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Evaluation of Proximate Composition of Beef of Arsi Cattle in Adama Town, Oromia, Ethiopia

Arse Gebeyehu
Adami Tulu Agricultural Research Center,
P.O. Box 35, Batu, East Shoa, Ethiopia
Email: arse.gebeyehu@yahoo.com

Mohammed Yousuf
Haramaya University,
P.O. Box 138, Dire Dawa, Ethiopia

Ameha Sebsibe
Food and Agricultural
Organization Ethiopia,
P.O. Box 5536, Addis Ababa, Ethiopia

***Abstract* – The study was conducted in Adama and Bishoftu towns, on carcass samples of Arsi breed cattle with objective of evaluating proximate qualities with standard procedures. Beef sample was aseptically collected from longissimus dorsi chuck proximate composition analysis. Breed type was determined by phenotypic traits and age was determined with dentition. The production system being practiced by the animals selling and buying farmers were subsistence production systems. There was no variation in proximate qualities due to age and production system effect and their interactions ($P > 0.05$). The protein and fat content of longissimus dorsi chuck of Arsi cattle were 22.10 and 6.86, respectively.**

***Keywords* – Age Group, Highland, Lowland and Protein, Fat, Ash and Moisture Content.**

I. Introduction

Ethiopia has huge livestock resources in Africa with estimated population of 52.13million, 24.22million, and 22.62million heads of cattle, sheep and goats, respectively (FAOstat, 2010; CSA, 2012). The livestock sector of Ethiopia is expected to continue growing over the next one to two decades given the large potential for increasing meat production, the expected growth in income, increased urbanization and improved policy environment (MoFED, 2010). Ahmed *et al.* (2003) and Anon (2008) indicated that the main driving force for the growth of the livestock sub-sector is the growth in demand for meat products**.** According to MoFED (2010) annual report, the national economy is growing in not less than double digits. This economic growth is likely to stimulate people's interest to high quality and value added products (von-Seggern, 2001). Education and economic prosperity makes people more sensitive and selective particularly healthier consumption of foods (Gary, S. Pers.comm, US-CME, 2009). In virtue of this, meat commercialization has a great potential to become a key source of income to smallholders of Ethiopia.

In recent years feedlot firms are flourishing and getting engaged in the export of processed meat and live animals. These firms are exporting live animals and processed carcasses to various countries in close proximity of Ethiopia *i.e.* Africa and the Middle East and absorbing in foreign currency from international markets. The Middle East and North African (MENA) countries prefer lowland live animals and meat; as a result, about 90% of live animals exported to the MENA countries are contributed by the lowland pastoral areas (Mohammed, 2007; ESGPIP, 2011). Why is meat from lowland animal preferred? Is there proximate quality difference between highland and lowland animals? These are the questions that need an immediate answer to properly utilize the resource. Standards such as optimum proximate components are being adopted by almost all international markets (Kirton, 1989; Anon, 2006). By studying the sources of variation in meat quality, the value addition work needed and value addition processes can be enhanced to satisfy the national and international consumers. According to the World Bank (2004) report, Ethiopian meat production and marketing has been plagued by lack of quality and sanitation, prevalence of disease and unqualified meat production process.

Though extensive research has been and is being done to improve production and productivity of local animals, limited and fragmented studies have focused on the meat quality characteristics (ESAP, 2006). Research on meat and meat products are given the lowest attention in Ethiopia (Anon, 2010a). Continuous study on meat and meat products is important to improve and sustain livestock production for the reason being that meat should be more consistent in quality *i.e.* optimum level of chemical composition to ensure consumers have a consistently good eating experience (Kirton, 1989; CRC, 2004; von-Braun, 2010). Pethick *et al.* (2011) survey result noted that the two most important quality areas for future research are lean meat yield and human nutritive value (proximate composition). It is argued that these areas have complex biological interactions, both antagonistic and complimentary, which require careful management so as to produce the best outcome for the industry and the consumer. Pethick *et al.* (2011) recommended a collaborative research that encompasses all stakeholders. Mirzaei *et al.* (2011) also indicates that optimization of cattle production requires knowledge of the variation in meat quality and carcass traits and the association between them.

Hence, the major objective of this study is to assess and document on proximate composition qualities of the beef produced from Arsi cattle across different ages and production systems.

II. Materials and Methods

2.1 The Study Area

The study site was Adama town. This town is situated on the highway from Addis Ababa to Harar. The town has mean altitude of 1666m above sea level and located at 100km east of Addis Ababa capital city of Ethiopia (Google Earth, 2012). According to CSA (2012a) population census report, Adama town has 271,562 residents. Adama is an epicenter of modern manufacturing industries and also hosts many East-Shoa zonal administrative offices and Oromia television station. The town is situated in the center of the country, thus most frequently visited by national and international tourists.

Adama town municipality has its own abattoir that gives service to town's community. The Adama abattoir is semi-modern that operates with services featuring cattle, sheep and goat slaughtering. The surrounding area of Adama is potential producer of crop and livestock (CSA, 2008). The town has several agro-industrial factories such as floor and oil mills that supply agro-industrial by-products to the feedlots in the areas. The town has also good infrastructures that facilitate linkage in markets and marketing in the national and international. Neighboring towns and districts have a great potential of crop and cattle production making Adama town trade center of all sort of products and livestock production inputs. The annual average minimum and maximum temperature of Adama town is 18 and 32°c respectively (Anon, 2011b and Zoover, 2011). The specific geographical location of the Adama town's abattoir is on the geographic coordinates of: 8° 33' 05.79"N and 39° 15' 34.83"E. The altitude of the abattoir is 1639m above sea level (Google Earth, 2012).

2.2 Sample collection

Before collecting representative samples, the production systems and age of the animals were identified with phenotypic characteristics and dentition at abattoir respectively. From the mass of animals identified, randomly 12 sample source cattle were tagged in the abattoir and sample materials were collected from each carcass owners on purchase on 12 hours after carcass harvest (AOAC, 2003). The sources of sample carcass were local cattle, Arsi breed of highland and lowland in different age categories. Half a kilogram samples were dissected from chuck areas muscle *longissimus dorsi* (Peraza-Mercado *et al.,* 2006; Bures *et al.,* 2007). The sample materials were collected between 6:30am and 8:30am (early in the morning) local time while the carcass is still fresh. The collected samples were labelled and placed in clean and dry polythene bag and put in an icebox and brought to the laboratory (AOAC, 1999). Until the laboratory process proceeded the samples were kept in refrigerators at -20°C to inhibit decomposition or change in chemical composition. Further sampling was done in the laboratory. Then the raw beef sample was dried and pulverized to determine moisture, ash, protein and fat contents according to AOAC (2003) official method of analysis of meat and meat products. All the components were determined in duplicate.

2.3 Protein content determination

The classical macro-Kjeldahl method (981.10) of nitrogen analysis was used to determine the crude protein content of sample beef (AOAC, 2003) as follows. Samples of about 0.5g were measured using digital balance in the tecator tubes, then about 6ml mixtures of sulphuric acid and orthophospheric acid were added in the tecator tubes and about 3g of selenium and potassium sulphate mixture was added, to facilitate the digestion process by catalyzing and by raising the boiling point temperature of sulphuric acid. After this, the mixture was placed in the digester at a temperature of about 37ºC for 1 and half hour. After digestion was completed, the digested sample was distilled using 40% NaOH (50ml/ sample) to neutralize the acid, after cooling with the addition of water and then titrated with 0.1N of HCl in the computerized distillation unit and the result was obtained from a displayed result on the screen of the distillation equipment.

2.4 Fat content determination

Soxhlet method of solvent extraction was used during determination of fat as stated in AOAC (2003) as follows. About 2g milled samples were measured in to an extraction thimble lined with fat free cotton. Then the thimbles with the samples were attached to the extraction apparatus. The aluminum cup with a boiling cheeps were placed in the oven at 100ºC for 30 minutes and cooled to room temperature in the desiccators for 30 minutes then the cup weight was measured using a digital balance and recorded as W1 (weight of cup), then 50ml of diethyl ether was added in to each cup, after which set up of the extraction apparatus was done.

The samples contained in the thimbles were soaked for about 1 hour by lifting the thimble down into the cup, started from the apparatus hot plate temperature reached 55ºC, after soaking the thimbles were lifted up and the extraction process took place for 5hours.

Then the recycling process made by the diethyl-ether was stopped to let the solvent evaporate from the aluminum cup with the extract, in the process the evaporated solvent was recovered in the apparatus. Then aluminum cup and the content were dried in the oven for 30 minutes at 100ºC to evaporate the remaining solvent in the cup. After drying, it was removed from the oven and cooled in the desiccators for 30 minutes then weighed and recorded as W_2 (cup + fat). The percentage fat was calculated using the following formula

$$\text{Fat (\%)} = \frac{[W_2 - W_1]}{[\text{Sample Weight}]} \times 100$$

2.5 Ash and moisture content determination

The moisture and ash constituents of beef samples were determined according to the Official Methods of Analysis of the AOAC (2003): moisture content by oven drying a 2g test sample at 102ºC to a constant weight (950.46); ash content by igniting a 3–5g test sample in a muffle furnace at 550ºC until light grey ash results (920.153).

2.6 Experimental design, model and statistical analysis

The experimental design of the study was 2^4 Factorial in a Completely Randomized Designed (Factorial-CRD). Age has four levels and production systems have two levels. There were 8 treatment combinations. Data of proximate composition were analyzed by GLM procedures of SAS version 9.1 (SAS, 2008) using a model that included a random effect: protein, fat, fibre, ash and moisture and fixed effect production systems (Highland and Lowland) and age categories (5-6, 7-8, 8-9 and ≥12yrs). Mean separation was done by DMRT when the F-test was significant ($P \leq 0.05$). The model was:

$$Y_{ijk} = \mu + \alpha_i + \beta j + \gamma_k + e_{ijk}$$

Where; Y_{ij} = the response variable
μ = Overall mean common to all observation
α_i = Age effect
βj = Production system effect
γ_k = Interaction effect
e_{ijk} = Random error

III. Results and Discussion

The overall effect of age and production system on protein, fat and ash and moisture content of beef are given in Table 1. The overall F-test of age groups, production systems and interaction of age by production systems were not statistically significant (P > 0.05). This report disagrees with Johnson (2000) and Skapetas *et al.* (2006) that reported the total fat percentage increases significantly with the increase of slaughter age from 30 (20.84%, on DM basis) to 90 days (23.59%). Johnson (2000) reported that age has a greater influence on carcass composition than breed type of the animal. But there was significant variation in moisture content (P < 0.05) due to age and production system difference. This is in agreement with the report of Patten *et al.* (2008) that moisture content of *longissimus dorsi* varied from 68.44 to 72.47% due to age. The result of this study is also comparable with Stercova *et al.* (2008) report of a moisture content of *longissimus dorsi* to be 74.5%. The result of this study is also consistent with FAO (1993) who indicated carcass variability in chemical composition much more than milk, the protein content of a carcass is more stable than the fat and moisture contents.

Even though, there is no significant effect due to age and production systems on other proximate components under investigation (P > 0.05) but the p-value of fat content tend to have lower F-test value in effect due to age as compared to production system and age by production system interactions.

Table1. Effect of age and production system on proximate compositions (LS means)

Variables	Protein (%)	Fat (%)	Ash (%)	Moisture (%)
Age (year)	Ns	Ns	Ns	*
5-6	23.220	5.591	0.997	70.190[a]
7-8	21.928	6.862	0.996	70.211[a]
8-9	21.446	7.683	0.998	69.872[b]
≥12	21.818	7.305	0.997	69.879[b]
SE	0.980	1.005	0.001	0.103
Prod	Ns	Ns	Ns	*
Highland	22.253	6.625	0.996	70.124[a]
Lowland	21.953	7.096	0.0.997	69.953[b]
SE	0.685	0.719	0.0001	0.090
Age*Prod	Ns	Ns	Ns	*

Age = different age groups, Prod = production systems, Age*Prod = age by production system interaction, SE = standard error of mean, yr = year, Ns = not significant at significance level of α = 0.05, Superscripts of different letter in the same column are significantly different at α =0.05.

Table 2 documents the mean proximate composition percentage of *longissimus dorsi*(chuck) muscle. The Protein, Fat, Ash and Moisture content of *longissimus dorsi* chuck of Arsi breed cattle were 22.1, 6.9, 0.99 and 70.04% respectively (Table 2). The protein content reported in this document is comparable with Stercova *et al.* (2008), Williams (2007), Bures *et al.* (2007), Peraza-Mercado *et al.* (2006). Accordingly, the protein content reported in this document is also comparable with Stercova *et al.* (2008) report of 23.06% for *longissimus dorsi* chuck but Arsi cattle's found to be a lower.

Melton *et al.* (1974) reported a 19.40% crude protein for the beef sourced from Herford cattle. But it is in agreement with Williams' (2007) range of 20-25g protein/100g and comparable with Bures *et al.* (2007) range of 20.6-21.29% for protein, 2.41-3.43% for fat, 0.976-0.992%, for ash and 73.74 - 74.98% for moisture contents, a bit disagreement with fat may be due to difference in breed and age of animals. Bures *et al.* (2007) reported that protein fat, ash and moisture content significantly varies between breeds and ages of animals. Ameha (2006) indicated a higher carcass fat improves meat eating qualities. Peraza-Mercado *et al.* (2006) reported a protein of 15.32±0.82, fat 4.07±0.90, moisture 74.35±0.79, ash 1.38±0.24 for *longissimus dorsi* of young cattle are comparable with this results. The fat and protein content reported by this study is consistent with John *et al.* (1995) 7.14% and 21.10%, but this slight difference could be due to difference in feeding scheme and breed, age and other source of variation. Jost *et al.* (1983) reported a protein content of 21.2%, moisture content of 72.9% and fat content of 3.9%.

Table 1: Proximate composition percentage of *longissimus dorsi* (chuck) muscle of Arsi cattle

Variables	N	Mean (%)	SD
Protein	12	22.10	1.608
Fat	12	6.86	1.698
Ash	12	0.99	0.011
Moisture	12	70.04	0.228

S.D = standard deviation, N = number of samples examined

The pearson correlation coefficients of protein, fat, ash and moisture content of *longissimus dorsi* chuck of Arsi cattle are given in Table 3. There was a negative relationship between fat and protein (P < 0.0001) and is in agreement with FAO (1993). This negative relation means that, nine units of the increase in fat percentage are accompanied by a reduction of one unit in protein percentage. Fat and moisture content have significant negative relationship (P = 0.14). The existence of strong negative relationship between fat and moisture content is also reported by Patten *et al.* (2008). Protein has no significant relationship with ash and moisture content (P > 0.2).

Table 3: Correlation matrix between components of proximate quality of beef

Variables	Protein	Fat	Ash	Moisture
Protein	1	-0.91	-0.28	0.33
Fat		1	0.27	-0.45
Ash			1	-0.09
Moisture				1

The correlation coefficients between the proximate components and eating quality components are given in Table 4. Crude fat has no significant relationship with tenderness and juiciness (P > 0.2). Melton *et al.* (1974) also reported a non-significant negative correlation (r = -0.26) between fat and tenderness. But Melton *et al.* (1974) reported a correlation coefficient of -0.46* between Fat and Juiciness. This research work has found out that fat and flavor has strong positive relationship (P < 0.005). But Melton *et al.* (1974) reported a non significant negative correlation (r = -0.26) between fat and flavour for Hereford American, breed, age, nutrition and general animal management difference may result in such difference.

There is no significant relationship between protein and tenderness (P > 0.2). Melton *et al.* (1974) reported a weak positive relation between tenderness and protein (r = 0.35). Again there is no relationship with protein and juiciness (P > 0.2). The correlation between protein and juiciness is in good agreement with Melton *et al.* (1974) report of a correlation coefficient of 0.20 between juiciness and protein. But protein and flavor has strong negative relationship (P < 0.005). Melton *et al.* (1974) reported a correlation coefficient of 0.50 between flavour and protein.

Jost *et al.* (1983) reported a non-significant correlation (r = 0.03) between moisture content and tenderness, (r = 0.13) between moisture content and flavour and (r = -0.17) between fat content and tenderness. Jost *et al.* (1983) reported a significant correlation(r = 0.18) between moisture content and juiciness and a correlation(r = 0.31) between protein content and tenderness. Jost *et al.* (1983) reported a significant correlation(r = 0.4) between protein content and juiciness and a correlation(r = 0.38) between protein content and flavour. Jost *et al.* (1983) reported a correlation value of -0.34, -0.26 and 0.26 between fat content and juiciness, between fat content and flavour and between protein content and moisture content respectively.

Table 42: Correlation matrix between Proximate and Eating Qualities of *longissimus dorsi* chuck of Arsi cattle beef

Variables	Protein	Fat
Tenderness	-0.18	0.19
Juiciness	0.07	-0.02
Flavour	-0.90	0.89

IV. Summary

This study was conducted to explore the proximate qualities of beef in Adama town, Oromia region, Ethiopia. The study entails the specific objectives of investigating the proximate qualities of Arsi, Ethiopian beef. Difference in age, production system of animals and interactions didn't result into statistically significant (P > 0.05) variation in some components of proximate quality. But interaction (between age and production system) is significant (P < 0.05) on moisture content. The Protein, Fat, Ash and moisture content of *longissimus dorsi* chuck of Arsi breed cattle were 22.1, 6.9, 0.99 and 70.04% respectively. Fat and protein has strong negative relationship (P < 0.0001). Fat has no significant relationship with tenderness and juiciness (P > 0.05). Fat and flavor has strong positive relationship (P < 0.005). There is no significant relationship between protein and tenderness (P > 0.05).

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