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Nutritional Quality of Meat from Cattle Breed in Livestock Production Area of Cameroon

Ronald Vougat Ngom[1*], Vincent de Paul Ndzana[2], Dangwang Bohounbele[3], Veronique Houli[3], Boubakary Oumara[4], Andre Zoli Pagnah[1]

[1]Department of Animal Production, School of Veterinary Medicine and Sciences, University of Ngaoundéré, Ngaoundéré, Cameroon
[2]Comité International de la Croix-Rouge, Antenne de Maroua, Maroua, Cameroun
[3]Far North Regional Delegation of Livestock, Fisheries and Animal Industries, Maroua, Cameroon
[4]Centre d'Appui à la recherche et au Pastoralisme, Maroua, Cameroun
Email: *romsonbey@yahoo.fr

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Abstract

In Cameroon, foods of animal origin are an important part of the population's diet. To improve meat consumption and assure its safety, the Government plan a project for the industrialization of cattle and pig industries by building a slaughter chain, cold stores and acquiring of vehicles and trucks for the transport of meat from livestock production areas to other parts of the country. Maroua city in the Far North Region has been selected to host a modern mixed slaughterhouse with a slaughter capacity of 150 cattle/day. To assess the impact of this project, it is important to define a baseline in term of beef quality prior to the implementation of such a project. Therefore, this study aimed to evaluate the nutritional quality of beef in Maroua (as a reference for livestock production area in Cameroon) in relation to demographics of cattle (production system, type of production, age, breed, body condition score [BCS], and sex). In 2014, data on demographics of 202 cattle, randomly selected in the traditional slaughterhouses of Maroua were collected. At the end of the slaughter chain, approximately 250 g of thigh were sampled from each animal selected. However, 76 randomly selected thigh meat samples were suggested for chemical composition analysis by using standard methods. Results revealed that dry matter (26.30% - 29.88% of fresh matter), ash (0.92% - 1.09% of fresh matter), total fat (10.12 - 19.58 of fresh matter) and protein (8.60% - 27.59% of fresh matter) content of beef were between the acceptable ranges for table meats. The total protein content found was affected by the BCS, the age at slaughter, the breed and the sex of the animal. In addition, as expected, the total fat content increased with the BCS and varied with the age at slaughter and the type of production. Since the fat content decreased with age and varied with the type of production, it would be interesting for further

study, to determine the fatty acids profile of meat from fattening cattle of less than 8 years old.

Keywords

Nutritional Quality, Chemical Composition, Beef, Cattle, Cameroon

1. Introduction

In developing countries, demand for animal products is soaring and over the coming years, is likely to increase further because of demographic growth and rising household purchasing power [1]. Consumers in these countries are becoming more cognizant of health-related hazards in the animal products they buy. Their awareness and desires for better quality and safer products are increasing [2]. In Cameroon, where foods of animal origin are an important part of the population's diet [3] the government in its vision of the development by 2035, set the objective of improvement of meat consumption and meat quality [4]. Indeed, meat ranks among one of the most significant and nutritious food products, which is quite important in maintaining a healthy and balanced diet [5]. The nutritional value of meat is an increasingly important factor influencing consumer preferences for meat. Awareness of nutritional composition of the food stuffs has become quite significant in having a balanced meal, which in-turn ensures the health status of individuals [6]. The nutrients are the elements which include both the macro- and micro-nutrients. Macro-nutrients which include proteins, fats and carbohydrates are those that are required by the human body in large amounts [7].

Among foods of animal origin, meat represents the most important source of animal proteins in the diet of population in Cameroon [8]. For this reason and given that in the era of globalization, ensuring the safety and wholesomeness of food is more than ever a key issue for all countries [9], the Ministry of Livestock, Fisheries and Animal Industries (MINEPIA) of Cameroon shelters a project on the three-year emergency government plan in 2014. This project aims the industrialization of cattle and pig industries by building a slaughter chain, cold stores and acquiring of vehicles and trucks for the transport of meat products. The project will then ensure the food safety of foodstuffs of animal origin through the establishment of a slaughter unit in production areas to improve the chain of values of livestock products and to ensure consumers with food of good quality. Indeed, despite its prominent place in the Central Africa subregion with about 6 million cattle [10], Cameroon has only two modern slaughterhouses located in the biggest cities of the country (Yaoundé and Douala). All this is also in line with the ambition of Cameroon to start exporting beef to surrounding countries. Cattle production was in first line in this project because, according to the results of the most recent Cameroonian Household Budget Survey (HBS/ECAM II),

beef (8.61 g/day/average individual) is the second meat consumed in the country after poultry (9.81 g cooked/day) [11]. In certain part of the country like Maroua, the daily consumption of beef is estimated at 133 g/per capita, which is 10 times higher than the worldwide average meat consumption [12] [13].

Because they have most of the cattle population, the three Northern regions of Cameroon (Adamawa, North and Far-North) are at the center of this project. Indeed, more than 80% of the cattle population of Cameroon are found in these regions (MINEPIA, 2019 unpublished). The city of Maroua is well chosen to host a modern mixed slaughterhouse with a capacity of 150 cattle and 100 ruminants per day and a cold storage of 400 m^3. Indeed, Maroua is the capital city of the Far North Region. The region with the second largest cattle herd in the country and the first highest small ruminants' population (MINEPIA, 2019 unpublished).

To assess the impact of the project of MINEPIA in few years, it is important to define a baseline in term of meat quality prior to implementation of such a project. Unfortunately, to the best of our knowledge, no study has highlighted the nutritional quality of beef in the cattle production area of Cameroon. Therefore, this study aimed to evaluate the nutritional quality of cattle meat consumed in Maroua (as a reference for cattle production area in Cameroon) in relation with demographics of cattle (production system, type of production, slaughter age, breed, body condition score, and sex).

2. Materials and Methods

2.1. Study Area

This study was carried out in Maroua and Godola in the Far North region of Cameroon. The city of Maroua, located between latitude 10˚ to 13˚ North of the Equator and longitude 13˚ to 15˚ East of the Greenwich meridian, is the biggest town in the Diamare Division of the Far North Region of Cameroon. Data were collected in the five traditional slaughterhouses (Municipal, Makabaye, Meskine, Kongola and Salak) of Maroua city. Godola slaughterhouse was also chosen because the most quantity of beef from this slaughterhouse is sold in Maroua (Report of Far North Regional Delegation of MINEPIA 2020-unpublished).

2.2. Sampling Strategy for Cattle Selection and Beef Sampling

Two hundred and two cattle were selected as already described in our previous study [14]. The demographics of cattle were collected (age, sex, body condition scoring, live weight, breed, etc.) according to the methods described by Nicholson and Butterworth [15], FAO [16], Pater [17], and Trudi *et al.* [18]. The *ante mortem* and *post mortem* examination results performed by veterinarians were also collected.

Other parameters such as the distinctive signs of the animal, coat color, the picture of the animal and cattle owner's name were recorded. Information re-

garding the origin of the animal (place of purchase, origin of the animal, production system, type of farming in which the animal was bred during the last month) and the purchase price were collected from the cattle owner's. The information which we could not get from cattle owners were collected after the work at the slaughterhouse. For cattle purchased out of town or in the livestock markets, we traced their origins after given access to the registers of the livestock market of Bogo, Moulvoudaye, Kongola and Maroua I (Far North Region). This part was facilitated by interviewing the conveyors of animals (people who conduct animals from livestock market to the slaughterhouses). During these interviews, the pictures of cattle sampled were presented to them to facilitate the identification of animals that they supposed to know. This work thus allowed to triangulate the information of the cattle sampled at the slaughterhouses with their source.

At the end of slaughter chain in slaughterhouse, approximately 250 g of thigh were sampled from each animal selected. The samples collected were directly wrapped in aluminum foil, then put in pre-identified bag, closed and placed in a cooler where the temperature was kept between 0 and 4˚C [19]. Collected samples were brought immediately to the National Veterinary Laboratory (LANAVET) in Garoua where they were stored in a refrigerator (−20˚C) till analysis. Due to the financial limitation, 76 samples of thigh were randomly sampling from the 202 that were collected.

2.3. Evaluation of the Nutritional Composition of Beef

The determination of the chemical composition of beef collected were performed at the Institute of Medical Researches and Medicinal Plants Studies (IMPM) in Yaounde. It was done according to the standard methods of AOAC [20] [21] and Bergeret [22] respectively for total protein, ash and total fat content. Details of the methods used can be found in supplementary material.

2.4. Statistical Analysis

One-way analysis of variance followed by Duncan's multiple range test or Fisher test was performed using Statgraphics 5.0. (Windows, www. statgraphics.com) to compare the data collected in the slaughterhouse. The survey data were analyzed with IBM® SPSS® Statistics version 20.0 (http://www.ibm.com/support) for descriptive statistics and the chi-squared test was applied to compare the percentage. The effect of the production system and the type of production on chemical composition of beef was evaluated by doing the Mann Whitney test using GraphPad Prism version 5.00 for Windows (GraphPad Software, San Diego California USA, www.graphpad.com.). One way ANOVA followed by Tukey's multiple comparison test was performed using the same software to analyze the effect of age, sex, breed and BCS of cattle on the ash, dry matter, total fat and protein content of beef. A probability level of 0.05 or less was accepted as significant.

3. Results

3.1. Slaughter Procedures

In each slaughterhouses, the slaughter procedure (traditional method) is the same. The animal is brought to the slaughterhouse by the assistant-butcher using a rope. Once the animal's four legs are fastened with a rope, the Malum slaughters the animal with a knife and rinses it immediately in a bucket containing water. Water is sometimes filled in the esophagus of the animal by the assistant-butcher to increase the size of the lungs. Once the blood has stopped flowing, the legs are spreard and the animal dressed. During this phase, the assistant-butchers are divided into four groups, one who divides the animal into two and then into four parts if necessary, another who is responsible for washing the divided carcass, another in charge of recovering the cleaned viscera and another concerned with the actual dressing. All the carcass is weighed before the veterinary service do the *post mortem* examination. After this examination, meat is transported by the carriers to the butcher shops.

3.2. Demographics of Cattle Sampled, and Meat Sampled

Table 1 shows the summary of the demographics of cattle slaughtered in Maroua and meat analyzed. The information in this table is a complement of data provide in our previous publication [14].

Table 1. Demographics of cattle slaughtered in Maroua

Variables	Number of cattle samples (Percentage) N = 202	Number of samples of beef for nutritional analysis (Percentage) N = 76
Age at slaughter (years)		
<8	37 (18.32%)	11 (14.47%)
[8 - 14]	152 (75.25%)	59 (77.63%)
>14	8 (3.96%)	3 (3.95%)
ND	5 (2.47)	3 (3.95%)
Category		
Young bull	2 (0.99%)	0
Bull	11 (5.44%)	4 (5.26%)
Heifer	1 (0.49%)	1 (1.32%)
Cow	184 (91.10%)	68 (89.47%)
Beef	4 (1.98%)	3 (3.95%)
Sex		
Female	185 (91.58%)	69 (90.79%)
Male	13 (6.44%)	4 (5.26%)
Castrated	4 (1.98%)	3 (3.95%)

Continued

Body condition scoring		
Score 1	38 (18.81%)	12 (15.79%)
Score 2	44 (21.78%)	19 (25%)
Score 3	49 (24.26%)	20 (26.31%)
Score 4	46 (22.77%)	15 (19.74%)
Score 5	18 (8.91%)	7 (9.21%)
Score 6	5 (2.47%)	3 (3.95%)
Score 8	1 (0.49%)	0
ND	1 (0.49%)	0
Breed		
Red Fulani	96 (47.52%)	30 (39.47%)
White Fulani	65 (32.17%)	27 (35.53%)
Arabe Shuwa	8 (3.96%)	3 (3.95%)
Kapsiki	9 (4.45%)	4 (5.26%)
Goudali	13 (6.43%)	4 (5.26%)
Toupouri	3 (1.48%)	3 (3.95%)
Peul	1 (0.49%)	1 (1.32%)
ND	7 (3.46%)	5 (6.58%)
Type of production		
Fattening	47 (22.89%)	18 (23.68%)
Mixed (milk and meat)	125 (62.19%)	35 (46.05%)
ND	23 (14.92%)	23 (30.26%)
Production system		
Sedentary	62 (30.69%)	22 (28.95%)
Transhumant	16 (7.92%)	6 (6.89%)
ND	124 (61.39%)	48 (63.15%)
***Ante mortem* examination**		
Sick	26 (12.87%)	9 (11.84%)
Healthy	173 (85.64%)	64 (84.21%)
ND	3 (1.48%)	3 (3.95%)
***Post mortem* examination**		
Sick	31 (15.42%)	12 (15.79%)
Healthy	170 (84.58%)	63 (82.89%)
ND	1 (0.50%)	1 (1.32%)

ND: No determined; score 1: emaciated, score 2: very thin, score 3: thin, score 4: moderately thin, score 5: moderate, score 6: moderately fleshy, score 7: fleshy, score 8: very fleshy.

3.3. Quality of Beef Sold in Maroua

This section presents the effect of various animal-related factors on the ash, total lipid, total protein and dry matter content of beef. Figure 1 presents the chemical composition of the beef consumed in the city of Maroua. The beef analysed contains 28.11% ± 2.12% of dry matter, 20.19% ± 4.69% of total protein, 13.17% ± 2.81% of total fat and 1.00% ± 0.15% of ash (n = 77).

3.4. Effect of Production System and Type of Production on Nutritional Quality of Beef

Table 2 summarizes the results of the effect of the production system and type of production on nutritional quality of beef. It appears that the proportion of dry matter, ash, total protein and total fat do not vary according to the production system. However, ash and total fat contents were significantly ($P < 0.05$ and $P < 0.001$, respectively) higher in beef from fattening cattle (1.09% ± 0.12% and 14.86% ± 2.77%, respectively) compared to others (0.98% ± 0.16% and 11.73% ± 1.12%, respectively).

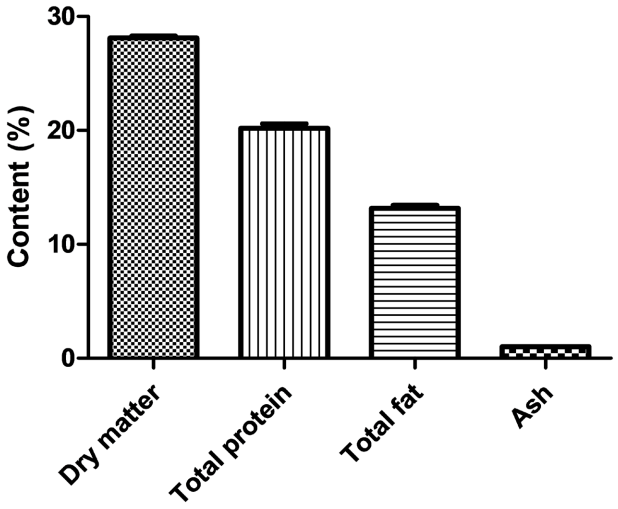

Figure 1. Chemical composition of beef (n = 76).

Table 2. Effect of breeding system and type of production on nutritional parameters cattle meat.

Variable (% of fresh matter)	Production system		Type of production		Significance	
	Transhumance (n = 6)	Sedentary (n = 22)	Fattening Cattle (n = 18)	Mixed (n = 35)	PS	TP
Dry matter	27.85 ± 1.66[a]	28.25 ± 2.91[a]	28.67 ± 1.38[a]	27.60 ± 2.42[a]	NS	NS
Ash	0.98 ± 0.20[a]	0.96 ± 0.24[a]	1.09 ± 0.12[a]	0.98 ± 0.16[b]	NS	*
Total fat	12.20 ± 1.41[a]	13.82 ± 2.8[a]	14.86 ± 2.77[a]	11.73 ± 1.12[b]	NS	***
Total protein	25.46 ± 2.15[a]	23.13 ± 2.41[a]	23.97 ± 2.85[a]	22.69 ± 1.10[a]	NS	NS

Values are means ± SEM of three repetitions; n: number of animals; Values with different letters of the French alphabet in the same row are significantly different; NS: Not significant. *P < 0.05; ***P < 0.001; PS: Production system; TP: Type of production.

3.5. Effect of Slaughter Age on Nutritional Quality of Beef

Table 3 shows the variation of the ash, dry matter, total fat and total protein content of beef according to the age of the animal. It came out that only total protein and total fat contents were significantly ($P < 0.001$) affected by the age of the animal at slaughter. The meat of cattle under 8 years had a significantly high total fat content (19.58% ± 5.10%) than that of the animals of the other two groups ([8 - 14] and >14). In contrary, the total protein content of meat from animals younger than 8 years (20.07% ± 4.98%) and for animals aged between 8 and 14 years (20.49% ± 4.16%) were statistically higher than that of meat of cattle with more than 14 years of age (8.60% ± 1.10%).

3.6. Effect of Breed on Nutritional Quality of Beef

From Table 4 which shows the results of the effect of breed on beef quality, it appears that only the total protein content was significantly ($P < 0.001$) affected by this factor. Indeed, total protein content was significantly higher in the Goudali compared to Kapsiki ($P < 0.05$), *Red Fulani* ($P < 0.05$) and *White Fulani* ($P < 0.001$). Similarly, the total protein content of the meat from *White Fulani* (18.05% ± 2.94%), which proved to be similar to that of Kapsiki breed (19.71% ± 1 87%), was significantly lower compared to those of meat from other breeds studied.

Table 3. Variation of nutritional parameters of meat according to the slaughter age of animal.

Variable (% of fresh matter)	Age (years)			Significance
	<8 (n = 11)	[8; 14] (n = 59)	>14 (n = 3)	
Dry matter	28.18 ± 2.90^{a}	28.49 ± 3.09^{a}	27.57 ± 3.63^{a}	NS
Ash	0.97 ± 0.18^{a}	1.037 ± 0.172^{a}	0.96 ± 0.27^{a}	NS
Total fat	19.58 ± 5.10^{a}	14.13 ± 3.17^{b}	10.12 ± 1.28^{b}	***
Total protein	20.07 ± 4.98^{a}	20.49 ± 4.16^{a}	8.60 ± 1.10^{b}	***

Values are means ± SEM of three repetitions; n: number of animals; Values with different letters of the French alphabet in the same row are significantly different; NS: Not significant; ***$P < 0.001$.

Table 4. Variation of nutritional parameters of meat according to the breed of the cattle.

Variable (% of fresh matter)	Breed						Significance
	Arabe Shuwa (n = 3)	Goudali (n = 4)	Kapsiki (n = 4)	Red Fulani (n = 30)	Toupouri (n = 3)	Red Fulani (n = 27)	
Dry matter	27.67 ± 0.64^{a}	28.07 ± 1.98^{a}	27.41 ± 1.09^{a}	28.33 ± 2.26^{a}	29.88 ± 0.82^{a}	28.04 ± 2.16^{a}	NS
Ash	0.98 ± 0.04^{a}	0.99 ± 0.19^{a}	0.92 ± 0.10^{a}	0.99 ± 0.23^{a}	1.03 ± 0.11^{a}	1.01 ± 0.33^{a}	NS
Total fat	10.92 ± 0.42^{a}	15.78 ± 2.81^{a}	11.26 ± 1.13^{a}	13.59 ± 3.14^{a}	10.58 ± 0.43^{a}	12.74 ± 2.10^{a}	NS
Total protein	27.30 ± 0.28^{abc}	25.81 ± 1.77^{b}	19.71 ± 1.87^{acd}	20.56 ± 4.59^{c}	27.59 ± 0.10^{cb}	18.05 ± 2.94^{d}	***

Values are means ± SEM of three repetitions; n: number of animals; Values with different letters of the French alphabet in the same row are significantly different; NS: Not significant. ***$P < 0.001$.

3.7. Effect of Sex on the Nutritional Quality of Beef

From Table 5 which shows the variation of dry matter, ash, total protein and total fat contents of beef according to the sex of the animal, it appears that only the total protein content was significantly influenced by this factor. Indeed, the total protein content of the meat from castrated males (10.37% ± 0.57%) was significantly lower ($P < 0.001$) than that of females (20.36% ± 4.40%) and entire males (23.80% ± 3.90%).

3.8. Variation of the Nutritional Quality of Beef According to the BCS of the Cattle Slaughtered

The nutritional quality of beef according to the BCS of the cattle slaughtered is given in Table 6. Only the protein ($P < 0.05$) and fat contents ($P < 0.01$) of meat were significantly varied with the BCS. The total fat content of the meat of emaciated cattle (11.38% ± 1.45%) was significantly lower compared to that of animals having a normal BCS (16.76% ± 2.37%). In contrary, the total protein content of the meat of those cattle (17.86% ± 0.80%) was significantly lower compared to the relatively thin cattle (23.55% ± 3.21%).

Table 5. Variation of nutritional parameters of meat according to the sex of the animal slaughter.

Variable (% of fresh matter)	Sex			Significance
	Female (n = 69)	Entire male (n = 4)	Castrated male (n = 3)	
Dry matter	29.02 ± 4.67^{a}	26.30 ± 0.40^{a}	26.81 ± 0.09^{a}	NS
Ash	1.00 ± 0.25^{a}	0.94 ± 0.12^{a}	1.075 ± 0.05^{a}	NS
Total fat	13.87 ± 3.75^{a}	14.08 ± 6.72^{a}	12.13 ± 0.67^{a}	NS
Total protein	20.36 ± 4.40^{a}	23.80 ± 3.90^{a}	10.37 ± 0.57^{b}	***

Values are means ± SEM of three repetitions; n: number of animals; Values with different letters of the French alphabet in the same row are significantly different; NS: Not significant. ***$P < 0.001$.

Table 6. Variation of nutritional parameters of meat according to the BCS of the animal.

Variable (% of fresh matter)	Body condition score						Significance
	Score 1 (n = 12)	Score 2 (n = 19)	Score 3 (n = 20)	Score 4 (n = 15)	Score 5 (n = 7)	Score 6 (n = 3)	
Dry matter	27.99 ± 2.38^{a}	29.42 ± 6.97^{a}	29.35 ± 4.85^{a}	28.23 ± 2.12^{a}	28.30 ± 1.59^{a}	28.97 ± 0.46^{a}	NS
Ash	1.02 ± 0.15^{a}	0.95 ± 0.15^{a}	1.02 ± 0.42^{a}	0.95 ± 0.19^{a}	1.06 ± 0.20^{a}	0.95 ± 0.08^{a}	NS
Total fat	11.38 ± 1.45^{b}	14.58 ± 4.01^{ab}	13.28 ± 4.08^{ab}	15.85 ± 4.16^{ab}	14.99 ± 1.86^{ab}	16.76 ± 2.37^{a}	**
Total protein	21.06 ± 3.79^{ab}	21.64 ± 3.07^{ab}	23.55 ± 3.21^{a}	20.84 ± 4.02^{ab}	22.99 ± 4.22^{ab}	17.86 ± 0.80^{b}	*

Values are means ± SEM of three repetitions; n: number of animals; Values with different letters of the French alphabet in the same row are significantly different; score 1: emaciated, score 2: very thin, score 3: thin, score 4: moderately thin, score 5: moderate, score 6: moderately fleshy; NS: Not significant. *$P < 0.05$. **$P < 0.01$.

4. Discussion

The majority of cattle sampled were over 8 years old. This is explained by the fact that the majority of these animals were females. Indeed according to MINEPIA Act 1976, the age for cattle slaughtering is 8 years and 4 years for female and male respectively. This is also why 78.33% of cows in the sample had more than 8 years. However, 21.67% of females and 23.08% of males selected in this study were less than 8 and 4 years respectively. This highlights the lightness with which the veterinarians do their job. Indeed in slaughterhouses where the study took place, *ante-mortem* examination are non-existent, exposing consumers to various risks [23]. The *ante-mortem* examination of animals is of utmost important from the standpoint of veterinary public health because it is the first step in the detection of any signs of disease, distress, injuries, etc., helps to make the appropriate decision before the slaughter of animals. It must be done correctly and consistently by veterinarians according to the law, for a good quality meat. Improper examination may lead to the unhealthy meat for human consumption. This includes dead animals, diseased meat, and fetuses [24]. This lack of seriousness had also been highlighted in some slaughterhouses in Nigeria [25]. Hence the fact that OIE and several studies have highlighted the very important role of veterinary services in the conservation of the food safety [9] [26].

The BCS of animals sampled varies between emaciated note (score 1) and very fleshy (score 8) with a majority being thin (score 3). This finding is explained by the fact that data were collected in the late dry-early rainy season, a period corresponds when most area are degraded and there is not enough fresh pasture. This distribution differs from that observed by Djaowe *et al.* [27] in their study on the comparison of pastoral production systems of anthropogenic plain of Lake Maga and natural floodplain of Waza-Logon in the Far-North Region of Cameroon. Indeed the data collected in May (time when we collected our data) by these authors show that the BCS of cattle ranged from very thin condition (score 2) to moderate (score 5) with the majorities at the very thin state (score 2). This difference could be attributed to the fact that some of the cattle in this study come from fattening. In fact 22.89% of them were fattened before slaughtering.

The results of *ante* and *post mortem* examination revealed that the majority of animals are free of disease. This could be justified by the fact that the animals have received treatment sometime before slaughter. Indeed the period we collected the samples corresponds to that in which the majority of farmers in the study area treat their livestock [28]. This observation is similar to that made by Adjelakara [29] in the slaughterhouses of Douala-Bonandale. The agreement of the results could be explained by the fact that the majority of cattle slaughtered in the southern Cameroon comes from the three northern regions [30]. Similarly research done by Fonteh *et al.* [31] whose objective was to highlight the general situation of bovine animals slaughtered in Cameroon emphasized the helminthic infections and tuberculosis as the most recurrent diseases.

The survey results have shown that most cattle (62.19% or 88) came from extensive production system (mixed). Among cattle which the production system where identified (78 of 202), 79.49% were from sedentary farming. This observation is consistent with the distribution of production systems and production methods made by the MINEPIA [32]. The fact that 22.89% of the sampled animals came from fattening, underline the increasingly importance given by the butchers of the study area to this type of farming. Indeed Blama *et al.* [33] during their work in the Far North region of Cameroon already mentioned it.

The analysis of the nutritional composition of beef showed that it has an acceptable composition because the dry matter, ash, total protein and total fat contents are within the recommended range for beef [34] [35]. Indeed, the chemical composition of beef is variable [36] [37] [38].

The ash and total fat contents were significantly influenced by the type of production. The highest values were recorded on the beef from the fattening cattle. This difference is surely due to the rich diet that these animals received. During fattening, feed is supplied to the trough and concentrates (cereals, roots and tubers, agro-industrial by-products, etc.) play an important role [39]. Several studies have also shown that the type of feed has an impact on the quality of beef [40] [41].

Chemical composition of beef did not significantly vary according to the production system. We suggest this is in part because data in this study were collected at the end of the dry season. During this period, because of the scarcity of pastures, transhumant are sometimes constrained to supplement the feeding of their animals before selling them, to increase their marketable values. These results are similar to those of Fonteh *et al.* [31]. Their study demonstrated that dry matter, ash, fat, protein content in beef from ranching system (sedentary system) were not significantly different from those of beef obtained from transhumant cattle. However, the variations between the mean values of both studies could be attributed to the difference of the two agro-ecological zones and cattle breeds studied. Fonteh *et al.*'s [31] research took place in the Western Highlands of Cameroon area with a nine month of rainy season (rainfall between 1500 et 2000 mm) and an average temperature of 19˚C [42] which promotes good pastures and fertile soil. In this study area the production potential of the pasturelands is limited due the climate (low and irregular precipitations) and low fertility of the soil [43] [44].

As expected, the total protein and fat content of meat were significantly affected by the BCS of cattle. Indeed BCS is a simple and repeatable system used to evaluate body fat stores and estimate cumulative energy balance through visual or tactile inspection [45]. The results show that dry matter, ash and total fat content were not affected by breed. In contrary, total protein varied according to this factor. The lower value of the total protein was found from *White Fulani*, *Kapsiki and Red Fulani*. This low influence of breed on meat quality may be due to the environmental effect and including parameters such as the degree of hybridization. Indeed, the crossing between breed can increase the quality of the meat [46]. This

result is similar to those obtained by Waritthitham *et al.* [34] and Xie *et al.* [47].

5. Conclusion

The objective of this study was to evaluate the nutritional quality of beef from cattle slaughtered in a livestock production area of Cameroon (Maroua in the Far North Region) as a baseline for an important MINEPIA's project which aims to improve beef quality consumed in Cameroon. The findings of this study, despite the reduced number of samples analyzed, show that the proportion of dry matter, ash, total fat and total protein content of beef were between the acceptable ranges for table meats. They also reveal that the total protein content is affected by the BCS, the age at slaughter, the breed and the sex of the animal. In addition, as expected, the total fat content is affected by BCS. This parameter also varied the age at slaughter and the type of production. Since the fat content decreased with age and varied with the type of production, it would be interesting for further study, to determine the fatty acids profile of meat from fattening cattle less than 8 years old.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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Additional File

Determination of the ash content by incineration in furnace

The ash content was determined according to AOAC (1984) [21] method. An empty crucible has been cleaned, oven dried and weighed (P_1). A mass (P_0) of the meat sample was placed in the crucible and the whole was placed in a furnace at 550˚C for 24 h. From the furnace, the crucible containing the ash was allowed to cool in a desiccator (P_2O_5) and was weighted (P_2) after cooling. Three replicates were performed for each sample.

The ash content is determined using the following formula:

$$\text{Ash content} = \frac{P_2 - P_1}{P_0} \times 100 \left(\frac{\text{g}}{100} \text{ g of dry matter} \right)$$

Determination of total fat content: hot extraction in soxhlet reflux

The total fat content of our samples was determined according to the method of Bergeret (1955) with few modifications. A flask containing 2 - 3 glass beads was placed in an oven for about 15 minutes, cooled and weighed (P_1: Mass balloon + glass beads). Two grams of the sample (P_0) carefully packed in a filter paper were placed in a cartridge in cellulose. The whole was then introduced into the extractor of the Soxhlet set on a balloon. The petroleum either used here as a solvent was added in the extractor until syphoning, then an additional volume of solvent was added up to the half level of the siphon. After setting the refrigerant on the extractor, the flask was heated for 6 h. After stopping heating, the flask containing the solvent and the fat extracted was set on a rotary evaporator to evaporate the solvent. The flask was finally put in an oven and weighed (P_2). Three replicates were performed for each sample.

The total fat content is given by the formula below:

$$\text{Total fat content} = \frac{P_2 - P_1}{P_0} \times 100 \left(\frac{\text{g}}{100 \text{ g}} \text{ of dry matter} \right)$$

Determination of total protein content

The determination of total protein content was performed according to the Kjeldahl method (AOAC, 1980) [20]. It was performed in three phases: mineralization, distillation and titration.

Mineralization

In a Kjeldahl flask, thoroughly washed and oven dried (at 105 ˚C for 30 min) then labeled, 0.5 g of beef sample were introduced. 10 ml of sulfuric acid was added and the whole was allowed to warm on the hood for 1 h. Mineralization was considered complete when the dark syrupy mixture at the start of heating became colorless. The mineral deposit thus obtained was allowed to cool for 30 min and then diluted with 10 ml of distilled water.

The mineralization is reflected by the following chemical equation: →

$$\text{Beef}\left(\text{dry matter}\right) + H_2SO_4 \rightarrow \left(NH_4\right)_2 SO_4$$

Distillation

In an Erlenmeyer flask, 10 ml of distilled water, 10 ml of absorbent solution

and 4 drops of Tashiro indicator were introduced. The Erlenmeyer and Kjeldahl flasks were then placed on the distillation apparatus, and a lever allows the neutralization of any acid present in the flask by NaOH. Ammonia moved by NaOH is thus entrained as a gas by steam current generated by tap water and condensed in ammonia at the refrigerant constantly supplied with tap water. The condensate was collected in the flask containing the absorbent solution, colored purplish pink (Tashiro indicator) to form ammonium borate. In the presence of the latter, the Tashiro indicator turns green.

The distillation was completed after 4 min and summarized by the following equations:

$$\left(NH_4\right)_2 SO_4 + 2NaOH \rightarrow 2NH_4OH + Na_2SO_4$$

$$2H_3BO_3 + 6NH_4OH \rightarrow 2\left(NH_4\right)_3 BO_3 + 6H_2O$$

Titration

The titration was continued until the color changes of Tashiro indicator from green to colorless. The obtained distillate was titrated with 0.1N sulfuric acid to form ammonium sulfate and regeneration of boric acid according to the chemical equation below:

$$2\left(NH_4\right)_3 BO_3 + 3H_2SO_4 \rightarrow 3\left(NH_4\right)_2 SO_4 + 2H_3BO_3$$

A control flask including no meat sample, but all other reagents, was submitted to the previous three phases to assess the traces of nitrogen that would come from reagents.

The nitrogen content is given by the following expression:

$$\text{Nitrogen conten} = \frac{0.14v}{P}\left(\frac{\text{g}}{100}\text{ g of dry matter}\right)$$