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FATTY ACID PROFILE AND PROXIMATE COMPOSITION OF SIRLOIN AND CHUCK OF SELECTED ETHIOPIA CATTLE TYPES

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ABSTRACT

The fatty acid composition of beef meat is important for nutrition and human health. This study examined the composition of sirloin and chuck of beef from three cattle breeds in Ethiopia (Boran, Senga, and Sheko). Twelve bulls aged 18 to 24 months were used, and standard methods were employed to measure various parameters. The results showed that moisture content ranged from 64.32±0.29% in Boran sirloin to 66.47±0.13% in Sheko sirloin, crude fat ranged from 10.79±0.36% in Sheko chuck to 13.25±0.38% in Boran chuck, and crude protein ranged from 21.65±0.50% in Senga sirloin to 26.83±0.78% in Boran chuck. The color evaluation revealed L* values of28.20±3.09 to 32.52±1.70 for senga chuck and Boran chuck, a* values of 5.18±0.88 to 9.35±2.96 for Boran sirloin and Senga chuck, and b* values of2.24±1.47 to 4.33±1.05 for Sheko sirloin and Senga sirloin. The dominant fatty acid was Palmitic acid (C16:0), comprising 24.64% to 31.60% of the total. The study found that the sirloin cut had significantly higher levels of monounsaturated fatty acids (42.38%) and lower levels of polyunsaturated fatty acids compared to the chuck cut. In conclusion, Sheko beef had higher moisture content, while Boran beef had higher levels of crude protein and fat compared to Senga and Sheko. Principal component analysis (PCA) identified fatty acid profiles as the main factors influencing variation among cattle breeds. This research provides valuable information for cattle breeding and meat quality improvement efforts in Ethiopia and beyond.

1.Introduction

Beef meat is known to contain a wide range of fatty acids, saturated fatty acids (SFAs), monounsaturated fatty acids (MUFAs), and polyunsaturated fatty acids (PUFAs) are only a few of the many fatty acids that are known to be exist in beef meat. The nutritional value of meat is significantly influenced by the amount and composition of fatty acids, which are a significant component of animal muscle (Xin Zhang, 2022). The quantity and kind of intramuscular fat and fatty acids have a considerable impact on the eating quality, sensory qualities (such as taste, tenderness, and flavor), as well as meat color, shelf life, and fat hardness in beef (Bhuiyan, 2018).

The fatty acid profile of beef meat plays a substantial role in the nutritional composition and has implications for human health. To evaluate the nutritional value and potential health impacts of beef meat, it is crucial to comprehend the composition and distribution of its fatty acids (Wood, 2008). Polyunsaturated fatty acids, comprising omega-3 (n-3) and omega-6 (n-6) fatty acids are essential for the body and cannot be produced internally, so they must be obtained through dietary sources

(Micha, 2012). Triglycerides from dietary sources and fatty acids make up the majority of the fat in meat animals (Dinh, 2021).

Additionally, about 30% of the fatty acid content in conventionally formed beef is made up of oleic acid (C18:1), a monounsaturated fatty acid (MUFA) that lowers cholesterol levels and other health benefits like lowering the risk of stroke and significantly lowering together systolic and diastolic blood pressure in vulnerable populations (Daley1, 2010). Due to their contribution to the odors of cooked meat, fatty acid content and the roles of each fatty acid in thermal oxidation during cooking are of interest (Dinh et al. 2021). Beef meat contains two important fatty acids called α- linolenic acid (α-LA) and linoleic acid (LA).

In comparison to beef from grain-fed cattle, grass-fed beef typically contains higher levels of monounsaturated fatty acids and polyunsaturated fatty acids, specifically omega-3 fatty acids (Daley1, 2010).

The fatty acid profile of beef meat has imperative implications for human health. Excessive intake of saturated fatty acids, particularly long-chain saturated fatty acids, has been related with an increased risk of cardiovascular diseases, such as coronary heart disease. While fatty fish and some plant sources are better suppliers of n-3 fatty acids than beef, grain-fed cattle may not have as much of these healthy fats as grass-fed beef (Simopoulos, 2002).

To the extent that we are aware, only a small number of publications have been found to evaluate beef from the Harar, Arsi, and Bale cattle breeds in Oromia, Ethiopia focusing on eating quality, as well as the instrumental tenderness of the meat. The proximate compositions and fatty acid profile of sirloin and chuck cuts have not yet been researched. Therefore, the purpose of this study was to evaluate the proximate composition and the fatty acid profile of sirloin and chuck meat cuts.

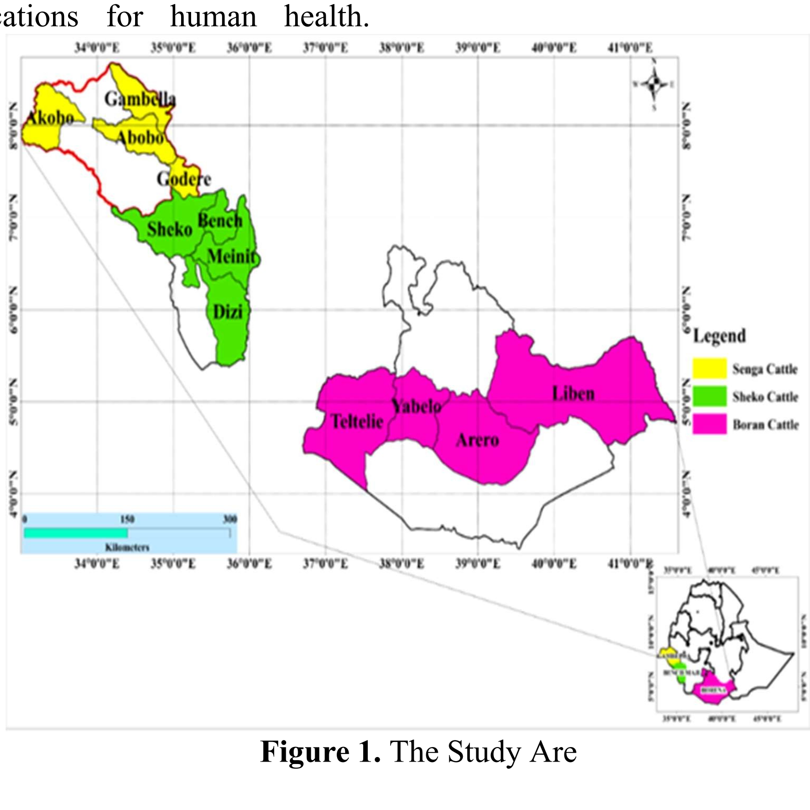

Figure 1. The Study Are

2.Materials and methods

2.1. Meat samples

A total of two cuts (sirloin and chuck) of 48 meat samples from three different cattle types namely Boran, Senga and Sheko (aged 18–24 months) were used in this study.

2.2. Study area

The Sheko and Senga cattle were gathered from south-western Ethiopia and the Akobo region of Gambella, respectively, while the Boran cattle originate from the Borana zone in the southern rangelands of Ethiopia (Figure 1). The southern rangelands of Ethiopia, particularly those in the Liben, Mega, and Arero plains, are the primary home of the Ethiopian Boran. Cattle are essentially huge, broad-framed cattle animals (Abdurehman, 2019). According to Coppock, (1994), 27% of the annual precipitation falls between September and November and 59% between March and May. Gambella is located in the southwest Ethiopian plains (Figure 1). The study area is divided into the four regional habitats of Akobo, Gambella, Abobo, and Godere (Kassie, 2020).

The height of the Bench Maji Zone, which is in the tropical area of the planet, ranges from 500 meters above sea level in the lowlands to more than 2,800 meters above sea level in the highlands. It is between 7.5° and 9.5° north latitude (Wubie, 2015).

2.3. Sample collection and preparation

From the study area, male indigenous breed cattle types were chosen. The samples were kept chilled until analysis after being collected and put in an ice box. Each animal's flesh sample, which was taken from three distinct native breeds, was examined. Sirloin and chuck were both have all visible fat removed (FAO, 2005).

2.4. Proximate composition

The proximate composition of the beef samples was evaluated in triplicate. Total moisture, total protein, and fat (ether extract) were calculated using the Association of Official Analytical Chemistry technique (AOAC, 2000).

2.4.1. Moisture determination

Based on AOAC 2000, method 101/1, the moisture content was determined. Two separate slices of fresh muscle samples (5g each) were obtained and baked at 1000°C for 24 hours. Following cooling in desiccators, the samples' weights were determined.

2.4.2. Determination of crude protein

Nitrogen was determined using the Kjeldahl technique, and crude protein was determined by multiplying the result by 6.25 (AOAC, 2000). The fresh meat sample was ground, and 1 g of it was used as the substrate for the digestion of 25 ml of concentrated H_2SO_4 and mercury tablets in a Kjeldahl flask. Nitrogen was distilled from the flask and then dissolved in 4% boric acid in a solution of 40% NaOH. The combination was titrated against solutions of 0.1 N HCl.

mg Nitrogen =VxNx14. (Hall et al.2013) (1)

2.4.3. Fat content determination

The petroleum ether extract was used to extract crude fat. From the sample, 15 grams were brought to the Soxhlet device. The samples underwent continuous ether extraction for six hours. The extract was then removed from the extractor and dried in the oven for two hours (AOAC, 2000). After cooling, the sample was weighed to determine the percentage of ether extraction.

2.5. Meat color

Four non-frozen meat samples from the LD were utilized in order to determine the meat color using the L*, a*, and b* standard CIE reference system. Using the MinoltaCR-400 colorimeter (Konica Minolta, Osaka, Japan) at 20C, in anaerobic and dark circumstances, the color was assessed. Each cut underwent a total of six scans, with the average measurements being utilized for statistical analysis. A standard white was used to calibrate L*, a*, and b*. A* ranges from green (-) to red (+), b* ranges from blue (-) to yellow (+), and L* is a brightness indicator (0 = black, 100 = white) (Lazăr et al, 2014). Chroma index (C*) measurements were made in accordance with (Purslow et al. 2016) by applying the following formula equation:

C* = ((a*)2+(b*)2)0.5. (Neto et al. 2015) (2)

2.6. Fatty acid profile analysis

Fatty acids were extracted from meat samples using 600µl of hexane. The resulting supernatant was collected in a vial for further analysis. The fatty acid analysis was conducted using the GC-FID method FAME 100 M SUPELCO and followed the AOAC 996.06 20th Ed.2016 met and test method. In the analysis, C23:0 (Sigma-Aldrich, Darmstadt, Germany) was used as the internal standard for measuring the total fatty acids in a 15 gm sample. For additional identification, the individual standards cis- 11-octadecenoic acid methyl ester, hexacosanoic acid methyl ester, 14-methyl- pentadecanoate, 14-methyl-hexadecanoate, and 16-methyl-heptadecanoate were all purchased. Every single chemical was of the analytical quality (Pleadin, 2021).

2.7. Statistical analysis

Statistical analysis was carried out using SPSS program version 25. The means of the beef meats that were put to the test were compared using one-way and two-way ANOVA testing as well as Tukey's post hoc test. To find out if there was a significant difference, a significance level of 0.05 was used. To analyze the fatty acid profile and proximate composition dataset, principal component analysis (PCA) was conducted using the XLSTAT 2022.4.1.1382 OS

Version software and SPSS version 20.

3. Results and discussions

3.1. Proximate composition of sirloin and chuck cuts of Boran, Senga and Sheko cattle

Table 1 shows percentage mean proximate composition and color of raw beef cuts from different cattle types. The high percentage mean moisture content of beef was 66.47±0.13 which represents the sirloin cuts of Sheko cattle and the lower values was from the sirloin of Boran cattle (64.32±0.29) and Boran chuck was significantly different ($p<0.05$) from Senga and Sheko cuts. The report of (Li, 2017) 66.63 ± 1.85 was in line with the current study particularly to the Sheko cuts. The water activity (aw) of the meat is the standard unit used by microbiologists to characterize the water needs of microorganisms. The present study's moisture content was lower than and inconsistent with the finding of (Alamin, 2019) that showed 70.54%.

The percent mean protein composition ranged from 21.57±0.45 to 26.83±0.7 in different animals, with the Boran chuck displaying the greatest protein content (26.83±0.78). The protein content of Boran sirloin and chuck was significantly different ($p<0.05$) from the protein contents of Senga and Sheko cattle. The protein contents reported by Karakok, (2010) ranged from 18–22%, and the report by Timketa, (Dagne T et al,.2021) ranged from 18.46±0.35 to 22.76 ± 1.04 was in line with the present study. The percentages mean aw content was ranged from 0.83±0.78 to 1.65±0.57. The Sheko chuck 1.65±0.57 was significantly different ($p<0.05$) from Senga and Boran cuts. The a_w result in the current study was similar to the 0.992 ± 0.001 result reported by (Li, 2017).

The percentage mean of fat content of the three cattle were ranged 10.79±0.36 (Sheko chuck) to 13.25±0.38 (Boran chuck) and Boran chuck contains high fat percentage. The report of Belhaj (Belhaj, 2021) the fat content was 5.50 ± 1.30 which was lower than the current study. These findings were corroborated those of (Oz, F and Celik, 2015) or this study's settings and moisture content support the work of (Hammuel, 2019).

3.2. The principal component analysis

The meat of three different types of cattle, namely Boran, Senga, and Sheko species, was analyzed for its composition and color using Principal Component Analysis (PCA), which breaks down the original data into different sets of scores and component loadings (Nkansah et al. 2021). Based on Eigenvalues greater than 1, primary components were chosen to keep in the analysis. Poor, moderate, and high loadings are denoted by component loadings below 0.5, between 0.5 and 1, and over 0.5, respectively. Figure 2 displays the findings of the PCA analysis for the chosen cattle types and meat slices.

Table1. The mean percentage values for proximate composition and color values of the Boran, Senga and Sheko cattle types and cuts

Cuttle cuts types	Moisture	aw	Crude protein	Crude fat	L*	a*	b*
Boran sirloin	64.32±0.29[a]	0.95±0.70[a]	24.95±0.70[a]	12.97±0.87[a]	30.79±4.06[a]	5.18±0.88[a]	2.92±0.68[a]
Chuck	65.06±o.93[c]	0.83±0.78[b]	26.83±0.78[b]	13.25±0.38[b]	32.52±1.70[a]	5.38±1.45[a]	4.11±1.41[b]
Senga sirloin	64.75±0.54[ab]	0.99±0.01[a]	21.65±0.50[c]	11.89±0.09[c]	32.05±5.12[a]	6.38±3.65[b]	4.33±1.05[b]
Chuck	65.06±0.87[b]	0.98±0.02[a]	21.57±0.45[c]	11.76±0.36[c]	28.20±3.09[a]	9.35±2.96[c]	2.90±2.42[ac]
Sheko sirloin	66.47±0.13[b]	0.99±0.01[a]	23.49±0.32[d]	11.21±0.38[c]	30.17±2.41[a]	8.36±3.71[c]	2.24±1.47[ac]
Chuck	65.31±0.23[b]	1.65±0.57[c]	22.14±0.24[c]	10.79±0.36[c]	29.12±1.60[a]	6.14±1.30[ab]	2.43±1.13[ac]

*Means with different superscripts within a column were significantly different at $P<0.05$
Abbreviations: aw=water activity, L=, brightness, a=, red, b= yellow.

Table 2. The loadings of the important principal components (PCs) for the proximatecomposition and color were analyzed using Eigen values

Parameters	**F1**	**F2**	**F3**	**F4**	**F5**	**F6**	**F7**
Eigenvalue	2.619	1.644	1.342	0.494	0.363	0.339	0.201
Variability (%)	37.409	23.480	19.165	7.051	5.185	4.837	2.874
Cumulative %	37.409	60.888	80.053	87.104	92.289	97.126	100.000

Table 5. Fatty acid content (%) of various meat cuts from Boran, Senga, and Sheko Cattle types.

Cattle types	**Boran**		**Senga**		**Sheko**	
Beef cuts	**Sirloin**	**Chuck**	**Sirloin**	**Chuck**	**Sirloin**	**Chuck**
Saturated	60.08±0.02^{c}	59.36±0.56^{b}	56.66±0.18^{a}	61.21±0.06^{e}	60.48±0.06^{d}	66.65±0.19^{f}
MUFA	25.65±0.13^{a}	35.76±0.67^{d}	42.38±0.55^{f}	37.49±034^{e}	34.85±0.11^{c}	29.20±0.26^{b}
PUFA	14.26±0.07^{g}	4.92±0.10^{e}	1.70±0.34^{c}	1.32±0.33^{b}	4.81±0.18^{d}	5.22±0.16^{f}
Trans	2.07±0.02^{c}	2.45±0.23^{ef}	1.52±0.23^{ab}	1.45±0.06^{ab}	4.36±0.18^{g}	4.38±0.19^{g}
Omega6	14.33±0.17^{g}	5.22±3.86^{c}	1.44±0.47^{a}	1.30±0.23^{a}	3.42±0.15^{b}	3.65±0.32^{b}
Omega3	1.94±0.05^{f}	1.85±0.04^{efg}	0.32±0.07^{a}	0.51±0.45^{ab}	0.37±0.03^{a}	0.82±0.33^{bc}
C14:0	4.47±0.21^{b}	4.26±0.26^{b}	5.34±0.18^{c}	6.16±0.33^{d}	3.67±0.19^{a}	4.45±0.21^{b}
C14:1	0.37±0.06^{ab}	0.81±0.15^{ab}	0.69±0.41^{abc}	0.90±0.09^{d}	0.57±0.15^{abc}	0.65±0.33^{abc}
C15:0	0.63±0.04d^{e}	0.31±0.02^{a}	0.60±0.11^{bcde}	0.49±0.07^{abcd}	1.16±0.11^{f}	0.81±0.22^{e}
C16:0	27.38±0.06^{d}	26.33±0.40^{c}	29.64±0.13^{e}	31.60±0.17^{f}	24.64±0.29^{a}	27.47±0.35^{d}
C16:1	1.08±0.93^{ab}	2.51±0.26^{g}	3.50±0.08^{h}	2.43±0.48^{g}	1.81±0.13^{d}	0.91±0.09^{b}
C17:0	0.71±0.13^{a}	0.80±0.13^{a}	1.57±0.26^{bc}	2.13±0.63^{d}	1.39±0.18^{b}	1.79±0.17^{bcd}
C17:1	0.00±0.00^{a}	0.00±0.00^{a}	0.84±0.21^{e}	0.76±0.10bc^{d}	0.49±0.32^{bcd}	0.00±0.00^{a}
C18:0	27.28±0.35^{def}	26.41±0.35^{bcd}	19.64±0.55^{a}	19.59±0.25^{a}	27.57±0.16^{bde}	31.56±0.34^{i}
C18:1n9t	2.16±0.14^{b}	2.30±0.12^{b}	1.68±0.30^{a}	1.71±0.25^{a}	4.32±0.11^{cd}	4.27±0.13^{cd}
C18:1n9c	21.64±0.09^{a}	31.03±0.03^{d}	35.59±0.03^{f}	32.25±0.23^{e}	27.87±0.09^{c}	22.82±0.14^{b}
C18:2n6c	9.76±0.03^{f}	3.80±0.30^{e}	1.51±0.41^{b}	1.07±0.06^{a}	2.79±0.13^{c}	3.39±0.25^{d}
C20:4n6	3.56±0.03^{e}	0.85±0.06^{d}	0.00±0.00^{a}	0.00±0.00^{a}	0.34±0.02^{bc}	0.00±0.00^{a}
C21:0	0.00±0.00^{a}	1.20±0.08^{cde}	0.00±0.00^{a}	2.11±0.12^{g}	1.71±0.05^{defg}	0.64±0.55^{b}
C18:3n3	0.00±00^{a}	0.00±0.00^{a}	0.37±0.15^{ab}	0.00±0.00^{a}	1.43±0.09^{d}	0.56±0.77^{ab}
C20:0	0.91±0.58b^{c}	1.21±0.01^{c}	0.44±0.39^{ab}	0.26±0.07^{a}	0.37±0.34^{a}	0.40±0.41^{ab}

** Means with various letters in a row differed significantly at $P<0$

Table 8. Correlation coefficients between different fatty acids found in beef need to

Variables	Saturated	MUFA	PUFA	Trans	Omega6	Omega3	Myristic	Myristic	Pentadecanoic	Palmitc	Palmit	Heptadeca	CisHeptadec	Stearic	TransElaidic	Linoleic	Arachidonic	ALinolenic	Arachidic
MUFA	**1**																		
PUFA	**-0.405***	**1**																	
Trans	0.006	**-0.892***	**1**																
Omega6	**0.662***	**-0.289***	0.032	**1**															
Omega3	0.014	**-0.712***	**0.742***	-0.041	**1**														
C14:0	**0.529***	-0.155	-0.056	**0.624**	-0.010	**1**													
C14:1	**-0.672***	**0.375***	-0.126	**-0.982**	-0.051	**-0.595***	**1**												
C15:0	**-0.428***	**0.761***	**-0.647***	**-0.623**	**-0.517***	**-0.318***	**0.682***	**1**											
C16:0	0.224	0.124	-0.223	**0.678**	-0.025	**0.372***	**-0.661***	**-0.347***	**1**										
C16:1	-0.168	**-0.794***	**0.918***	**-0.274**	**0.758***	**-0.242***	0.185	**-0.434***	**-0.404***	**1**									
C17:0	**-0.483***	**-0.274***	**0.472***	-0.162	0.163	-0.220	0.157	**-0.300***	-0.138	**0.555***	**1**								
C17:1	**0.718***	**-0.274***	0.016	**0.931**	-0.091	**0.603***	**-0.920***	**-0.530***	**0.540***	**-0.301***	**-0.283***	**1**							
C18:0	**-0.331***	**0.848***	**-0.769***	**-0.276**	**-0.597***	-0.096	**0.347***	**0.662***	0.159	**-0.653***	**-0.264***	-0.225	**1**						
C18:1n9t	**0.572***	**-0.767***	**0.593***	**0.771**	**0.472***	**0.401***	**-0.825***	**-0.861***	**0.377***	**0.319***	0.056	**0.736***	**-0.704***	**1**					
C18:1n9c	**0.658***	**-0.246***	0.001	**0.978**	-0.062	**0.612***	**-0.973***	**-0.595***	**0.697***	**-0.314***	-0.229	**0.937***	-0.217	**0.739***	**1**				
C18:2n6c	0.010	0.097	-0.123	-0.133	-0.093	-0.002	0.126	**0.254***	-0.063	-0.058	-0.100	-0.121	0.135	-0.168	-0.084				
C20:4n6	0.082	**-0.747***	**0.808***	0.003	**0.933***	-0.053	-0.102	**-0.565***	-0.035	**0.757***	0.121	-0.013	**-0.637***	**0.534***	-0.007	**1**			
C21:0	-0.109	**-0.631***	**0.765***	-0.178	**0.909***	-0.192	0.081	**-0.425***	-0.092	**0.779***	0.187	-0.207	**-0.506***	**0.342***	-0.171	**0.957***	**1**		
C18:3n3	0.082	-0.011	-0.076	0.020	-0.085	0.023	-0.058	-0.008	0.209	0.066	**0.273***	-0.085	0.137	-0.118	0.017	-0.134	-0.052		
C20:0	**0.487***	0.116	**-0.312***	**0.884**	**-0.285***	**0.536***	**-0.854***	**-0.344***	**0.784***	**-0.609***	**-0.338***	**0.828***	0.039	**0.497***	**0.900***	**-0.240***	**-0.389***	**1**	
MUFA	-0.120	**-0.726***	**0.832***	-0.097	**0.649***	-0.146	0.038	**-0.444***	-0.192	**0.845***	**0.482***	-0.100	**-0.502***	**0.383***	-0.119	**0.653***	**0.664***	**-0.406***	**1**

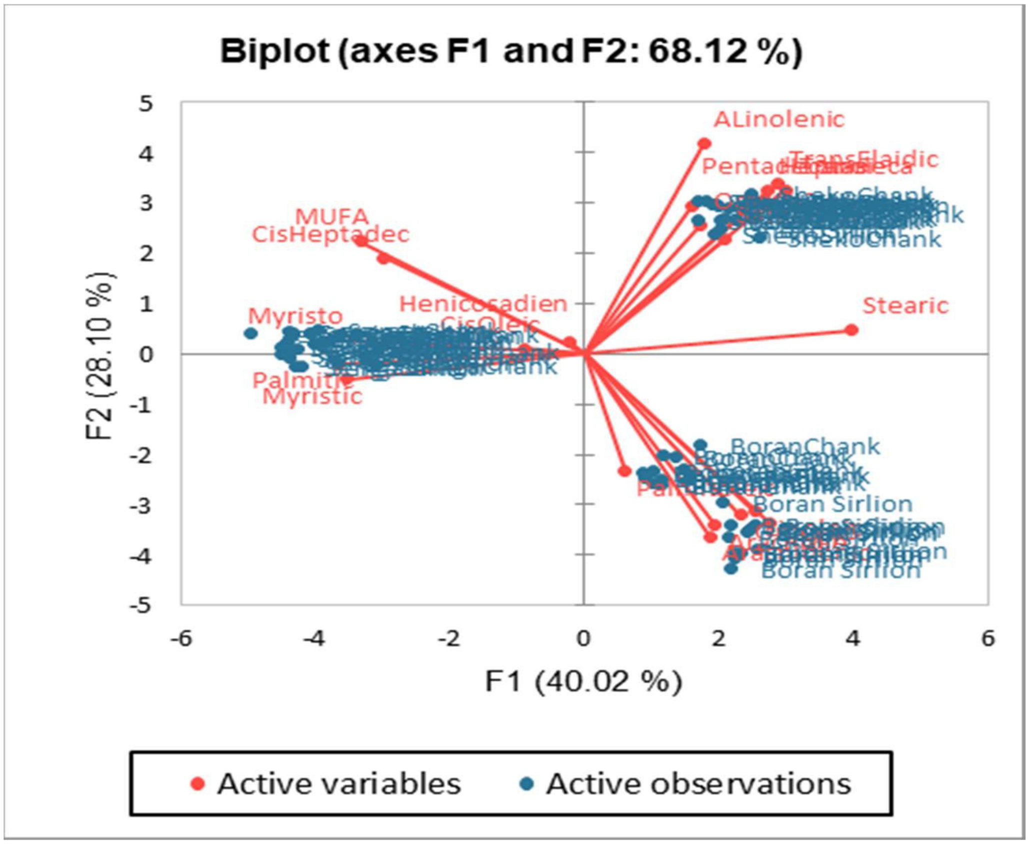

Figure 2. For the combined datasets of the proximate composition and color of meat cuts from theBoran, Senga, and Sheko breeds, a score plot of the principal component analysis (PCA) scores isused to visually display the results. Abbreviations: aw=water activity, L=, brightness, a=,red,b=yellow

The principal component (PC) analysis revealed that the first five PCs accounted for 100% of the variance among the two cuts of the three cattle types. The eigenvalues of PC1 to PC4 were 2.619, 1.644, 1.342, and 0.363, respectively, indicating their relative contributions to the total variance (Table 3). PC1 explained 37.409% of the variance in the dataset. Its loadings showed strong positive correlations with L*, a*, b*, and Fat%, suggesting that this PC represents the overall color and fat content characteristics of the beef samples. PC2 had high positive loadings for a_w, moisture%, and L*, a*, b*, while it had negative loadings for crude protein% and Fat%. This indicates that PC2 captures the relationship between water activity, moisture, and color, as well as the inverse relationship with protein and fat content. The top contributors to PC3 were crude protein%, moisture%, and a_w, suggesting that this PC reflects the protein and water-related properties of the beef samples. PC4 was primarily influenced by the L*, a*, b* color parameters, whereas PC5 was mainly associated with moisture content (Table 3).

The principal component loadings (Table 3) provided insights into the relationships and grouping patterns among the analyzed variables. The two-dimensional visualization of the loadings demonstrated the correlations between the variables and the positioning of the different cattle types and their cuts in the multivariate space.

Table 3. Principal component (PC) loadings for the significant cattle types and their cuts according to an Eigen analysis

Parameters	F1	F2	F3	F4	F5
moisture%	-0.625	0.143	0.635	0.008	0.402
Aw	-0.64	0.392	0.485	-0.147	-0.351
crude protein%	0.337	-0.501	0.742	-0.027	-0.101
Fat%	0.724	-0.535	0.232	-0.139	-0.072
L*	0.673	0.384	0.293	0.53	0.015
a*	0.429	0.787	0.095	-0.09	-0.13
b*	0.737	0.408	0.069	-0.404	0.214
Eigenvalue	2.619	1.644	1.342	0.363	0.201
Variability (%)	37.409	23.48	19.165	5.185	2.874
Cumulative %	37.409	60.888	80.053	92.289	100

Pearson's correlation coefficients between components of the proximate composition and color(L*, a*, b*) of meat

Table 4. Pearson's correlation between variables of proximate compositions and meat color of different cattle breeds and their meat cuts slices.

Cuttle cuts types	Moisture (%)	aw	Protein (%)	Fat (%)	L*	a*	b*
Moisture (%)	1						
aw	**0.606***	1					
Protein	0.127	-0.051	1				
Fat (%)	**-0.368**	**-0.502**	**0.614***	1			
L*	-0.186	-0.179	0.213	**0.277***	1		
a*	-0.100	0.050	-0.139	-0.036	**0.498***	1	
b*	**-0.314**	**-0.242**	0.085	**0.331***	**0.506***	**0.543***	1

*Values in bold differ from 0 with a significance difference level of alpha = 0.05.

In Quadrant 1, Figure 2, these variables are located in the lower right corner. Additionally, the second quadrant's area, represented by PC1 (37.31%), has a positive correlation with the color parameters (L*, a*, and b*). This quadrant includes cuts with the highest content of these color components (Figure 2), and the color parameter represented by Senga cattle (specifically sirloin cuts).

In principle component analysis (PCA), new axes known as principal components (PCs) are created by using the baseline data for crude protein, crude fat, water activity, moisture content, and color parameters L*, a*, and b* Table 2. These primary components, which are orthogonal to one another, show the most notable patterns of variation in the initial data. Table 2 displays the findings of the principal component analysis for each of the five main components. The results of the research show that the first principle component explains around 37.409% of the total variation, the first two principal components about 60.888%, and the first three main components about 80.053% of the total variation Table 2.

The first three PCs, with eigenvalues of 2.619, 1.644, and 1.342 in that order, explained 80% of the variance among the three species of cattle (Table 2). These figures represent significant contributions made by each PC to the overall variance. Crude protein, crude fat, and color L*, a*, and b* had high loadings on PC1, which explained 37.409% of the variance in the data set. Likewise, PC2 displayed top positive loadings for water activity (aw) and moisture levels.

Protein and moisture content did not significantly correlate, while there was a negative link between meat color and fat percentage and between protein and moisture content ($P<0.05$). Comparably, there was no association between protein content and color parameter L*. However, there was one between protein and color parameter a* that was negative. Conversely, there was a positive association ($P<0.05$) among protein and fat content. Additionally, no correlation was found between water activity and color parameter a*, and a negative association was observed among water activity and moisture content, fat, and protein. Likewise, a positive correlation ($P<0.05$) was observed among fat and color value, except for color parameter a*, which showed a negative association with fat. Furthermore, strong positive correlations ($P<0.05$) were found between meat color represented by L*, a*, and b* as shown in Table 4.

3.3. Fatty acid profiles

The percentage of intramuscular saturated fatty acids (SFAs) in sirloin and chuck slices of three different beef types Boran, Senga, and Sheko is shown in Table 5.

Each breed's total fatty acids were made up of about 60% SFAs, with Palmitic acid (C16:0), stearic acid (C18:0), and cis-oleic acid (C18:1n9c) accounting for more than 90% of the total saturated fatty acids. These results were in agreement with the results documented by Liu (2020) and (Kazala, 1999). Variations among breeds were observed in multiple fatty acids. In particular, the Senga cattle type exhibited significantly higher levels ($p<0.05$) of C16:0 in both the sirloin (29.64±0.13) and chuck cuts (31.60±0.17) compared to the Boran and Sheko breeds in both types of cuts(Acar et al,.2008). Conversely, C18:0 levels tended ($p<0.05$) to be higher in Sheko chuck (31.56±0.34) compared to the Boran and Sheko cuts of both sirloin and chuck (27.28±0.35, 26.41±0.35, 19.64±0.55, and 19.59±0.25, respectively). These findings align with the results reported by (Lisitsyn, 2017).

The presence of specific saturated fatty acids (SFAs) like C16:0 and C14:0 in meat is widely recognized to contribute to elevated levels of total cholesterol and low-density lipoprotein, increasing the threat of coronary heart illness (Barton, 2010). In contrast, the Senga breed demonstrated significantly higher levels ($p<0.05$) of heptadecanoic acid (C17:0) in both the chuck (2.13±0.63) and sirloin (1.57±0.26) cuts compared to the Boran breed, as well as higher levels ($p<0.05$) of myristic acid (C14:0) in the sirloin (5.34±0.18) and chuck (6.16±0.33) cuts compared to both Sheko and Boran breeds (4.47±0.21, 4.26±0.26, and 3.67±0.19, 4.45±0.21), as illustrated in the data Table 5. The result is in line with the study of (Dagne, 2021) In addition, Senga cattle tended to have lower ($p<0.05$) trans fatty acid in sirloin 1.52±0.23 and chuck 1.45±0.06 than Boran and sheko cattle in their both sirloin and chuck (2.07±0.02, 2.45±0.23 and4.36±0.18, 4.38±0.19) cuts of meat respectively, lower ($p<0.1$). Similarly, there was also high transelaidic acid (C18:1n9t) in Sheko cuts (sirloin and chuck) 4.32±0.11and 4.27±0.13 than in Boran and Senga (2.16±0.14, 2.30±0.12 and 1.68±0.3, 1.71±0.25) sirloin and chuck respectively (Tarricone, 2020).

Senga cattle type in sirloin 56.66±0.18 and chuck 61.21±0.06 constituted lower ($p<0.05$) total SFA than Boran and Sheko sirloin and chuck (60.08±0.02, 59.36±0.56 and 60.48±0.06, 66.65±0.19) respectively. These findings were similar with the study of Rennaa (Rennaa, 2019). Since SFA, particularly 12:0, 14:0, and 16:0, have historically been linked to higher levels of blood cholesterol and, as a result, with coronary heart disease (CHD) and cardiovascular disease (CVD), saturated fatty acid (SFA) is recognized as a significant predisposing factor (Pighin et al. 2016). Table 4 details the sirloin and chuck muscles' intramuscular unsaturated fatty acid (MUFA) content in the three breeds of cattle. In sirloin muscle slices, total MUFA ranged from 25.65% to 42.38%, while in chuck muscle cuts, it ranged from 29.20% to 37.49% (Table 5). These outcomes align with the findings of Pleadin et, al. (Pleadin, 2021). MUFA constituted the largest proportion of UFA, and the most plentiful MUFA was oleic acid (C18:1n9c). There was a significant difference in the amount of cisoleic acid (C18:1n9c) among different breeds. Table 5 for showed more detailed information. These findings align with a previous study by Manuela et al. (Renna et al,. 2019). One particular polyunsaturated fatty acid (PUFA) which is considered beneficial for human health is C18:3n3 (Frank, 2016). The observed trend of higher C18:3n3 levels in Sheko cattle are consistent with previous investigations that have reported significantly higher C18:3n3 content (Barton, 2007). For sirloin cut, C16:1 had relatively ($p<0.05$) to be higher (3.50 ± 0.08) in Senga cattle than in Boran and Sheko breed (1.08 ± 0.93 and 1.81 ± 0.13) respectively. These findings were consistent with the report of (Liul, 2020) showed that C16:1 of three different mussels had 0.91 ± 0.36, 1.33 ± 0.43 and 1.91 ± 0.40.

According to (Ekine-Dzivenu et al. 2017), PUFAs possess certain preventive properties against cardiovascular disease and can potentially delay the progression of atherosclerosis. As a result, there have been active efforts to enhance the PUFA composition in beef in order to meet the preferences of consumers. Differences in breed have been noticed in the average proportions of saturated fatty acids (SFA) to unsaturated fatty acids (UFA) and monounsaturated fatty acids (MUFA) to polyunsaturated fatty acids (PUFA) in various beef cuts. Specifically, Boran cattle exhibited a significantly lower ($p<0.05$) SFA/UFA ratio than Sheko cattle, but they had greater amounts of saturated fatty acids when matched to Senga cattle. In contrast to Senga and Sheko cattle, the average MUFA content of Boran cattle was significantly lower ($p< 0.05$) than that of Senga and Sheko cattle, whereas the average PUFA content of Boran cattle was significantly greater (see Table 5). A high SFA/UFA ratio is widely established to be strongly associated with a number of pathological disorders in humans, including an elevated risk of vascular and coronary illnesses (Philip, 2003).

Principal component analysis (PCA) was utilized to analyze a combination of fatty acid profile, proximate composition, and color (L*, a*, b*) data of meat from three different types of cattle (Figures 3). When examining the fatty acid profile, the first and second principal constituents (PCs) accounted for 68.12% of the total variation, with PC1 explaining 40.02% and PC2 explaining 28.10% (Figure 3). Along the PC1 axis, three distinct groups were observed in the fatty acid profile, with Sheko cattle types being clearly separated from the other two types of cattle. In the first quadrat, Boran cattle contained linoleic acid (C18:2n6c), palmitoleic (C16:1), arachidic acid (C20:0), arachdonic acid (C20:4n6), and omega-6 PUFA. Alinolenic acid (C18:3n3), pentadecanoic acid (C15:0), omega-3 fatty acids, heptadecanoic acid (C17:0), and trans eliadic acid (C18:1n9t) were all present in Senga type, in contrast.

The research findings demonstrate that the first principal component explains approximately 40.020% of the total variation observed, the first two principal components collectively account for around 68.118% of the variation, and the first three major components combined explain approximately 76.001% of the overall variation (Table 6).

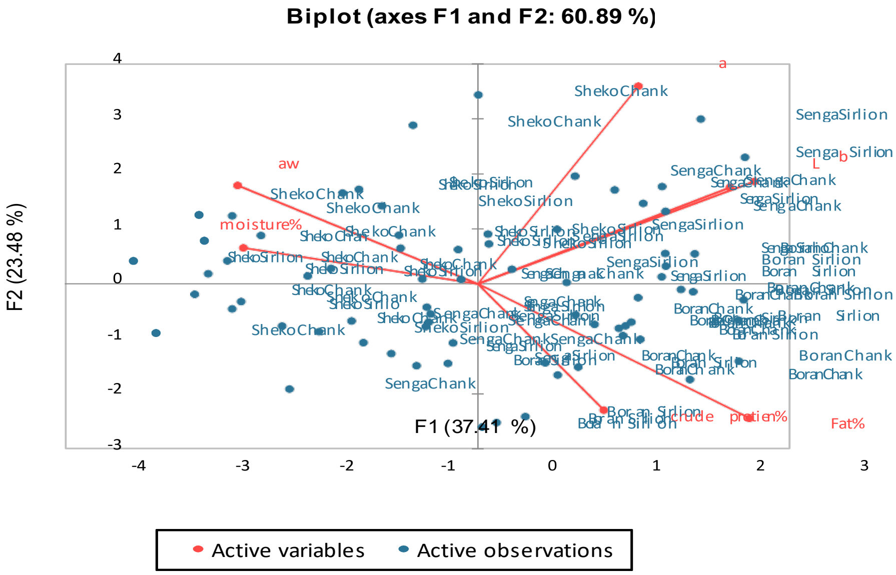

Figure 3. Presents a score plot obtained from a principal component analysis (PCA) using a comprehensive dataset that combines the fatty acid content of meat cuts from the Boran, Senga, and Sheko cattle breeds. The plot visually represents the PCA scores. The abbreviations used in the plot are as follows: saturated fatty acids = SFA, monounsaturated fatty acids = MUFA, polyunsaturated fatty acids = PUFA, and linoleic acid = LA

The first five PCs had eigenvalues of 8.404, 5.901, 1.655, 1.254, and 1.127 in that sequence, and they accounted 87.3% of the variation across the three species of cattle (Table 6). These figures represent significant contributions made by each PC to the overall variance. PC1 explained 40.020% of the variance in the data set, and its loadings indicated that it has high contributions from Myristoleic acid (C14:1;-0.318), Pentadecanoic acid (C15:0; -0.318,), Heptadecanoic acid (C17:0; 0.051, Stearic acid (C18:0; -0.251), cisOleic acid (C18:1n9c; -0.074), Heneicosanoic acid (C21:0; -0.018). Myristic acid (C14:0; - 0.265), palmitoleic acid (C16:1; 0.598), and Henicosadienoic acid (C21:0; 0.314) were the main donors to PC3. Contrarily, cis-oleic acid (C18:1n9c; 0.537), Henicosadienoic acid (C21:0; 0.666), pentadecanoic acid

(C15:0; 0.545), linoleic acid (C18:2n6c; 0.304), and arachidonic acid (C20:4n6; 0.389) were the major influences on PC4 and PC5, respectively.

Table 6. The loadings of the significant principal components (PCs) for the meat cuts of variouscattle types are subjected to Eigen analysis.

	F1	F2	F3	F4	F5	F6	F7
Eigenvalue	8.404	5.901	1.655	1.254	1.127	0.814	0.571
Variability (%)	40.020	28.098	7.883	5.972	5.369	3.877	2.720
Cumulative %	40.020	68.118	76.001	81.974	87.342	91.220	93.939

3.4. Correlation of PCs with fatty acid composition parameters

The principal component loadings (Tables 7) showed how much the examined variables affected how the kinds were grouped as well as how strongly they were related to one another. The loading projections showed the location of the variables, the cuts in the two-dimensional plot, and their related correlations for each of the three species of cattle. Positive correlation exists between variables that are both near and far from the plot origin. In the cattle kinds, the results, for instance, reveal a favorable link between MUFA and Cis- Heptadec acid (C17:1) as well as between Palmitic acid (C16:0) and Myristoleic acid (C14:1) (Table 8). The PC scores were also computed for a correlation analysis with parameters for fatty acid composition. Table 8 displays the factor score coefficients that were utilized to determine the scores for each PC. After that, Pearson's correlation analysis was done to find the associations among PC and the parameters of the fatty acids profiles. In the current research, significant ($p<0.05$) positive correlations were obtained between saturated fatty acid and Omega6 fatty acid, Myristic C14:0), TransElaidic(C18:1n9t), cisOleic(C18:1n9c) and Arachidic (C20:0) ($r=0.662$, 0.529, 0.572, 0.658 and 0.487) which, in turn, were negatively correlated with PUFA, Myristoleic acid (C14:1), Pentadecanoic acid (C15:0) and Heptadeca acid (C17:0) (Table 8).

4.Conclusion

The nutritional value and health impact of beef are influenced by its fatty acid content and composition, which are determined by factors such as genetics, diet, and environmental conditions. Variations in fat levels can be found in different beef cuts, affecting both nutritional value and consumer health. In a recent study, we examined the fatty acid composition of sirloin and chuck cuts, and found that the composition is significantly influenced by the breeds of cattle. Specifically, the levels of saturated, monounsaturated, and polyunsaturated fatty acids differ among Boran, Sheko, and Senga cattle. There were also notable differences in the overall composition and fatty acid content between the three breeds and the beef cuts. Several factors, including feed, sex, origin, and genetics, likely contributed to the variations in composition and fatty acid profiles among the cattle breeds studied. The study further revealed that animals grazing on pasture until slaughter had higher fat content and increased levels of n-3 polyunsaturated fatty acids compared to those fed other types of feed. However, adult cattle had lower concentrations of polyunsaturated fatty acids than young cattle, despite benefiting from pasture. To enhance human diets and overall health, it is advisable to select beef cuts with a healthy balance of fatty acids. This data can inform consumer guidelines, influence dietary choices, and assist producers in tailoring beef cuts to meet consumer demands for specific fatty acid profiles. Additionally, resource mapping helps identify knowledge gaps and potential research areas, contributing to our understanding of beef's fatty acid profiles and their impact on human health.

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