



RESEARCH ARTICLE

TECHNOLOGICAL AND NUTRITIONAL CHARACTERIZATION OF CATTLE FEET AND HEADS CONSUMED IN OUAGADOUGOU

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Abstract

Background: Beef feet and heads, prepared in soup or incorporated into sauces, are widely consumed in Ouagadougou. However, very little scientific information exists on the nutritional quality of these beef co-products offered to consumers. This study focused on determining the technological and nutritional characteristics of smoked feet and heads, as well as dried bovine feet sold in Ouagadougou.

Methods: Production monitoring was carried out at the "Bouzout Yaar" market in order to describe the processing of beef feet and heads intended for human consumption. Twenty samples were then collected and analysed for macronutrient and mineral content using standard methods.

Results: The processing technology for beef feet and heads is artisanal and based on the steps of grilling feet and heads on a grid over a wood fire and removing the hair with blades or knives. The average fat and protein contents (g/100 g) of beef feet and heads samples ranged from 6.83 to 10.98 and from 18.16 to 21.37 respectively. The average iron, zinc and magnesium contents (mg/100 g) ranged from 8.87 to 19.66, 1.42 to 1.86 and 7.12 to 20.11 respectively.

Conclusion: Results showed that beef feet and head meat are fatty meats, rich in protein and iron. The consumption of these products is increasing over time and it would be very important for the actors to be trained on processing technologies for these products in order to guarantee safe products for human consumption. This processing site requires a waste management plan to avoid microbial contamination to these meat co-products.

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Introduction:-

In Burkina Faso, livestock production contributes significantly to the growth of the national economy, with cattle, sheep and goats estimated at 7,609,000, 10,589,000 and 12,956,000 respectively in 2020 (MAAH, 2021). Indeed, livestock farming represents about 10 to 20% to Gross Domestic Product (GDP) and contributes nearly 30% to

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national exports (FAO, 2019). Most exports are in the form of live animals, and very little of the meat. The national production of controlled meat is about 2,200,000 tons per year (MRAH, 2020). It represents the vast majority of meat products sold on the national market. In addition to meat, co-products or fifth quarter products such as cattle heads, hides, tail and feet are processed to be marketed for human consumption. The processing and marketing of these products take place sporadically in the area around slaughter areas throughout the Ouagadougou city. However, in the district 11 of Ouagadougou, there is a market where these activities seem to be the majority, hence the name "Bouzout Yaar" (market for goat heads in the local Moore language) and this market has been the subject of several media reports (Tahi and Zohouri, 2015 ; Kaboré, 2022). The specificity of this market is the commercialisation of feet, tails, skins and heads of small and big animals. These products are consumed locally, but are also exported to coastal countries such as Côte d'Ivoire, Ghana, Benin, Togo and Nigeria (Kaboré, 2022). Prepared in soup or incorporated into sauces, these products are widely consumed in Burkina Faso. However, very little scientific information exists on the treatment processes as well as the nutritional quality of these beef co-products offered to consumers. This study focused on determining the technological and nutritional characteristics of smoked feet and heads, as well as dried bovine feet sold in Ouagadougou.

Methods:-

Study site and sampling

This study involved twenty (20) samples including five (5) samples of beef smoked feet, five (5) samples of beef dried feet and ten (10) samples of beef smoked heads. The sampling was carried out in district n°11 of the Ouagadougou city at "Bouzoutyaar", the largest cattle heads, hides, tails and feet processing and sale market. The samples were packaged in sterile freezer bags and sent to the laboratory for analysis. A questionnaire was developed to collect information on the processing of cattle feet and heads.

Sample processing :

The analyses were carried out on feet muscle and head muscle without bones, tongue, skin and brain. The muscles have been ground for nutrients analysis.

Sample analysis :

The samples analysis included pH measurement, moisture determination, protein content, fat content, total sugar content, ash content and mineral content (iron, zinc, potassium, magnesium, sodium).

Samples pH was measured with an electronic pH-meter (Model HI 8520; Hanna Instrument, Singapore). For each sample, 10 g of product were mixed with 20 mL of distilled water prior to pH measurement. Water content was determined by drying the sample at $105\text{ }^{\circ}\text{C} \pm 2\text{ }^{\circ}\text{C}$ for 24 h according to the standard ISO (ISO 665, 2000). Ash content was determined by incineration at $650\text{ }^{\circ}\text{C}$ overnight, according to international standard ISO (ISO 2171, 2007). Crude fat content was determined by soxhlet extraction using n-hexane according to ISO (ISO 659, 2009). Crude protein content ($\text{N} \times 6.25$) was determined by the Kjeldahl method described in ISO 20483 (ISO 20483, 2013). Total carbohydrates content was determined by the differential method according to the formula: % Total carbohydrates = $100 - [\text{Moisture} (\%) + \text{protein content} (\%) + \text{fat content} (\%) + \text{ash content} (\%)]$. Fat, protein, total carbohydrates and ash contents were expressed in g/100 g dry matter (DM). The energy value was calculated according to the Atwater method (Merrill and Watt, 1973). Mineral elements were determined by flame atomic absorption spectrometry (Perkin-Elmer model 303) according to the standard (AOAC, 2005). Samples were analysed in triplicate for each parameter.

Statistical analyses of data

All the data were submitted to Analysis of Variance (ANOVA) with the statistical software XLSTAT-Pro 7.5.2 and the means were compared using the test of Fisher (LSD) to the probability level $p < 0.05$.

Results:-

Process and diagram for the treatment of cattle feet and heads

The various monitoring allowed to describe a processing diagram for smoked and dried cattle feet (Figure 1) and smoked cattle heads (Figure 3). The main stages in the processing of cattle feet are:

1. **scalding:** beef feet are soaked in boiling water for about 15 to 30 minutes;
2. **dehairing and exongulation:** the cattle's feet are removed from the water and then using a knife, the hair and the hooves are removed;

3. **soaking in warm water (50-60 °C):** coarse hairless feet are soaked in warm water for 15 minutes;
4. **full hair removal:** using a razor blade, the remaining hair is removed;
5. **rinsing:** the dehaired feet are rinsed with clean water;
6. **draining:** dehaired and cleaned feet are drained for 10 minutes;
7. **cloven hooves separation:** the feet are separated at the cloven hoof with a knife. At this stage, the feet are processed in two ways:
 - a. **smoking:** on a grid placed over a well-activated wood fire, the feet are placed and then smoked for about 1.5 hours. Then, they are sun-dried for 2 to 3 days to obtain smoked feet ;
 - b. **salting and drying:** the feet are salted (NaCl) and then sun-dried for 2 or 3 days to obtain dried feet.

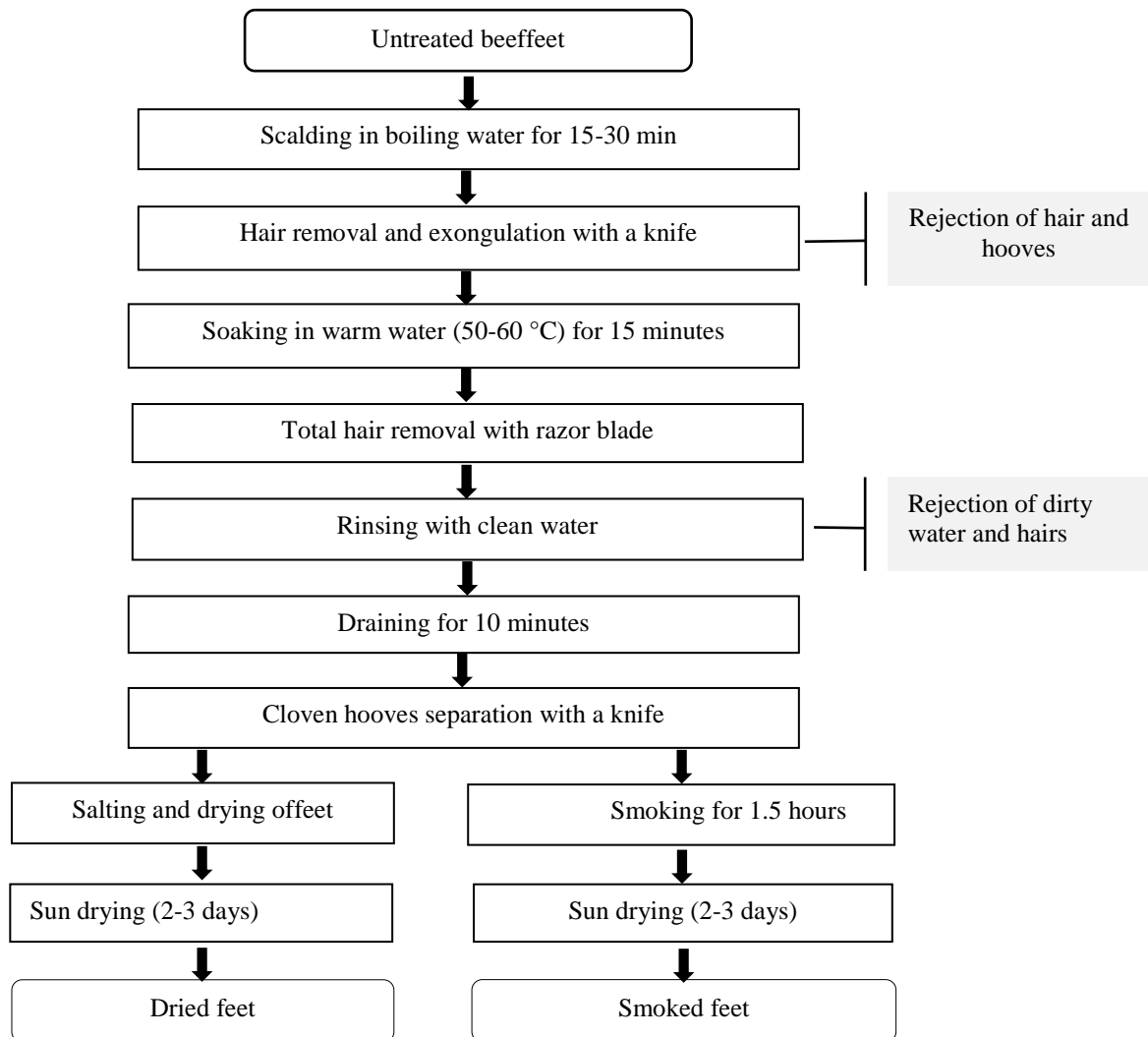


Figure 1:- Cattle feet processing diagram.

The Figure 2 illustrates some steps in cattle feet processing

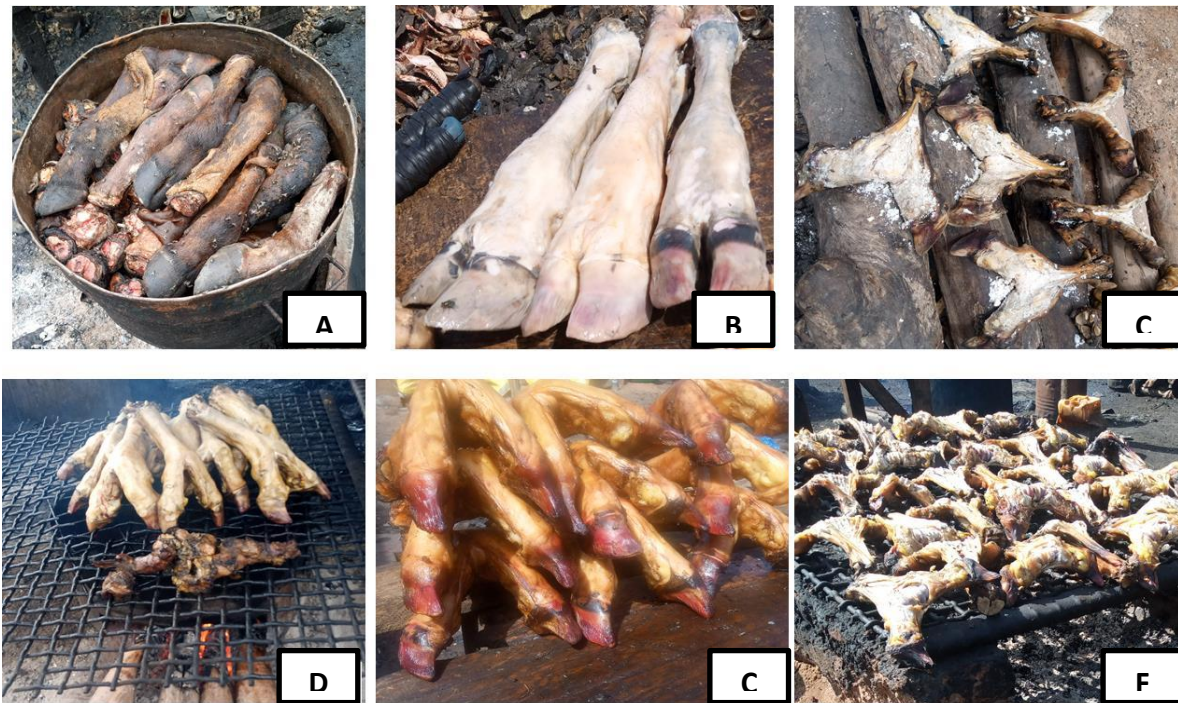


Figure 2: Pictures illustrating some steps in cattle feet processing
 Legend: A) Scalding, B) Dehaired and cleaned feet, C) Salted feet, D) Smoking of feet, E) Smoked feet and F) Dried feet

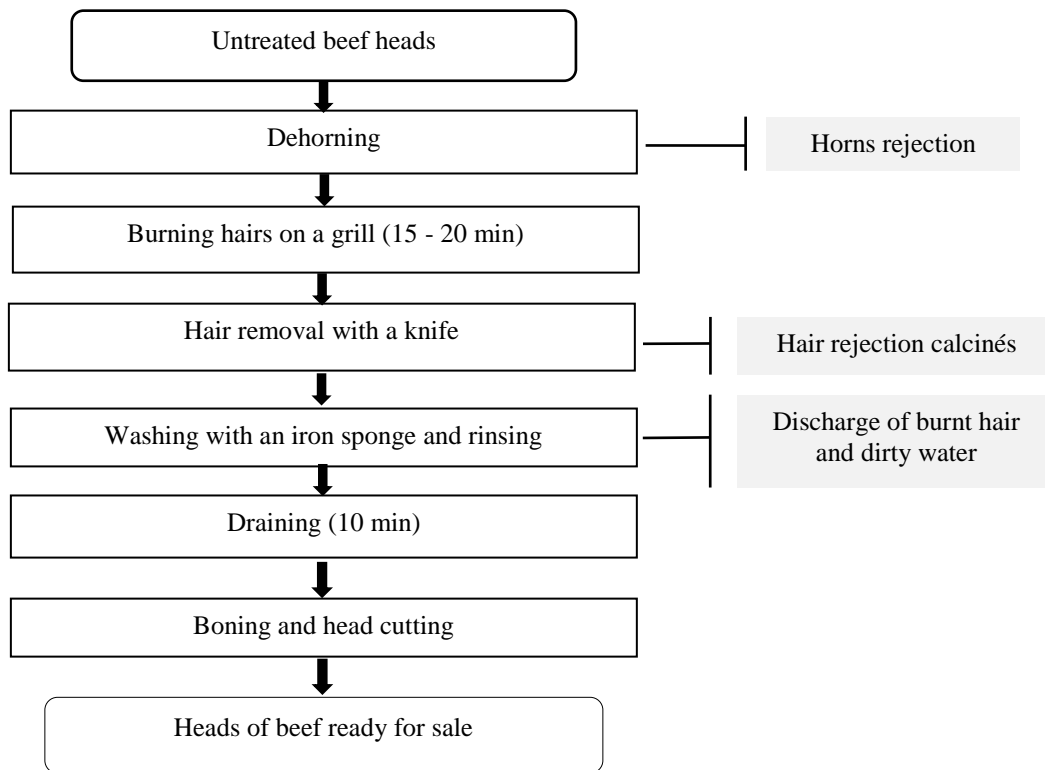


Figure 3:- Beef head processing diagram.

The main stages of cattle head processing are:

- **dehorning:** the horns are cut off with a very sharp knife;
- **hair burning:** the heads are placed on a grid over a wood fire to burn the hair for about 15 to 20 minutes;
- **hair removal:** the hairs are removed with a knife, the grill can be renewed to continue the hair removal process to remove all the hairs;
- **washing and rinsing:** the heads are washed with an iron sponge to remove burnt hair and then rinsed with clean water;
- **boning and slicing:** depending on how the upper and lower jaw fit together, the heads are boned and then sliced with a knife for sale.

The Figure 4 illustrates some steps in beef heads processing



Figure 4: Photos illustrating main stages of cattle head processing

Legend: A)Dehorning, B) Heads burning of, C) Dehairing, D) Washing of dehaired heads, E) Smoked heads, F) Cutting

Nutritional characteristics of beefsmoked heads, smoked feet and dried feet

Physico-chemical analyses results are presented in Table 1 and Table 2. The average pH was 5.88 ± 0.20 for smoked heads, 6.44 ± 0.34 for smoked feet and 6.91 ± 0.52 for dried saltedfeet ($p < 0.001$). The moisture was $37.40 \pm 16.82\%$; 55.18 ± 10.48 and $72.93 \pm 3.32\%$ ($p < 0.001$) for dried salted feet, smoked feet and smoked heads, respectively. Ash contents ranged from 1.01% in smoked heads and feet to $6.82 \pm 1.51\%$ in dried feet ($p < 0.001$).

Table 1: pH, moisture and ash content of samples

Parameters	pH	Moisture (%)	Ash (%)
Smoked heads,	$5,88 \pm 0,20^a$	$72,93 \pm 3,32^a$	$1,01 \pm 0,25^a$
Smoked feet	$6,439 \pm 0,345^b$	$55,18 \pm 10,48^b$	$1,02 \pm 0,19^a$
Dried feet	$6,91 \pm 0,52^c$	$37,40 \pm 16,82^c$	$6,82 \pm 1,51^b$
Significance level	$< 0,0001$	$< 0,0001$	$< 0,0001$

The average fat contents (g/100 g) were 10.20 ± 1.55 , 10.98 ± 2.82 and 6.83 ± 3.02 for smoked feet, dried feet and smoked head meat respectively. Protein contents (g/100 g) of 18.16 ± 1.71 , 20.77 ± 2.65 and 21.37 ± 1.87 were obtained in smoked head, smoked feet and dried feet meat, respectively.

Table 2:- Fat, protein, total carbohydrates contents and energy.

Parameters	Fat g/100 g	Protein g/100 g	Carbohydrates g/100 g	Energy kcal/100g
Smoked head	6,83 ± 3,02 ^a	18,16 ± 1,71 ^a	1,07 ± 0,84 ^a	138,42 ± 26,73 ^a
Smoked feet	10,20 ± 1,55 ^b	20,77 ± 2,65 ^b	4,85 ± 2,98 ^b	194,15 ± 20,69 ^b
Dried feet	10,98 ± 2,82 ^b	21,37 ± 1,87 ^b	3,43 ± 3,02 ^b	198,03 ± 32,13 ^b
Significance level	< 0.0001	< 0.0001	< 0.0001	< 0.0001

Mineral contents of beef head and feet meat

The contents of iron, zinc, potassium, sodium and magnesium (mg/100 g) in the samples of smoked and dried head and feet meat are shown in Table 3.

Table 3:- Mineral elements contents.

Content in	Fe mg/100g	Zn mg/100g	K mg/100g	Na mg/100g	Mg mg/100g
Smoked head	19,66±2,56 ^a	1,86±0,66 ^a	186,37±37,97 ^a	149,78±28,15 ^a	20,11±6,26 ^a
Smoked feet	12,60±5,68 ^b	1,85±1,35 ^a	75,23±7,85 ^b	232,49±2,70 ^b	7,12±0,85 ^b
Dried feet	8,87±5,08 ^c	1,42±0,30 ^b	83,44±9,02 ^b	713,73±431,1 ^c	11,93±1,79 ^c
Significance level	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001

Discussion:-

The "Bouzout Yaar" market is an atypical market and easily spotted by the smell of burning, the nauseating smell of waste, the black smoke and the squeaking of knives. The flames from the firewood are used to strip cattle heads and feet hairs. However, other combustibles, such as rubber debris or old tyres, are used to activate the flame. These combustibles are composed of toxic chemicals and could contaminate the treated cattle heads and feet. The same observations have been made by Kaboré (2006) and Kaboré (2022). The stagnant water from cleaning and the proximity of the waste could constitute a source of contamination by pathogenic microorganisms. Indeed, the monitoring of the processing of feet and heads during this study shows that the processing technology is done in an artisanal way with rudimentary equipment under questionable hygienic conditions. These co-products are highly appreciated by the population and their consumption is increasing over time (Kaboré, 2022). It would therefore be very important for this sector to be organised for the use of hair removal techniques that guarantee safe products for human consumption. This market provides considerable income to the actors, also brings foreign currency to the commune through the payment of taxes and most of the products are exported outside Burkina Faso. This market therefore requires a development and waste management plan.

The average pH of smoked head meat is similar to the normal pH of fresh meat, which is between 5.5 and 5.7. However, in smoked and dried feet meat the average pH obtained is higher than the normal pH of meat. The pH is a chemical parameter that influences the preservation capacity of the meat and its organoleptic quality (Cartier and Moevi, 2007). Low pH values are known to have a bacteriostatic action that regulates the microbial balance, thus contributing to the conservation of the meat. A high pH of meat (above 5.8), such as the pH of the studied samples, favours the development of microorganisms responsible for altering the taste, smell and colour of the meat, as well as pathogenic microorganisms (Renand et al., 2002).

The average moisture contents of samples (37,40 ± 16,82% to 72,93 ± 3,32%) are lower than that of bovine muscle, which is 75% (Coibion, 2008). However, these water contents remain high. The water contents of these samples showed that these meats are neither smoked for a long time nor correctly dried. They are set on fire in order to facilitate the removal of hairs, according to the process used by the actors. These meats always remain wet and therefore are exposed to biochemical and microbial degradation.

The ash contents of dried feet (6.82 ± 1.51%) is higher than those of smoked heads and feet (1.01%) (p < 0.001). This difference could be due to the addition of salt before drying.

In general, fat, protein, total carbohydrates and energy content were significantly higher in the feet samples than in the heads samples (p < 0.001). This low macronutrient content could be explained by the high water content of

smoked head meat compared to leg meat. The fat contents varied greatly between head samples the one hand and between feet samples one the other hand. This could be explained by the breeding conditions of cattle and processing techniques. These meats can be described as fatty parts. Indeed, according to Duchène et al., (2010) and Coibion (2008), meat fat contents vary considerably from one part to another, with lean parts having less than 3% of fat mass, low-fat parts with 4 to 6% of fat mass and fatty parts with up to 20% fat mass. For beef, the fat contents range from 2 to 3 g/100 g for the leanest parts, such as tenderloin and scoter, to 8 or 9 g/100 g for the richest parts, such as entrecote (without the fat). The other parts are between 5 and 7 g/100 g. The high fat content gives the meat of smoked heads, smoked feet and dried feet a high calorific potential, thus contributing to their improved nutritional composition.

The protein contents of beef head and leg meat are similar to those described in several studies on beef. Indeed, raw red meat contains on average 20-24 g of protein per 100 g (Williamson et al., 2005). Protein contents vary from 19 to 23 g/100 g for different parts of beef and from 17 to 22 g/100 g for tripe products (Duchène et al., 2010). Thus, the beef feet and heads analysed contain as much protein as the other parts and are a good source of animal protein.

In general, the total carbohydrates obtained are low, and the head meat had the lowest total carbohydrates. In general, the total sugar content of the meat is low and varies very little from one piece to another (Coibion, 2008; Duchène et al., 2010).

The lowest energy value was obtained in the smoked head meat (138.42 ± 26.73 kcal/100 g). Fat are nutrients with high calorific potential and the high fat content in the feet would explain the higher energy values in the feet meat compared to the heads. Generally, the energy value of beef varies from 92 to 154 kcal depending on the piece. Energy values above 200 kcal have been obtained in some meats such as beef entrecote and tripe products (Duchène et al., 2010). The results of this study show that the energy values of the head and foot meats are comparable to the energy values of the fatty parts of beef.

Iron levels were significantly higher in head samples (19.66 ± 2.56 mg/100 g) than in feet samples (12.60 ± 5.68 and 8.87 ± 5.08 mg/100g). Lower iron contents than those obtained in this study were obtained in fresh beef carcass (2.2 to 3.7 mg/100 g) and in pieces such as heart, liver and kidney (5 to 7 mg/100 g) (Bauchart et al., 2008; Duchène et al., 2010). Similar levels to our results were noted in beef (1.77 to 21.78 mg/100 g) in a review on the nutritional benefits of minerals in meat and meat products (Falowo, 2021). Zinc levels in the samples varied very little but remained low (1.42 ± 0.30 to 1.86 ± 0.66 mg/100 g). Similar levels to those obtained in this study (1.5 to 3.6 mg/100 g) have been found by some authors in beef products (Duchène et al., 2010). However, other studies presented higher zinc values in beef (3.3 to 7 mg/100 g) (Falowo, 2021).

The highest potassium content was obtained in the smoked head meat samples (186.37 ± 37.97 mg/100 g) and the lowest in the smoked feet meat samples (75.23 ± 7.85 mg/100 g) ($p < 0.001$). The different levels obtained are lower than those reported by (Falowo, 2021) on beef, which varied from 320.4 to 430.1 mg/100 g of meat. Thus, feet and head meat are less rich in potassium than the other parts of beef. Due to the salt addition in the dried feet, the highest sodium content was obtained in the dried feet meat (713.73 ± 431.15 mg/100 g). Smoked head meat had the lowest sodium content (147.78 ± 28.15 mg/100 g). In a review on the nutritional values of meat, lower sodium concentrations were obtained in beef (35.2 to 74.1 mg/100g) (Falowo, 2021). With very high salt levels in the dried legs in the present study, it would be prudent for these meats to be soaked in water first in order to reduce the salt level or to take into account the salt level before adding more salt to the preparations.

The highest average magnesium content (20.11 ± 6.26 mg) was observed in the head meat samples and the lowest value (7.12 ± 0.85 mg/100 g) in the feet samples ($p < 0.001$). Compared to magnesium-rich meat products, results of this study showed that beef feet and heads have low magnesium contents. Indeed, beef meat contains 23.6 to 32 mg/100 g and the highest magnesium content in meat products is found in chicken meat (78 to 121.6 mg/100 g) (Falowo, 2021).

In general mineral content is higher in the head meats compared to feet meats except for the sodium. The consumption of beef co-products could therefore contribute to diet mineral intake.

Conclusion:-

This study described the processing techniques for cattle heads and feet. Indeed, after slaughter, the heads and feet of cattle undergo a succession of processing operations in order to provide consumers and traders with products intended for human consumption. Physico-chemical analyses allowed to assess the nutritional quality of these products and to show that the meat of bovine feet and heads is rich in protein with a good energy value, given its fat content. They also contain minerals such as iron, zinc, potassium and magnesium. However, the consumption of these meats requires great care because of the lack of control over the transformation process of these products. Research on sanitary quality (presence of toxic molecules and pathogenic microorganisms) must be conducted in order to propose healthy production diagrams for these meats which sale is very profitable.

Statement of Competing Interests

The authors have no competing interests.

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