef quality

Table 12: Instrumental beef tenderness (Shear force) and beef cooking loss between grades of animals before slaughter

Beef quality	Body conformation Grade						SL
	Grade 1	SEM	Grade 2	SEM	Grade 3	SEM	
CL (%)	24.13[b]	0.69	27.29[ab]	0.85	31.99[a]	2.68	*
WBSF	3.51[b]	0.13	4.56[b]	0.18	6.45[a]	0.72	*
N	143		78		6		

[a,b,c] *Mean values with different letters of superscript within the rows of are significantly different at 5% probability level, WBSF = Warner Bratzler Shear Force, SEM = Standard error of mean, SL = significance level, N= number of animals per group,CL=cooking loss.*

The animals were graded according to Ethiopian body conformation grading procedures. From the animals selected for sampling 63% of them were graded 1, 34% were graded 2 and 2.6 % of them were graded 3. The cattle with better body conformation exhibited better tenderness of their meat. Animals from Tula area were relatively smaller in size and exhibited lesser weight the animals from other locations of the study.

Instrumental tenderness and cooking loss were significantly different between cattle body conformation grades at $p \leq 0.05$, as shown in Table 9.

4.2.4. LiveWeight of the Slaughtered animals

The live weight of the animals was estimated by heart girth measuring method.

The live weght of the animals sampled was grouped in to three goups. Group one weighed 208 to 326 Kg, group two weighed 327 to 432 Kg and group three weighed 433 to 710 Kg.

The WBSF was 2.99±0.25kgf, 3.98±0.11kgf and 6.33±0.44kgf for group one, two and three, respectively.

The cooking loss (%) was 22.97±1.79,25.55±0.57 and 30.89±0.99 for group one, two and three, respectively.Both WBSF (beef tenderness) and the cooking loss (%) of beef at Hawassa abattoir were significantly different between different live weight groupsat $p \leq 0.05$, (see Table 6)

Live weight of the animals at the abattoir ranged from 208 kg to 660 kg with the mean of 379.43±6.64Kg. This result sowed superior average live weight when we compare with the study conducted by Hasan et al., 2017, on live weight and carcass percentage of some Ethiopian cattle breeds, in Northern Ethiopia, which showed the mean live weight of oxen of Begait, Abergelle, Arado and Raya were recorded to be 324.04kg, 320.36kg, 319.35kg and 327.32kg, respectively, and mean warm carcass percentage of 44.90% for Abergelle and 44.09 % for Begait.

Table 13: Live weight versus Instrumental beef tenderness (Shear force) and beef cooking loss

Beef quality attributes	**Live weight group**			**SL**
	One (208 to 326 Kg)	Two (327 to 432 Kg)	Three (433 to 710 Kg)	
CL (%)	22.97±1.79^{b}	25.55±0.57^{b}	30.89±0.99^{a}	*
WBSF	2.99±0.25^{c}	3.98±0.11^{b}	6.33±0.44^{a}	*
N	32	185	10	

^{a,b,c} *Mean values with different letters of superscript within the rows of are significantly different at 5% probability level, WBSF = Warner Bratzler Shear Force, SL = significance level, N= number of animals per group,CL=cooking loss.*

There were significant (<0.05) difference in live weight effect on shear force and cooking loss for slaughter animals. As live weight increased both WBSF and cooking loss (%) increased(i.e. as weight increased the beef quality decreased). This was related to age because the age of the animals was high and as age increased the WBSF and cooking loss increased.

4.2.5. Age of the Slaughtered Animals

Age of the animals at slaughter is in the rage 35 months to 75 months with the mean of 54±0.72months of age.As age increased the instrumental beef tenderness decreased.

The age of the animals sampled was grouped in to three groups and roup one were 30 to 42 months old, group two were 43 to 72 months old and group three were above 73 months of age.

The WBSF was 2.99±0.26kgf, 3.98±0.12kgf and 6.33±0.45kgf for group 1, 2 and three respectively.

The cooking loss(%) was22.97±1.79(%), 25.55±0.57(%) and 30.89±0.99 (%) for group one, two and three respectively.

Both beef tenderness (Shear force) and the cooking loss of beef at Hawassa abattoir were significantly different between different age groupsat $p \leq 0.05$, (see Table 7)

Table 14: Instrumental beef tenderness (Shear force) and beef cooking loss between different age groups

Beef qualityattrivutes	**Age group**			**SL**
	One (30 to 42 months)	Two (43 to 72 months)	Three (above 73 months)	
CL (%)	22.97±1.79[b]	25.55±0.57[b]	30.89±0.99[a]	*
WBSF (kgf)	2.99±0.26[c]	3.98±0.12[b]	6.33±0.45[a]	*
N	32	185	10	

[a,b,c] *Mean values with different letters of superscript within the rows of are significantly different at 5% probability level, WBSF = Warner Bratzler Shear Force, SL = significance level, N= number of animals per group,CL=cooking loss.*

4.2.6. Sexof the Slaughtered Animals

From the 227 animals selected for sampling 97.8% of them were male (bull and or oxen) whereas 2.2 of them were females which were either old aged or not reproductive. The number of the female animals was very small to compare with the number of male animals.However, beef tenderness (WBSF) and cooking loss (%) were affected by the gender of the animal slaughtered (Jamie *et al., 2019).*

4.2.7. Breedof the Slaughtered Animals

From the 227 animals selected for sampling 215of them were local breed/type and 12 of them were cross bred animals (Local cross to Holstein Frisians)

Table 15: WBSF-Instrumental beef tenderness (Shear force) and beef cooking loss between the local and crossbred cattle

Beef quality attributes	Breed		SL
	Local	Cross	
CL (%)	25.23±0.56	28.89±1.57	Ns
WBSF	3.93±.012	4.28±0.34	Ns
N	215	12	

[a,b,c]*Mean values with the same letters of superscript within the rows of are not significantly different at 5% probability level, WBSF = Warner Bratzler Shear Force, SL = significance level, N= number of animals per group,CL=cooking loss.*

The difference of both WBSF (beef tenderness) and beef cooking loss were not significantly different between the local breeds and the cross bred cattle*at* $p \leq 0.05$ as shown in the table 8.Meat quality attributes such as tenderness and cooking loss (%) were ought to be different by breed (table 12). However, the blood level of the cross bred animals was unknown and they were also old aged. Moreover, the best beef is often thought to come from the traditional beef breeds of cattle like the Hereford and Aberdeen Angus rather than the dairy breeds like the Friesian, Holstein and Jersey(UDSA, 2015).

4.2.8. Location Effect on Beef quality

Table 16: Instrumental beef tenderness (Shear force) and beef cooking loss between locations

Beef quality attribute	**Location**			**SL**
	Hawassa	Wolayita	Arsi Negelle	
CL (%)	26.12±0.84	23.81±0.92	25.20±1.14	Ns
WBSF	3.97±0.15	3.70±0.22	4.03±0.28	Ns
N	112	51	48	

[a,b,c] Mean values with the same letters of superscript within the rows of are not significantly different at 5% probability level, WBSF = Warner Bratzler Shear Force, SL = significance level, N= number of animals per group,CL=cooking loss.

The mean WBSF at all locations was 3.95±0.11kgf. The WBSF was 3.97±0.15kgf, 3.70±0.22kgf, 4.03±0.28kgf and 4.37±0.44kgf at Hawassa, Wolayita, Arsi Negelle and BishanGuracha, repectively and were not significantly different between the locations of the study area*at $p \leq 0.05$* (see Table 13).

The mean cooking los at all locations was 25.42±0.54 (%). The cooking loss (%) was 26.12±0.84 (%), 23.81±0.92 (%), 25.20±1.14 (%) and 26.53±1.9 (%) at Hawassa, Wolayita, Arsi Negelle and BishanGuracha, repectively and were not significantly different between the locations of the study area*at $p \leq 0.05$* (see Table 16).

Table 17:Pearson Correlation between Instrumental Beef Tenderness (WBSF) and Cooking Loss

Variable	**WBSF**	**CL**
WBSF	1	0.48**
CL	0.48**	1

**. Correlation is significant at the 0.01 level,*WBSF = Warner Bratzler Shear Force,*CL=cooking loss.

The cooking loss showed positive correlation with instrumental (r=0.48) at (P<0.05) and this result is supported by the findings of Birmaduma (2019).

5. Conclusion and Recommendations

5.1. Conclusion

The results of current survey study in the three locations sowed that there are factors identified which affect beef quality adversely. The animals were sold at old ages 4 to 8 years,this practice has negative impact on beef tenderness because as age increases beef tenderness decreases. The farmers usually sold their animals after using them for farm power production (plough) and this affects beef tenderness adversely (i.e. the beef became tougher).The fatteners interviewed mainly fed local grasses and crop residues as basal feed which is relatively low energy feed and these type of basal feed resources have less contribution to beef tenderness as coparedhgigh energy feeds increase beef tenderness.

Length of fattening period was around 105 day which is in the recommended margin (≤ 120 days)for better beef tenderness and therefore should be kept in that margin.

Eventhough the traders transported the animals to Hawssa by truck (as shown in fig 7) the farmers trekked their animals long distance to the local market areas (as shown in fig 8 &9). Trekking the animals long distance to causes stress and fatigue to the animals, as a result depletes glycogen in the muscle of the animals and results in poor beef quality (DFD)which results in decreased beef tenderness (Warriss, 2000).Therefor, it is recommended to trekk the animals for oly short distance or give them enough resting time before slaughting if the farmers can not us trucks to transport their animals to the market places.

The reseacher observed the resting place of the animals after they are transported to Hawassa from different locations and before they are taken to the abattoire. One trader my bymay animals at a market place and transport them to Hawassa and let the animals stay in

the temporary shades for one to five days they take the animals one by one to the abattoire. The place where the animals let to stay were shades which were not roofed, muddy and poorly constructed (as shown in the figure 10). In addition to that the animas might fight and injuries can occur, and the animals would not rest properly, fatigued and excitement would occur. These conditions are not conducive for the animals and therefore cause stress and as a result negatively affect the beef tenderness, should be replaced by well constructed, roofed and well drained resting shades.

The shear-force value of the beef in wet season was 4.16±0.15Kgf which can be graded as intermediate tender beef, while the shear-force value in the dry season was 3.7±0.16Kgf which can be graded as tender beef. The difference of beef tenderness between wet and dry season was significantly different significant at $p \leq 0.05$.

Cooking loss was 23.49±0.84% at dry season and 27.08±0.66% at wet season. The cooking loss of the wet season was larger when compared to that of the dry season, and the difference was significant at $p \leq 0.05$.

Cross bred animals did not show superior meat tenderness and but higher live weight than the local ones in all locations. This might be because of the low level exotic blood level.

5.2.Recommendations

Since young bulls produced more tender meat than the older ones, finishing and supplying young bulls for slaughter should be promoted.

Genetic improvement activities should be implemented by cross breeding the local animals with Hereford and Aberdeen Angus rather than the dairy breeds like the Holstein-Friesian to increase size of the animals and also to improve their meat tenderness.

The abattoir lairage hosts more than 300 animals and seems over crowded during the festive times. In those cases Pre-slaughter inspection and handling would be difficult, animas might fight and injuries can occur, and the animals would not rest properly, fatigued and excitement would occur which might result in poor quality beef.

Animals should not be trekked long distance and time of rest should be allocated before slaughtering the animals to get good quality beef and this idea is supported by Esterhuizen, (2008). Therefore, Trekking animal long distance to market areas may affect meat tenderness negatively because of stress. Therefore, farmers should be organized in cooperatives or in groups to higher car transportation to take their animals to far local markets.

Sensory evaluation of beef quality by using trained personnel and relate the results with instrumental beef tenderness. Study relationship with beef tenderness and beef muscle fiber diameter, across different cattle breeds of Ethiopia.

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7. APPENDIXES

Questionnaires

The Sequence of the survey activities

a. The Butchery house/ Hotel/ Restaurant will be interviewed only in Hawassa city.
b. The consumers will be interviewed only in Hawassa city.
c. At the survey areas of Tula, Wolayita (Dimtu), BishanGurracha, and Arsi Negelle: the sequence of interview is stated as follow:
d. Contact the local Government Agriculture and Livestock development office, get the development agent for that specific area and get information of fattening practice and the fattening men,
e. Select, visit/observe, and interview the fattening men,
f. If most of the respondent fattening men respond that they usually buy most of the animals they fatten from the local farmers at their local markets, you proceed to interview the local farmers,
g. If most of the respondent fattening men respond that they usually buy most of the animals they fatten from other farmers at markets far away, then you must go that place to interview the framers at that respective locality,
h. Interview the traders at the respective local markets, and
i. Use the assistant data collectors as translators of the local language whenever it is necessary.

Appendixes 1: Questionnaires of the survey – to interview farmers, customers, Fatteners, butchery owners, traders and hotel owners

The questionnaire to the farmers (market actor): cattle owners/farmers will be selected randomly and interviewed

Name of the enumerator _____ date _____

Name of the Location: _____

1. Name of the informant/ respondent:_____

2. What species of the livestock does the farmer own and what is their number?

1. Cattle number:_____
2. Sheep number:_____
3. Goats number:_____
4. Donkey number:_____
5. Horse number:_____
6. Mule number:_____

3. Classify the cattle by sex? 1.Male ; _____ 2. Female; :_____

4. Classify the cattle by breed/type and number? 1. Local: ___ 2. Cross ____ 3. Exotic _____

5. Does the farmer practice crop farming in addition to cattle keeping? 1. Yes

2. No

6. Types of crop the farmers raise(main crop should be written on the first place)? _____,

7. Types of feed resources available in area

1. Grasses

2. Crop residue: type of crop_____, _____, ____

3. Supplementary feeds: name: _____ , _____,

8. Which season of year does the farmer think there is ample amount of feed

1. Kiremt (Summer): June, July, and August

2. Tseday (Autumn): September,October,and November

3. Bega (Winter): December,January,and February

4. Belg (Spring): March,April,andMay

9. Which season of year does the farmer think there is scarcity of feed

1. Kiremt (summer): June, July, and August;

2.Tseday (autumn): September,October,and November;

3. Bega (winter): December, January, February ⁞

4. Belg (spring): March, April, May

10. Does the farmer use the oxen for farming draught power? 1. Yes 2. No

11. Does the farmer practice fattening? 1. Yes 2.No

12. When does the farmer sale his oxen?

1. before using for draught power, 2. After using for draught power

13. When does the farmer fatten his oxen : 1. before using for draught power , 2. after using for draught power

14. How do you know the age of your cattle? 1. Estimate by dentition ⁝ 2. By counting from the birth date of the animal, 3. Estimate by other method _____

15. At what age does the farmer sale his bull or oxen? _____ years

16. At what age does the farmer usually fatten his cattle? _____Years⁝⁝

17. At which season of Ethiopian year does the farmer practice fattening?

1. Kiremt (summer): June,July,and August;

2. TsedayBelg (autumn): September,October,and November;

3. Bega (winter): December,January, February ⁝

4. Belg (spring): March, April, and May.

18. What type of feed does the farmer use to fatten : _____, _____, _____, _____

19. Concentrate/Supplementary feeds for fattening _____, _____, _____

20. For haw many days doe fattening take? _____ Days.

1. How many times in a year do you practice fatten? 1.once a year, 2.twice ayear, 3 three times a year, 4. Four times a year.

21. How many animals are fattened at a time? _____ Animals.

22. To whom does the farmer sale his animals if he sales before fattening?

1. to traders, 2. to fattening men, 3. To butcher, 3.Other:_____

23. To whom does the farmer sale his animals if he sales after fattening? 1. to traders/, 2. To fattening men, 3.Tobutcher, 4.Other: _____

23. How does the farmer take his animals to the market place 1. By trekking, 2. By car

24. How much time does it take you to take animals to the local market place? :_____hrs. and estimate the distance by km _____KM

Questionnaires of the survey – Questionnaire to interview fatteners

Name of the enumerator_____ date _____

Name of the Location: _____

1. From where do you usually get the animals you fatten?

   1. From local farmers/Local market,

   2. Other markets far from his location(name of the market places) _____, _____

2. How do you know the age of the animals? 1. Estimate by Dentition, 2. Ask the farmers when you by the animas, 3. Estimate by other methods _____

3. What age of Oxen do you prefer to fatten? 1. Young/ estimate age _____ year 2. Of meddle age/estimate age __ year 3. Of old aged/estimate age __years

4. Of what working status (concerning draught power) of oxen do usually use for fatten purpose ?

   1. I usually buy oxen which were sold after used for draught power to plough farm lands

   2. I usually buy oxen which were not used for draught power to plough farm lands

5. At which season of Ethiopian year does the fattening men practice fattening?

   1. Kiremt (Summer): June, July, and August;

   2. Tseday(Autumn): September, October, and November;

   3. Bega (Winter): December, January, February ⁞

   4. Belg (spring): March, April, May

7. How many times do you practice fattening within a year?1. Once a year 2.twice a year t, 3 three times a year, 4. four times
8. What type of feed you use to fatten: _____,

9. Concentrate/Supplementary feeds for _____, _____, _____
10. For haw many days doe fattening take? _____ days
11. How many animals are fattened at a time?_____ animals.
12. To who does the fattening men sale his animals?1. To traders, 2.Tobutcher,

    3 .Other: _____
13. How do you take the animals to the market place? 1.By trekking, 2. By car 3.The buyers come to my station
14. Ho far is the market place (take estimation)?:_____hrs and estimate the distance by km _____KM.

Questionnaires of the survey – Questionnaire to interview consumers

The questionnaire to consumer: the consumer will be selected randomly at Butchery or Hotel or restaurant

Name of the enumerator_____ date _____

Name of the Location: _____

1. Name of the consumer respondent:_____
2. Name of the Butchery house/ Hotel/ Restaurant(: _____
3. Do you frequently/usually visit this Butchery house/ Hotel/ Restaurant? 1. Yes 2. No I only come occasionally
4. What would be the reason which makes you visit this butcher frequently/usually? 1. Good quality beef, 3. Other reasonssuch as reasonable price, good customer services, … etc)
5. Do you think there is quality variation of beef from one butchery house/ Hotel/ Restaurant to another butchery house/ Hotel/ Restaurant? 1. Yes 2. No
6. If you think there is quality variation, which qualities of the meat do you like the most?1. The Tenderness (ease of chewing) 2.othere quality attributes_____, _____
7. Do you ask the butcher from what market area does he/she usually buy the animals he/she slaughters? 1. Yes, I usually ask, 2. Yes, I ask some times,3. No, I do not ask

8. From which market area do you prefer to consume the meat?

   1. Meat of Cattle from Tula market

   2. Meat of Cattle from Wolayita (Dimtu) market

   3. Meat of Cattle from Arsi Negelle market

   4. Meat of cattle from BishanGurracha market

   5. Meat of cattle from Borena market

   6. Other:_____, _____, _____

9. Why do you prefer the meat of specific market area (he can choose more than one attributes of the meat he prefers)?

   1. Tenderness (easy to chew) 2.othere quality attributes_____, _____, _____

Type of the respondent:- Butchery owners

RN	Name of the informant/ respondent	Name of the Butchery House	Number of the animals he bought	Breed/Type			From where do you buy the animals (Name of market)	How far would you transport the animals (KM)	By what means of transportation would you bring the animals		Holding area			How many days will you hold the animals before slaughter	What type of feed do you provide
				Local	Cross breed	Pure exotic			Trekking	By Car	Do you have animal holding area (Yes/No)	If yes-Type of the holding Area			
												Open pen	Sheltered pen		
1															
2															
3															
4															
5															
6															
7															
8															
9															
10															

Name of the data collector: _____ Date: _____

Type of the respondent:-Trader

Name of the local market: _____

Questionnaire to trader

RN	Name of the informant	How many animals do you usually buy in one market day	Origin of the animals you usually buy	Where are you going to take the animals	How far are you going to take the animals after you buy(KM)	By what transportation do you take the animals		Which breed /type do you buy			Do you have animal holding area (Yes/No)	If yes-Type of the holding Area		How much time will you keep the animals (days)	What type of feed do you supply for the animals
						Trekking	By car	Local	Cross breed	Pure exotic		open pen	sheltered pen		
1															
2															
3															
4															
5															

Name of the data collector: _____ Date: _____

Appendixes 2: Ethiopian Warner-Bratzler Shear Force Procedures

1. Heat the cooking skillet to a constant 204^{o}C. Also, a small amount of cooking oil should be added in order to prevent the steak from sticking during cooking.
2. Following product collection, steaks should be cut 1 in (2.5cm) in thickness perpendicular to the long axis of the *longissimus dorsi* (LD). This will produce steaks that are cut <u>across the grain</u> of the muscle fibers. This is <u>critical</u> that the steaks are cut across the grain.
3. Remove the external heavy connective tissue.
4. Weigh the steak and record the initial weight.
5. Insert the thermocouple into the geometric center of the steak following the AMSA guidelines and instructional videos
6. Record the initial steak temperature
7. Place the steak in the pre-heated 204^{o}C skillet
8. Flip the steak when the internal temperature reaches 45^{o}C.
9. When the steak reaches 70^{o}C, remove from the skillet.
10. Watch the thermocouple output and record the peak cooked temperature.
11. Remove the thermocouple from the steak.
12. Weigh and record final cooked weight of the steak.
13. Allow the steak to rest and cool to room temperature prior to WBSF analysis (> 1 hour).
14. After cooling, cut across the long axis of the steak (knife tip on heavy connective tissue side (dorsal) and knife handle on ventral side) to expose the fiber direction

15. Remove 6 cores parallel with the muscle fibers. It is critical that the muscle fibers run parallel with the core so that the shear will be across the grain.
16. Use the WBSF device to shear each core. The shear should be across the middle (center) on each core. Record the peak WBSF value in kg for each core.
17. The values for each core are averaged for the determination of a single value for each steak.

Appendixes 3: **Warner-Bratzler Shear Force: Cooking Data Sheet**

RN	Season	Sample ID	On Temp. (^0C)	On Wt. (gm)	Off Temp. (^0C)	Off Wt. (gm)	Cooking loss (gm)	Cooking loss (%)

Appendixes 4: **Warner-Bratzler Shear Force: Shear Data Sheet**

RN	Season	Sample ID	Core 1 SF	Core 2 SF	Core 3 SF	Core 4 SF	Core 5 SF	Core 6 SF	Aver SF

Apendix1: Tables Showingtheresults of Survey Work

Appendix 1: Type (used/not used for farm power) of oxen used for fattening by fatners in the urban areas

Responses	Percent
Oxen fattened after being used for draught power	80.0
Oxen fattened were not used for draught power	20.0
Total	100.0

Appendix 2: Favorable fattening seasons for Fatners in the urban areas of Hawassa, Arsi Negelle, Wolayita

Responses	Percent
Summer (June, July & August)	26.7
Summer and Autumn (from January to November)	13.3
Summer and Spring (from March to August)	13.3
All seasons of the year	33.3
Total	86.7

Appendix 3: Rounds of fattening per year for Fatners in the urban areas of Hawassa, Arsi Negelle, Wolayita

Responses	Percent
one round	40.0
Two rounds	30.0
Three rounds	26.7
Four rounds	3.3
Total	100.0

Appendix 4: Means of transportation to market place for local farmers after fattening their animals

Responses	Percent
Trekking	100.0
by Truck	0

Appendix 5: The number of livestock (in TLU) per household in the study areas

Type of livestock	Cumulative	Hawassa	Wolayita	Arsi Negelle
Cattle	6.53 ±0.623	5.83±0.223	3.15±0.458	9.47±1.243
Sheep	0.41±0.0712	0.26±0.0434	0.12±0.042	0.75±0.145
Goats	0.2±0.0741	0.107±0.0431	0.09±0.419	0.36±0.187
Donkey	0.36±0.08	0	0.3±0.082	0.77±0.153
Horse	0.15±0.063	0	0.08±0.08	0.32±0.152
Total TLU per House hold	7.64±0.784	6.2±0.233	3.74±0.615	11.67±1.521

Appendix 6:The percent of the consumers which frequently visited the same butchery

Consumers' responses	Percent
Yes	43.3
No	56.7

Appendix 7:The percent of the consumers which believed that there was variation of beef quality between butchery houses

Consumers' responses	Percent
Yes	100.0
No	0

Appendix 8:The percent of the consumers which usually requested the source market area of the cattle slaughtered by the butcher

Consumers' responses	Percent
Usually ask the source	13.3
Ask only some times the source	66.7
Never ask the source	20.0

Appendix 9:The area of Origin of the cattle which the consumers preferred to consume

Consumers' responses	**Percent of Respondent**
Hawassa – Tula	20.0
Wolayita	33.3
Arsi Negelle	36.7
BishanGurracha	3.3
Borena	6.7

Appendix 10:The percent of consumers who preferred the beef because it was easy to chew (good tenderness)

Consumers' responses	**Percent**
Yes	90.0
No	10.0

Appendix 11:The percent of consumers who preferred the beef because of its good taste

Consumers' responses	**Percent**
Yes	100.0
No	0

Appendix 12:Crop farming experience of farmers

Response	Percent
Yes	97.5
No	2.5

Appendix 13:Farmers which used oxen for crop farming power

Response	Percent
Yes	97.5
No	2.5

Appendix 14:Type of Oxen (Used/not used for farm power) the usually sold out by farmers

Response	Percent
Before using for draught power	2.4
After using for draught power	95.1

Appendix 15:Type of Oxen (Used/not used for farm power) the usually fattened at farmers level

Response	Percent
Before using for draught power	7.3
After using for draught power	92.7

Appendix 16:Cattle age estimation methods

Response	Percent
Estimate by looking at its teeth	85
Use other methds	
(such as by asking or recalling their birth date)	15

Appendix 17:Preferred Season for Farmers to practice fattening Activity

Season	**Percentof respondent**
Summer	41.5
Winter	4.9
Summer and Autumn	39
Autums and Winter	12.2
Winter and Spring	2.4

Appendix 4: Analysis of Variance (ANOVA)

Appendix 18:Analysis of variance for season and Live weight (kg)

Corrected Total	DF	Sum of squares	Mean Square	F Value	Pr>F
Model	1	616614.964	616614.964	87.97	<0.0001
Error	225	1577162.586	7009.611		
Corrected Total	226	2193777.551			

Appendix 19:analysis of variance for Age and Cooking loss (%)

Corrected Total	DF	Sum of squares	Mean Square	F Value	Pr>F
Model	2	495.48481	247.74240	3.87	<0.0223
Error	224	14352.39031	64.07317		
Corrected Total	226	14847.87512			

Appendix 20:Analysis of variance for Age and WBSF (kgf)

Corrected Total	DF	Sum of squares	Mean Square	F Value	Pr>F
Model	2	86.0502917	43.0251458	17.71	<0.0001
Error	224	544.2051992	2.4294875		
Corrected Total	226	630.2554909			

Appendix 21:Analysis of variance for Breed and cooking loss (%)

Corrected Total	DF	Sum of squares	Mean Square	F Value	Pr>F
Model	1	152.59020	152.59020	2.34	<0.1278
Error	225	14695.28492	65.31238		
Corrected Total	226	14847.87512			

Appendix 22:Analysis of variance for Breed and WBSF (kgf)

Corrected Total	DF	Sum of squares	Mean Square	F Value	Pr>F
Model	1	1.3865610	1.3865610	0.50	0.4820
Error	225	628.8689299	2.7949730		
Corrected Total	226	630.2554909			

Appendix 23:Analysis of Variance for Body Conformation Grade and cooking loss (%)

Corrected Total	DF	Sum of squares	Mean Square	F Value	Pr>F
Model	2	772.41953	386.20976	6.15	0.0025
Error	224	14075.45559	62.83686		
Corrected Total	226	14847.87512			

Appendix 24:Analysis of Variance for Body Conformation Grade and Cooking loss (%)

Corrected Total	DF	Sum of squares	Mean Square	F Value	Pr>F
Model	2	772.41953	386.20976	6.15	0.0025
Error	224	14075.45559	62.83686		
Corrected Total	226	14847.87512			

Appendix 25:Analysis of Variance for Body Conformation Grade and WBSF(kgf)

Corrected Total	DF	Sum of squares	Mean Square	F Value	Pr>F
Model	2	94.3816833	47.1908417	19.73	<0.0001
Error	224	535.8738076	2.3922938		
Corrected Total	226	630.2554909			

Appendix 26:Analysis of variance for Live Weight and Cooking loss (%)

Source	DF	Sum of squares	Mean Square	F Value	Pr> F
Model	2	495.48481	247.74240	3.87	0.0223
Error	224	14352.39031	64.07317		
Corrected Total	226	14847.87512			

Appendix 27:Analysis of variance for Live Weight and WBSF(kgf)

Source	DF	Sum of squares	Mean Square	F Value	Pr> F
Model	2	86.0502917	43.0251458	17.71	0.0001
Error	224	544.2051992	2.4294875		
Corrected Total	226	630.2554904			

Appendix 28:Analysis of Variance for Location and Cooking loss (%)

Corrected Total	DF	Sum of squares	Mean Square	F Value	Pr>F
Model	4	212.19748	53.54937	0.81	<0.5184
Error	222	14633.67764	65.91747		
Corrected Total	226	14847.87512			

Appendix 29:Analysis of Variance for Location and WBSF (kgf)

Corrected Total	DF	Sum of squares	Mean Square	F Value	Pr>F
Model	4	6.2605501	1.5651375	0.56	<0.6942
Error	222	623.9949408	2.8107880		
Corrected Total	226	630.2554909			

Appendix 30:Analysis of Variance for Season and Cooking loss (%)

Corrected Total	DF	Sum of squares	Mean Square	F Value	Pr>F
Model	1	727.16549	727.16549	11.59	<0.0008
Error	225	14120.70963	62.75871		
Corrected Total	226	14847.87512			

Appendix 31:Analysis of Variance for Season and WBSF (kgf)

Corrected Total	DF	Sum of squares	Mean Square	F Value	Pr>F
Model	1	12.371806	12.3718062	4.51	0.0349
Error	225	617.8836847	2.7461497		
Corrected Total	226	630.2554909			

Appendix 32:Analysis of Variance for Transportation and Cooking loss (%)

Corrected Total	DF	Sum of squares	Mean Square	F Value	Pr>F
Model	1	84.04554	84.04554	1.28	0.2589
Error	225	14763.82958	65.61702		
Corrected Total	226	14847.87512			

Appendix 33:Analysis of variance for Meanse of Transportation and WBSF (kgf)

Corrected Total	DF	Sum of squares	Mean Square	F Value	Pr>F
Model	1	1.2076026	1.2076026	0.43	0.5117
Error	225	629.0478883	2.7957684		
Corrected Total	226	630.2554909			

Annex: Photos of some activities during the research work

Figure 7: Transporting the animals by truck

Figure 8: Trekking animals to the abattoir

Figure 9: Trekking animals to the abattoir

Figure 10: Uncomfortable resting pens

Figure 11: Dentition method of age estimation (old cattle)

Figure 12: Dentition method of age estimation (young cattle)

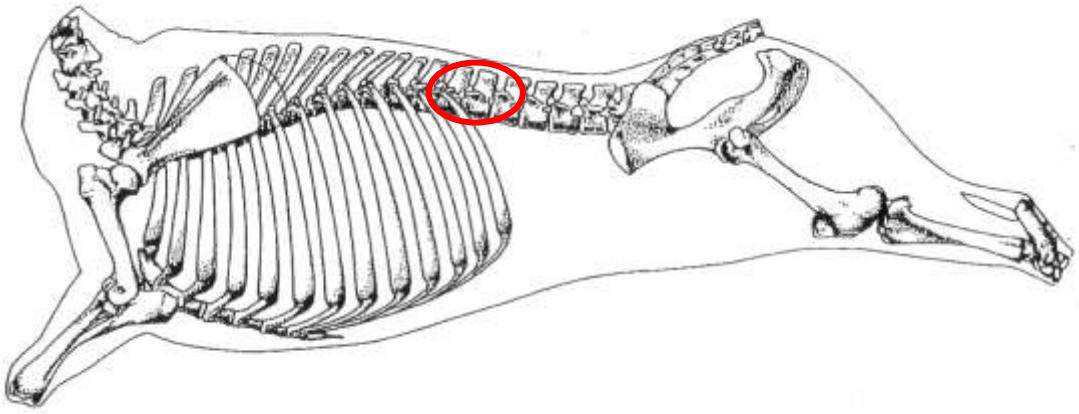

Figure 13: The location of muscle longissimus dorsi (LD), at the 13th (last, most posterior) rib section.

BIOGRAPHICALSKECH

The author, Mr. Solomon MarkosSamago was born on July, 25, 1976 in Boricha Wereda, Sidama zone, Ethiopia. He attended his education at Fullasa St. Josef Primary School (grade 1-6), Leku Secondary School (grade 7-8) and Hawassa Comboni High School (grade 9-12) at Hawassa City from September 1993 to July, 1997. He then joined the Hawassa University, Hawassa College in September, 1997 and awarded B.Sc. degree in Animal Production in July, 2001.

After graduation, was employed by Ethiopian Institute of Agricultural Research (EIAR) and Joined Werer Agricultural Research Center, as junior researcher at December 26, 2001 to January 08, 2006 GC as assistant researcher in Animal research division.

After four years of service, he left EIAR and he was then employed by Southern Nation's Nationalities Government Region, Sidama Zone in Boricha Wereda and Gorche Wereda from June 09, 2006 to April 10, 2009 in different Positions. Since, October 09, 2014 to date, he is working in Hawassa City Administration,Municipalityoffice, as an Animal Production expert. He joined School of Graduate Studies at Hawassa University to pursue his graduate study in Animal Production.