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Processing Properties, Rheological Characteristics, and Nutritional Composition of the Main Game Meats and Frogs Consumed in Benin

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Abstract

Meat from unconventional animal resources such as bushmeat, amphibians, reptiles, rodents, and wild birds represents an important part of the food system components in Benin. This study aimed to assess the processing properties, rheological characteristics, and nutritional value of the main game meats and frogs consumed in Benin. To this end, carcasses of 8 deer, 10 grasscutter (*Thryonomys swinderianus*), 10 monitor lizard (*Varanus exanthematicus*), 10 partridge, and 36 frog (*Hoplobatracus occipitalis*) were aseptically sampled and analysed according to the procedure of AOAC procedures. Individual animals were treated as independent experimental units. The results showed that deer and grasscutter meats were rich in protein (21.5 - 22.9 g/100g), low in fat (2.2 - 2.8 g/100g), and exhibited strong water-holding capacity (25% - 34%) with intense red coloration, reflecting their suitability as lean red meats with stable technological properties. Frog and partridge meats were less rich in fat (0.9 g/100g to 1.8 g/100g) and pale, with high protein content (18.6 - 23.3 g/100g) but lower water-holding capacity. Monitor lizard meat displayed an intermediate profile, combining high protein (22.9 g/100g), moderate fat (2.9 g/100g), and distinctive yellow index. Variations in drip and cooking losses, color stability, and pH among species underscored species-specific differences in meat functionality and processing behavior. Overall, these unconventional and game meats offer diverse nutritional and technological attributes, providing opportunities for dietary diversification and enhancing food security in Benin and in West Africa.

Keywords

Benin, Characterization, Macronutrients, Technological Properties, Unconventional Meat

1. Introduction

In sub-Saharan Africa, unconventional animal resources such as bushmeat, amphibians, reptiles, rodents, and wild birds continue to play a crucial role in local diets, both as cultural delicacies and as essential contributors to household food security [1]-[7]. These non-conventional meats are valued not only for their availability but also for their nutritional richness, particularly in contexts of protein deficiency and food insecurity [4]-[6]. In Benin, a wide variety of species are consumed, including deer (*Cervus elaphus*), wild grasscutter (*Thryonomys swinderianus*), partridge (*Francolinus bicalcaratus*), monitor lizard (*Varanus exanthematicus*), frogs such as *Hoplobatrachus occipitalis*, and edible insects like *Cirina butyrospermi* and *Zonocerus variegatus* [8].

The nutritional value of these resources has been increasingly highlighted by recent research. For instance, grasscutter meat is recognized for its high protein content and favorable emulsifying characteristics, which vary according to dietary energy levels [9] [10]. Cane rat meat has also been associated with promising sensory and carcass traits, making it an important alternative to conventional livestock products [7] [11]. Similarly, the nutritional and technological quality of deer and wild boar meat has been extensively studied in Europe, showing that wild meats can compete with conventional species in terms of nutrient density and functional properties [12]-[15]. Amphibians, particularly frogs, represent another underutilized but nutritionally rich source of animal protein. Studies on bullfrog (*Lithobates catesbeianus*) have reported high carcass yield and favorable proximate composition [16] [17], while research has also documented the technological potential of frog meat and its by-products as functional ingredients [18] [19]. Cooking and processing methods significantly influence both the nutritional value and contaminant profiles of frog meat, underlining the importance of technological considerations in its consumption [20]. In avian game species, partridge meat has gained attention due to its physicochemical and rheological characteristics, with research showing variations linked to sex, intramuscular fat, and rearing conditions [21]-[24]. Monitor lizard meat has also been characterized for its nutrient composition, carcass traits, and potential contribution to food security in West Africa [25]. According to [8] and [21], the seven main non-conventional species most consumed—including mammals, reptiles, birds, amphibians, and insects, are deer (*Cervus elaphus*), grasscutter (*Thryonomys swinderianus*), partridge (*Francolinus bicalcaratus*), monitor lizard (*Varanus exanthematicus*), frogs (*Hoplobatrachus occipitalis*), grasshoppers (*Zonocerus variegatus*), and shea caterpillars (*Cirina butyrospermi*). Despite their importance, comprehensive comparative studies on the technological, rheological, and nutritional properties of these main unconventional meats in the Benin context remain scarce. Characterizing such properties is essential for establishing their potential role in sustainable diets and for integrating them into strategies that address food insecurity and malnutrition. This study therefore aimed to assess the processing properties, rheological characteristics, and nutritional value of the main game meats and frogs consumed in Benin. Specifically, it is to:

- Determine the techno-functional properties of the main game meats and frogs consumed in Benin.
- Assess the nutritional composition of these main game meats and frogs consumed in Benin.

2. Materials and Methods

2.1. Study Area

The study was conducted with the hunters and game meat traders of Parakou in the Department of Borgou, Partogo (Djougou) in the Department of Donga, and Zogbodomey in the Department of Zou (Figure 1). The lab analyses were conducted jointly at the Quality and Food Safety Unit/LARAEQ of the University of Parakou, the lab of the Faculty of Agronomical Sciences of the University of Abomey-Calavi, and the laboratory of the National Agency of Food Safety of Benin (LCSSA/ABSSA).

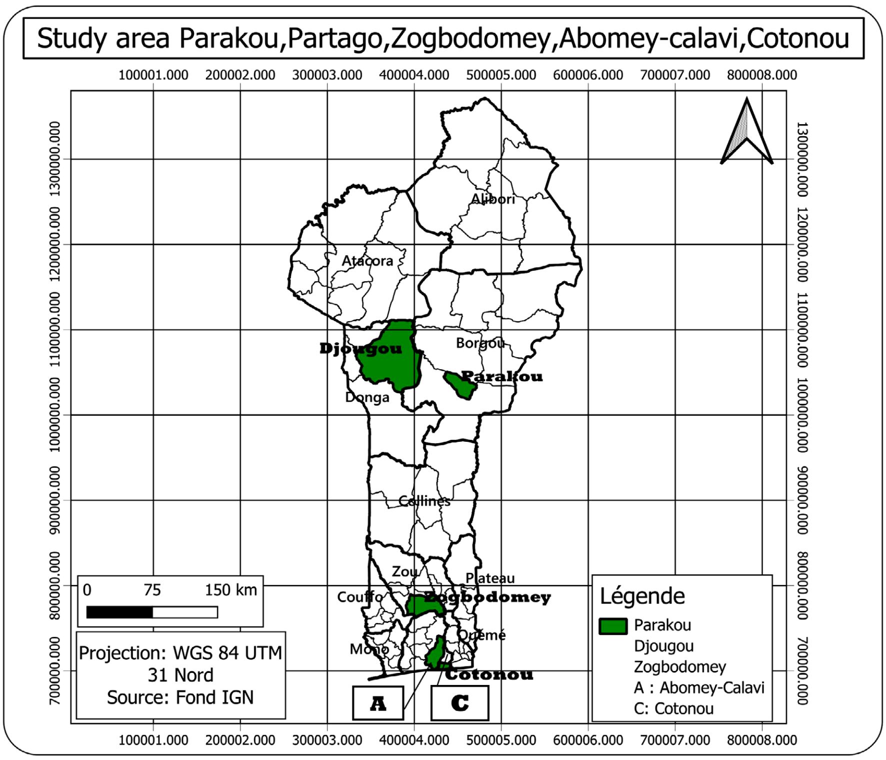

Figure 1. Study area.

The Department of Borgou is located in northern Benin, between 8˚52' and 10˚25' N latitude and 2˚36' and 3˚41' E longitude, covering an area of 25,856 km^2. The climate is Sudanese type, characterized by a dry season (November to May) and a rainy season (June to October) with annual rainfall of 900 - 1200 mm [26]. With a Sudanian-Guinean type of climate, the Department of Donga is characterized by a rainy season (mid-April to mid-October) and a dry season (mid-October to mid-April). This climatic pattern is similar to that of the Atacora Department. However, the average annual rainfall, ranging from 1200 mm to 1300 mm, is higher than in Atacora. The month of August records the heaviest rainfall. Zou Department borders Collines Department to the north, Plateau Department to the east, Ouémé Department and Atlantique Department to the south, Kouffo Department to the south-west, and Togo to the west. The department is characterized by plateaus, ranging from 20 to 200 m above mean sea level, which are split by valleys running from north to south, created by the Zou River and Kauoffo River. The southern regions of Benin receive two spells of rain from March to July and September to November, while the northern regions of the country receive one season of rainfall from May to September. The country receives an average annual rainfall of around 1200 mm [26].

2.2. Meat Sampling

Samples from seven species of freshly shot unconventional animal resources consumed as meat were taken from 3 different hunting grounds in 3 municipalities of Benin. According to Tohozin *et al.* [8], the unconventional animal resources consumed as meat in northern Benin come from Partogo (Djougou) in the Department of Donga and Zogbodomey in the Department of Zou and are sold in Parakou. In most cases, the hunts lasted more than six hours. After the end of the hunt, all harvested animals were transported to a central marketing point for processing and sampling. Approximately four hours after hunting, the animals were processed for about 45 - 60 minutes to allow for carcass evisceration and sampling. A total of 8 deer, 36 frogs, 10 monitor lizards, 10 grasscutters, and 10 partridges were collected and used for the study (**Figure 2**). These unconventional animals were collected by accredited hunters in accordance with the hunting regulations of Benin. Individual animals were treated as independent experimental units. On each carcass of deer, wild grasscutter (*Thryonomys swinderianus*), and monitor lizard, 500 g of meat were sampled, combining thigh, back, and shoulder muscles as a composite sample. For partridge, 250 g of composite samples from breast and thigh muscles were collected, while for frog (*Hoplobatrachus occipitalis*), 80 g of composite samples from calf, forechest, and thigh muscles were taken.

The samples were kept at +4˚C until laboratory analysis according to the recommended ISO standards.

2.3. Evaluation of Technological Quality

The technological measurements performed on the meat of each batch included pH, color, drip loss, cooking loss, and water-holding capacity (WHC). Drip loss was determined on samples of Longissimus dorsi muscle. These samples were tied with wire, placed in Stomacher bags (without direct contact between meat and bag), and stored at 4˚C. The samples were then weighed 24 hours later. Drip loss was expressed as a percentage of the initial weight before refrigerated storage [27].

(a) Grasscutter (b) Frog (c) *V. exanthematicus* (d) Deer (e) Partridge

Figure 2. Unconventional animals sampled for the study.

The meat samples used for drip loss determination were subsequently vacuum-packed and cooked at 95˚C in a thermostatically controlled water bath for 60 minutes. After cooking, the samples were cooled under running water to equilibrate to ambient temperature, then blotted dry and weighed. Cooking loss was expressed as a percentage of the weight before cooking [6] [27].

The drip loss and cooking loss were calculated according to equation (1):

$$\text{Juice loss}(\%) = \frac{(\text{Weight before treatment} - \text{Weight before cooking}) \times 100}{\text{Weight before treatment}} \quad (1)$$

The sum of drip loss and cooking loss represents the water-holding capacity (WHC) of the meat.

The pH was measured 24 hours post-mortem using a portable HANNA pH meter equipped with a specialized probe inserted into the Longissimus thoracis muscle. For each determination, five replicates were performed. Prior to use, the pH meter was calibrated with two standard buffers (pH 4 and pH 7) according to the manufacturer's instructions (HANNA Instruments®, Italy).

Meat color was determined according to the standards of the International Commission on Illumination (CIE Lab). *L* corresponds to luminance, a to the redness index, and *b* to the yellowness index. Chroma (*C*) and hue angle (*h*) were calculated using the formulas as given in equations (2) and (3):

$$\text{Hue}(H^*) = \frac{1}{\text{Tan}\left(\frac{b^*}{a^*}\right)} \quad (2)$$

$$\text{Chromaticity}(C^*) = \sqrt{a^{*2} + b^{*2}} \quad (3)$$

For each measurement, five replicates were carried out on meat samples from each batch.

2.4. Proximate Composition Analysis

Proximate analyses were conducted according to the recommendations of the Association of Official Analytical Chemists [28] and as described by Tougan *et al.* [6]. All measurements were performed in duplicate to ensure accuracy and reproducibility.

Dry matter content was determined by oven-drying the samples at 105˚C until a constant weight was obtained. The percentage of dry matter was calculated as the ratio of the final dry weight to the initial weight of the sample as given in equation (4).

$$\text{Dry matter content}(\%)=\frac{\text{Weight after drying}\times 100}{\text{Initial sample Weight}} \quad (4)$$

Ash content was measured by incinerating 5 g of sample in a muffle furnace at 550˚C until light grey ash was obtained, corresponding to the complete oxidation of organic matter. The percentage ash content was expressed relative to the initial sample weight, as given in equation (5).

$$\text{Ash content}(\%)=\frac{\text{Ash Weight}\times 100}{\text{Initial sample Weight}} \quad (5)$$

Crude protein content was assessed using the Kjeldahl method. Briefly, the samples were digested with concentrated sulfuric acid (H_2SO_4) in the presence of a catalyst to convert organic nitrogen into ammonium sulfate. The digest was then neutralized with sodium hydroxide (NaOH) and distilled, releasing ammonia, which was captured in a boric acid solution and titrated with standardized hydrochloric acid. Nitrogen content was converted to protein using the conventional factor of 6.25 as given in equation (6).

$$\text{Crude protein content} = \text{Nitrogen content}\times 6.25 \quad (6)$$

Crude fat content was determined according to the NF V 04-402 standard (January 1968; ISO 1443:1973), involving acid hydrolysis with hydrochloric acid (HCl) followed by filtration and solvent extraction of lipids. The solvent was evaporated, and the remaining fat residue was weighed to express crude fat content as a percentage of the original sample weight [28], as given in equation (7).

$$\text{Fat content}(\%)=\frac{\text{Fat Weight}\times 100}{\text{Initial sample Weight}} \quad (7)$$

2.5. Statistical Analysis

Statistical analysis was performed using Statistical Analysis System software [29]. Means were calculated using the PROC MEANS procedure. Individual animals were treated as independent experimental units. The procedure Proc GLM of SAS was used for variance analysis. The variation source used was the animal species. The Student T test was used to compare the means.

The mathematical expression of the model used is as follows:

$$Y_{ij}=\mu+E_i+e_{ij}$$

with:

- Y_{ij} = performance mean of individual *I*, of species *I*;
- μ = average performance;
- E_i : fixed effect of species *i* (deer, grasscutter, partridge, monitor lizard, frogs);
- e_{ij} : Effect of random residual average performance of individual *I*, of species *i*.

3. Results

3.1. Nutritional and Technological Properties of Deer Meat

The processing properties, rheological characteristics, and nutritional value of the local Deer meat consumed in Benin are given in Table 1. The analysis of physico-chemical and color parameters showed that the dry matter content, crude protein content, fat content, and ash content of fresh Deer meat were respectively 25.15 g/100g, 21.53 g/100g, 2.19 g/100g, and 1.12 g/100g.

Table 1. Nutritional and technological properties of deer meat.

Variables	Mean	Standard Error	CV
Dry matter (g/100g)	25.15	0.16	1.55
Fat (g/100g)	2.19	0.07	7.27
Crude protein (g/100g)	21.53	0.21	2.41
Ash (g/100g)	1.12	0.03	6.75
Drip loss (%)	1.13	0.05	11.84
Cooking loss (%)	24.11	0.38	3.90
Water Holding Capacity (%)	25.23	0.37	3.59
Luminance L*	34.75	0.50	3.52
Red index a*	23.43	0.62	6.46
Red index b*	1.68	0.07	10.40
Chromaticity C*	23.49	0.62	6.45
Hue H*	13.98	0.48	8.44
pH	5.92	0.04	1.69

CV: Coefficient of variation.

As for technological characteristics, the drip loss was 1.13%, cooking loss was 24.11%, and water holding capacity was 25.23%. Color parameters indicated luminance of 34.75, redness of 23.43, yellowness of 1.68, chromaticity of 23.49, and a hue angle of 13.98. The average pH was 5.92. These findings provide baseline information on the quality profile of frog meat, which may support its valorization as an unconventional animal protein source.

3.2. Nutritional and Technological Properties of Frog Meat

The technological properties and the nutritional value of the local frog meat consumed in Benin are presented in Table 2. The analysis of this table revealed that the dry matter content, crude protein content, fat content, and ash content were, respectively, 21.21 g/100g, 18.60 g/100g, 0.92 g/100g, and 1.05 g/100g.

Table 2. Nutritional and technological properties of frog meat.

Variables	Mean	Standard Error	CV
Dry matter (g/100g)	21.21	0.15	2.26
Fat (g/100g)	0.92	0.01	5.14
Crude protein (g/100g)	18.60	0.12	1.96
Ash (g/100g)	1.05	0.01	4.43
Drip loss (%)	0.53	0.03	15.61
Cooking loss (%)	8.15	0.15	5.69
Water Holding Capacity (%)	8.67	0.16	5.92
Luminance	49.79	0.78	4.96
Red index	3.24	0.08	7.36
Red index	3.03	0.04	4.69
Chromaticity	4.44	0.06	3.95
Hue	0.74	0.04	18.86
pH	6.76	0.03	1.21

CV: Coefficient of variation.

Regarding technological characteristics, the drip loss was 0.53%, cooking loss 8.15%, and water holding capacity 8.67%. Color measurements indicated a luminance of 49.79, redness values of 3.24 and 3.03, chromaticity of 4.44, and hue angle of 0.74. The mean pH was 6.76. These results provide baseline information on the quality profile of frog meat, highlighting its potential as a promising unconventional animal protein source.

3.3. Nutritional and Technological Properties of Grasscutter Meat

The processing properties, rheological characteristics, and nutritional value of the grasscutter meat consumed in Benin are presented in Table 3. The analysis of physicochemical and color parameters showed that the dry matter content, crude protein content, fat content, and ash content were, respectively, 28.50 g/100g, 20.90 g/100g, 2.75 g/100g, and 4.08 g/100g.

As for technological characteristics, the drip loss was 1.78%, the cooking loss was 32.50%, and the water holding capacity value was 34.28%. Color measurements indicated that the luminance, the redness, and the yellowness of grasscutter meat were respectively 37.87, 19.12, and 1.56. The chromaticity of grasscutter meat was 19.19, and its hue angle was 12.47. The mean pH was 6.25. These findings provide relevant baseline information on the quality profile of grasscutter meat, supporting its potential valorization as a nutritious and unconventional protein source.

Table 3. Nutritional and technological properties of grasscutter meat.

Variables	Mean	Standard Error	CV
Dry matter (g/100g)	28.50	0.90	1.43
Fat (g/100g)	2.75	0.05	4.11
Crude protein (g/100g)	20.90	0.09	1.00
Ash (g/100g)	4.08	0.14	7.63
Drip loss (%)	1.78	0.34	42.49
Cooking loss (%)	32.50	0.30	2.08
Water Holding Capacity (%)	34.28	0.22	1.42
Luminance L*	37.87	0.36	2.11
Red index a*	19.12	0.48	5.55
Red index b*	1.56	0.10	14.58
Chromaticity C*	19.19	0.47	5.45
Hue H*	12.47	0.93	16.64
pH	6.25	0.02	0.69

CV: Coefficient of variation.

3.4. Nutritional and Technological Properties of Monitor Lizard Meat

The processing properties, rheological characteristics, and nutritional value of monitor lizard meat consumed in Benin are presented in Table 4. The analysis of physicochemical parameters revealed that the dry matter, crude protein, fat, and ash contents were, respectively, 28.46 g/100g, 22.92 g/100g, 2.93 g/100g, and 1.71 g/100g.

Regarding technological properties, the drip loss was 1.83%, the cooking loss was 25.57%, and the water holding capacity was 27.40%. Color characteristics showed a luminance of 44.88, redness values of 12.38 and 16.16, chromaticity of 20.40, and a hue angle of 0.26. The mean pH was 6.36. These findings provide baseline information on the quality profile of monitor lizard meat, which may contribute to its valorization as a non-conventional animal protein source.

Table 4. Nutritional and Technological properties of meat *of Varanus exanthematicus*.

Variables	Mean	Standard Error	CV
Dry matter (g/100g)	28.46	0.18	1.43
Fat (g/100g)	2.93	0.10	7.59
Crude protein (g/100g)	22.92	0.05	0.45
Ash (g/100g)	1.71	0.04	5.23
Drip loss (%)	1.83	0.08	10.15
Cooking loss (%)	25.57	0.34	2.98
Water Holding Capacity (%)	27.40	0.35	2.82
Luminance	44.88	0.24	1.20
Red index	12.38	0.74	13.39
Red index	16.16	0.45	6.23
Chromaticity	20.40	0.57	6.24
Hue	0.26	0.10	81.68
pH	6.36	0.02	0.69

CV: Coefficient of variation.

3.5. Nutritional and Technological Properties of Partridge Meat

The processing properties, rheological characteristics, and nutritional value of partridge meat consumed in Benin are presented in Table 5. The analysis of physicochemical parameters showed that the dry matter, crude protein, fat, and ash contents were, respectively, 27.40 g/100g, 23.34 g/100g, 1.79 g/100g, and 1.04 g/100g.

Table 5. Nutritional and technological properties of partridge meat (*Francolinus bicalcaratus*).

Variables	Mean	Standard Error	CV
Dry matter (g/100g)	27.40	0.27	2.23
Fat (g/100g)	1.79	0.16	19.79
Crude protein (g/100g)	23.34	0.09	0.84
Ash (g/100g)	1.04	0.05	11.08
Drip loss (%)	0.93	0.05	12.95
Cooking loss (%)	7.20	0.16	4.93
Water Holding Capacity (%)	8.13	0.15	4.07
Luminance L*	48.78	0.08	0.37
Red index a*	5.48	0.29	11.64

Continued

Red index b*	8.28	0.12	3.13
Chromaticity C*	9.94	0.18	3.95
Hue H*	0.05	0.08	399.55
pH	5.94	0.04	1.41

CV: Coefficient of variation.

For technological properties, the drip loss was 0.93%, cooking loss 7.20%, and water holding capacity 8.13%. Color attributes revealed a luminance of 48.78, redness values of 5.48 and 8.28, chromaticity of 9.94, and a hue angle of 0.05. The mean pH was 5.94. These results highlight the favorable nutritional and technological profile of partridge meat, supporting its potential valorization as a non-conventional animal protein source.

3.6. Variability of the Quality of Unconventional Meat Resources According to the Species

The analysis of variance presented in **Table 6** clearly demonstrates that species had a highly significant effect ($p < 0.001$) on all physicochemical, technological, and colorimetric parameters of the meats studied. The very high F-values observed, particularly for water-holding capacity ($F = 2167.01$), cooking loss ($F = 1840.93$), and yellowness b ($F = 1113.86$), indicate that interspecies differences were most pronounced for technological properties and color attributes. Ash content ($F = 457.31$), redness a ($F = 449.43$), and chromaticity C* ($F = 524.18$) also revealed strong discriminatory power among species, suggesting substantial variability in both nutritional mineral composition and pigmentation.

Table 6. Variability of the quality of the unconventional meat resources according to the species.

Variables	F-value	P-value
pH	155.98	0.000
Dry matter content (g/100g)	443.69	0.000
Fat content (g/100g)	138.33	0.000
Crude protein content (g/100g)	234.85	0.000
Ash content (g/100g)	457.31	0.000
Drip loss (%)	20.75	0.000
Cooking loss (%)	1840.93	0.000
Water Holding Capacity (%)	2167.01	0.000
Luninance L*	113.43	0.000

Continued

Red index a*	449.43	0.000
Yellow index b*	1113.86	0.000
Chromaticity C*	524.18	0.000
Hue H*	310.20	0.000

Moderate but still highly significant F-values were recorded for pH (F = 155.98), fat content (F = 138.33), and luminance L* (F = 113.43), confirming that these traits also varied between species, though less markedly than technological losses and colorimetric indices. Drip loss (F = 20.75) was the least variable trait across species, even though differences remained statistically significant.

Overall, these results highlight that meat quality attributes are strongly species-dependent. The technological parameters related to water dynamics (cooking loss, water-holding capacity) and the visual colorimetric indices (L, a, b, C, H*) are the most discriminating factors, while the basic proximate composition (protein, fat, ash, dry matter) also contributes to the differentiation, reflecting both nutritional and functional diversity among the meats.

4. Discussions

The evaluation of physicochemical and color attributes across deer, frog, grasscutter, monitor lizard, and partridge meats reveals marked species-specific differences that reflect both their nutritional value and technological functionality.

Deer meat displayed a balanced proximate composition, with moderate dry matter (25.15%) and high protein content (21.53%), positioning it as a lean red meat source suitable for human consumption. Its relatively low fat (2.19%) and stable ash content (1.12%) align with previous reports on red deer and other wild ruminants, which highlight lean carcass composition and favorable protein-to-fat ratios [12] [13] [30]. Technologically, deer meat exhibited stable water-holding capacity (WHC = 25.23%) and moderate cooking loss (24.11%), characteristics that are critical for culinary performance and product yield in processing [14]. The dark reddish coloration (34.75; 23.43) and pH of 5.92 are consistent with typical wild ruminant meat, where high myoglobin content and postmortem glycolytic metabolism contribute to color stability and shelf-life [15]. Overall, deer meat presents as a protein-rich, moderately juicy, and visually appealing option for consumers seeking traditional game meat.

Frog meat, by contrast, exhibited a highly lean profile, with very low fat content (0.92%) and reduced dry matter (21.21%) and protein (18.60%) levels compared to mammalian species. These results corroborate prior findings on bullfrog meat, which emphasize its low lipid content and delicately textured muscle [16] [17] [20]. Technologically, frog meat displayed minimal drip loss (0.53%) and moderate cooking loss (8.15%), alongside limited water-holding capacity (8.67%), reflecting its fragile tissue structure and the challenge of maintaining juiciness during cooking. Its very high luminance (49.79) and low redness (3.24) confirm its pale appearance, which is a recognized characteristic of amphibian muscles [18]. The slightly higher pH (6.76) may enhance microbial stability and influence the perception of tenderness, yet may also limit Maillard browning during thermal processing [19]. Consequently, frog meat represents an ultra-lean, light-colored meat with limited processing flexibility but high nutritional appeal for low-fat diets.

Grasscutter meat exhibited significant variability in dry matter, likely reflecting differences in diet and age at slaughter [10] [31]. Nevertheless, protein content remained high (20.90%), with low fat (2.75%) and the highest ash concentration among the studied species (4.08%), indicating rich mineral content and potential micronutrient benefits. Technologically, grasscutter meat demonstrated substantial drip loss (1.78%) and cooking loss (32.50%), but compensated with excellent water-holding capacity (34.28%), which may preserve juiciness despite thermal losses, consistent with previous observations on rodent meat [7] [9]. Its color parameters (37.87; 19.12; 19.19) suggest moderate redness with stable chromatic intensity, positioning it between darker ruminant meats and lighter avian or amphibian species. This combination of protein richness, mineral density, and favorable water-holding capacity underscores the potential of grasscutter meat as both a nutritious and technologically multifunctional resource [7] [9].

Monitor lizard meat exhibited an intermediate profile, with relatively high protein (22.92%) and moderate fat (2.93%), coupled with dry matter of 28.50% and mineral content of 1.71%, consistent with prior studies on *Varanus exanthematicus* meat [25]. Its technological traits, including moderate drip loss (1.83%), cooking loss (25.57%), and WHC (27.40%), indicate good functional properties for meat processing. Colorimetric analysis revealed high luminance (44.88), moderate redness (12.38), and higher yellowness (16.16), producing a visually lighter meat that contrasts with mammalian game. The stable pH (6.36) further suggests favorable postmortem metabolic stabilization, supporting both shelf life and processing reliability. Monitor lizard meat thus represents a nutritionally rich and functionally versatile alternative, bridging the characteristics of mammalian and avian meats.

Partridge meat shared similarities with frog in its low fat content (1.79%) and high protein levels (23.34%), highlighting its nutritional leanness [22]-[24]. Drip (0.93%) and cooking losses (7.20%) were modest, although WHC remained limited (8.13%), potentially affecting juiciness during preparation. Its color profile—light (48.78), low redness (5.48), and moderate yellowness (8.28)—confirms the pale appearance typical of small avian game [22]. While pH (5.94) indicated stable postmortem metabolism, high variability in hue angle suggests inconsistent pigmentation, which may influence consumer perception and visual appeal during processing.

Taken together, these results highlight the distinct nutritional and functional profiles of the examined meats. Deer and grasscutter offer darker, protein-rich meats with higher water retention, suitable for traditional culinary applications, while frog and partridge provide ultra-lean, light-colored options with limited WHC but excellent nutritional quality. Monitor lizard occupies an intermediate position, combining high protein, moderate fat, and a distinctive color profile. Such diversity underscores the potential of unconventional meat sources for diversifying protein supply, addressing nutritional needs in Benin, and providing culturally acceptable alternatives to conventional meats. However, species-specific challenges for processing, preservation, and sensory optimization must be considered to maximize their value in both household and industrial contexts [25] [32] [33].

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Conflicts of Interest

The authors have declared that no competing interests exist.

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