

COMPARATIVE EFFECTS OF VARIOUS FROG MEAT PROCESSING METHODS ON QUALITY, NUTRITION, AND SENSORY ATTRIBUTES

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ABSTRACT

This study compares the effects of different processing methods on the sensory qualities and overall quality of frog meat. Processing methods examined include grilling, deep frying, shallow frying, and smoking. The samples underwent sensory, proximate, and chemical analyses to assess the impact of these methods. The proximate analysis revealed that the deep-fried samples had the following composition: moisture 6.30%, protein 47.59%, fat 23.29%, and texture 2.519%. The shallow-fried samples showed moisture 10.50%, protein 56.12%, fat 10.28%, and texture 0.95%, while grilling yielded results of moisture 17.70%, protein 38.05%, fat 13.77%, and texture 0.58%. The smoked samples revealed moisture 9.60%, protein 53.51%, fat 8.01%, and texture 1.71%. Sensory evaluation indicated that deep-fried samples were the most favored, while smoked samples were the least preferred. However, local Gashua merchants primarily utilize the smoking method due to its cost-effectiveness. Additionally, differences were noted in the color, taste, aroma, and texture of frog meat processed by the various methods. While there was no significant difference in color between deep-fried and shallow-fried samples, taste varied among processing methods, although all were acceptable to panelists. The mineral analysis showed significant differences in calcium content across the samples, with deep-fried frog meat having considerably lower calcium levels compared to those processed by other methods.

Keywords: Frog meat, processing methods, quality, nutrition, sensory attributes

INTRODUCTION

Frogs, as amphibians, were the first vertebrates to adapt to life on land, typically thriving in tropical regions, including Nigeria (Oldham, 2000). Being cold-blooded, their body temperature fluctuates with environmental conditions. During colder periods, some frogs seek refuge underground or in muddy ponds (Larrea, 2001; Caleb *et al.*, 2018). Frog meat is sourced from both aquaculture and wild populations. Aquaculture frogs tend to be lighter and milder compared to those caught in the wild, which may also carry risks of Salmonella contamination (Zancanaro, 1999). Gashua has become a key producer of frog meat for both domestic and export markets. Mello *et al.* (2006) and Nobrega *et al.* (2007) suggest that incorporating frog meat into diets can help manage cholesterol, obesity, hypertension, and various gastrointestinal disorders. Similarly, Paixao *et al.* (2009) noted its benefits for gastrointestinal ailments and dietary restrictions. Beyond taste, the nutritional advantages of frog meat position it favorably against other protein-rich meats due to its low-fat content (0.3% lipids) and predominance of polyunsaturated fatty acids (Noll and Lindau, 1987). There is a growing interest in the slaughtering and processing of frog meat in Gashua, although quality standards remain unregulated. There is a pressing need for the Sanitary and Industrial Inspection Regulation of Animal Products (RIISPOA), which categorizes frog meat under the fish category (Ramos *et al.*, 2005). Numerous frog species are consumable, with significant suppliers located in Nigeria, particularly Gashua, Potiscum, and other southeast and south-south regions.

Frogs straddle both terrestrial and aquatic habitats, classified as amphibians within the Anura order (meaning "without tail") and encompassing over 5,450 species across 48 families (Vitt and Caldwell, 2009). Frog meat is prized not just for its taste but also for its high biological protein

Comparative Effects of Various Frog Meat Processing Methods on Quality, Nutrition, And Sensory Attributes

value (Vieira, 1993). Most frogs consumed in developed countries are sourced from developing regions, leading to an uptick in frog exports due to rising demand. Onadeko et al. (2011) documented the popularity of frog legs in Europe and their consumption even in regions where hunting is prohibited. In various Asian and African cultures, frogs are likened to "jumping chickens" due to similar flavors (Altherr et al., 2011). The taste and texture are comparable to chicken wings, and frogs are also harvested for leather, souvenirs, and traditional medicine. However, over-extraction of these resources poses a significant threat to biodiversity. Frog legs are rich in protein, omega-3 fatty acids, vitamin A, and potassium. While consumers increasingly seek minimally processed, preservative-free meat with longer shelf lives, there's a trend toward using natural additives over synthetic ones. Research into meat processing typically prioritizes technological and microbiological aspects, but selecting preservation methods should also take into account broader sensory, nutritional, and consumer appeal factors (Beriaín et al., 2011)

Varieties of Frogs and their Uses

Frog species utilized for food, medicinal purposes, and the pet trade across different regions are typically derived from amphibian species, which can have both direct and indirect effects on these species and their ecosystems. Amphibians play a crucial role in various terrestrial and aquatic ecosystems, and their decline or extinction could significantly impact these environments and their interconnected species (Toledo et al., 2007; Mohneke and Rodel, 2009). The wild population of frogs is diminishing (Mohneke et al., 2011). In Africa and globally, the farming of these frog species has largely been overlooked, though their commercial use is growing steadily.

Processing Methods for Frog Meat

Frog meat can be preserved using several techniques to extend its shelf life and reduce spoilage:.

Smoking: This involves cooking food with hot smoke from burning materials, differing from roasting due to lower temperatures and controlled smoke application. Though smoking has been utilized since ancient times for preservation, today its effects on color and sensory qualities are just as significant as its preservation benefits, especially with modern refrigeration methods (Immaculate *et al.*, 2020). The primary goal of smoking is to enhance flavor and aroma while extending shelf life through antibacterial and antioxidant properties (Tacnur Baygar and Nevin Ozgur, 2010). Frog meat can be smoked using traditional combustion methods (either cold smoking at temperatures below 30°C or hot smoking above 60°C), high-voltage electrostatic fields that facilitate smoke deposition, or liquid smoke, which minimizes the presence of harmful compounds (Goulas and Kontominas, 2005).

Nutritional and Sensory Effects of Smoking

Smoking alters the sensory and nutritional characteristics of meat, providing benefits such as improved flavor, color, and aroma. The impact increases with smoking time, and various smoking techniques can be employed including hot smoking, cold smoking, and electrostatic smoking. Typically, the meat is smoked at temperatures between 20-25°C with high humidity for cold smoking or at 75-80°C for hot smoking. Electrostatic smoking reduces processing time, while liquid smoke is utilized when protein denaturation is not desired. Smoking also combats pathogens (e.g., *Staphylococcus aureus*, *Escherichia coli*) and reduces lipid oxidation, which can lead to off-flavors and rancidity. Moreover, in sausages, smoking helps prevent discoloration and can enhance quality when combined with other ingredients like ginger extract during storage.

Frying Methods

Frogs can be cooked in oil through frying techniques: Deep frying involves submerging frog meat in hot oil until it achieves a light brown color, typically after heating the oil for 3-5 minutes. This requires less oil, so the meat must be turned frequently to prevent burning. Sun-drying method involves drying meat in open air is common in developing regions. A study examined sun versus

oven-drying on the nutritional value of various meat types (Ayanwale *et al.*, 2007). Dried meats often have hardened textures and can develop a distinct aroma due to lipid oxidation. The color shifts from red to brown during drying, with salt further darkening it. Compounds like nitrates/nitrites may enhance flavor and color.

Nutritional Advantages of Frog Meat

Frog meat is recognized for its balanced amino acid content and low fat levels, making it a suitable option for low-calorie diets (CASALI *et al.*, 2005; PIRES *et al.*, 2006; NÓBREGA *et al.*, 2007). It is advised for those managing cholesterol, obesity, hypertension, or gastrointestinal conditions, particularly among athletes, convalescents, children, or individuals with sensitivities to animal proteins (MELLO *et al.*, 2006; NÓBREGA *et al.*, 2007). The amino acid profile shows a favorable chemical score without essential amino acid deficiencies (PAIXÃO and BRESSAN, 2009).

Health Benefits of Frog Meat

Frog meat is beneficial for individuals suffering from calcium deficiency and osteoporosis due to its high calcium content, which is readily absorbable, comparable to milk. This makes it an excellent protein source for those who are lactose intolerant, as it has a higher protein level than both milk and beef (PAIXÃO *et al.*, 2009).

Weight Loss Aid: As a nutritious alternative to chicken and red meat, frog meat can assist with weight loss. A 100-gram serving of frog legs contains only 0.3 grams of fat, significantly lower than the 3 grams found in the same serving of grilled chicken breast. Consuming frog legs can help manage fat intake effectively. Incorporating fruits and green vegetables is also recommended to meet vitamin and mineral needs.

Rich Source of Protein: Frog legs provide a substantial protein supply, with 100 grams offering 16 grams of protein, which is essential for muscle building and energy production. They can regenerate damaged cells effectively. For those seeking high-protein options, beans and frog legs are ideal.

Low Calorie Content: Due to their low calorie content, frog legs are an excellent addition to meals. A 100-gram serving of stir-fried frog legs contains 70 calories, whereas chicken thighs contain 280 calories, making frog legs a smart dietary choice. Foods with low-calorie counts help reduce the risk of blood clots and assist with weight management.

Cognitive Benefits: To enhance cognitive function, it is advisable to consume healthy foods such as mackerel, frog legs, salmon, and other seafood; the Omega-3 fatty acids in these foods contribute to a healthier lifestyle.

Sodium Source: Frog legs serve as a significant source of sodium, with 100 grams providing 58 milligrams. Sodium is essential for muscle contraction and fluid balance in the body, as well as blood pressure management. However, it is advisable to prepare frog legs without added salt to avoid excessive sodium intake, which can lead to heart complications like stroke and heart attack.

Potassium Benefits: Frog legs are also rich in potassium, which contributes to muscle strength. A 100-gram serving contains 285 mg of potassium, which lowers blood pressure and enhances muscle and bone mineral density. Consuming potassium-rich foods like frog legs and lettuce can yield health benefits.

Supports Bodily Functions: Frog legs are an excellent iron source, important for oxygen transport in the body, enhancing brain function, and hemoglobin formation. Including frog legs in a diet alongside other iron-rich foods such as beans and red meat can provide significant health advantages. Iron deficiency can increase the risk of anemia.

Enzyme Function: Frog legs contain magnesium, which is critical for enzyme function in the body. Consuming magnesium-rich foods like frog legs also promotes cardiovascular and bone health.

Energy Provision: The protein content in frog legs is essential for energy production, making them suitable for individuals looking to increase their energy levels for various activities.

Comparative Effects of Various Frog Meat Processing Methods on Quality, Nutrition, and Sensory Attributes

Antibiotic Properties: The skin of frog legs has antibiotic properties that help prevent microbial growth, reducing the risk of infections and diseases.

Impotence Treatment: Frog legs may aid in treating impotence in men. Juice derived from frog meat is believed to be effective in enhancing stamina and libido, assisting those looking to boost sexual desire.

Vision Enhancement

Frog legs are a good source of Vitamin A, which plays a significant role in maintaining healthy vision by preventing vision loss and macular degeneration. To further support eye health, incorporating fruits and vegetables like carrots is essential.

Blood Regulation: Iron is crucial for regulating blood flow and preventing anemia. Both potassium and iron contribute to cardiovascular health and protect against heart diseases.

Cancer Prevention: Research indicates that certain proteins found in frog meat can help combat cancer by inhibiting blood vessel growth and destroying tumors (S.O. Oyibo, G.C. Akani, C.C. Amuzie, 2020).

Study Objective

The primary goal of the study is to evaluate how different processing methods affect both the nutritional and sensory qualities of frog meat. Specific objectives include processing frog meat using various techniques, assessing its nutritional value, and evaluating its sensory characteristics.

Justification

Frog meat serves as an affordable source of animal protein for individuals unable to purchase lean meats. The quality of meat can vary based on the processing method used, and this research aims to identify the optimal processing techniques for frog meat.

MATERIAL AND METHOD

Fresh frogs were sourced from the Gashua river in Yobe State, with additional materials obtained from the Home Science and Management Laboratory at the Federal University of Gashua.

Research design

The experimental research design involved processing frog meat through various methods, such as smoking, grilling, deep-frying, and shallow-frying, and evaluating the effects of these methods on nutritional and sensory quality using standards set by AOAC (1990). After processing, sensory analyses were performed in the Home Science and Management Laboratory, involving a panel of ten evaluators.

Preparation of frog meat:

5kg of frog meat—slaughtering—removal of intestine—washing—salting

Deep frying

Shallow frying

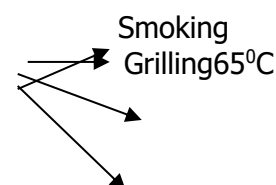


Figure1: Flow chart Methods of processing frog meat (Ayanwale *et al.*, 2007)

Grilling Method: Frog meat is salted and drained, then coated with oil and grilled at 60°C for 30 minutes.

Smoking Method: Frogs are salted and then smoked at a controlled temperature of 65°C until dry.

Deep-Frying Method: Frog meat is salted, then fried in heated oil.

Shallow-Frying Method: Frog meat is salted and pan-fried with heated oil until browned.

Sensory Evaluation

Samples were assessed for their sensory attributes, including color, aroma, texture, and overall acceptability, using a 9-point descriptive hedonic scale. A panel of ten untrained judges from the department performed the evaluations.

Proximate Analysis

Samples were analyzed in the Food Science Laboratory to determine the nutritional impact of the different processing methods.

Sample preparation: Each of fresh samples for the different method of processing were cleaned and cut open and the stomach content completely removed before the proximate composition was done. The analysis was carried out in Food science laboratory of federal university Gashua.

Moisture content: Two grams (2 g) of the samples each was weighed and placed into clean metallic moisture can of known weight. Samples were weighed with a weighing balance (model no AC 223). The weighted samples were allowed to dry for a period of 1hr at 130°C in a preheated oven (model No. DHG 9140A). The sample was removed with the aid of forceps and transferred to the desiccator where was allowed to cool for 15 – 20 minutes and weighted to a constant weight (Ozogul et al (2008).

Calculation:

Sample weight = wt of can+ wt of the sample before drying – wt of an empty can

Moisture loss= wt of can + sample before drying – wt of can + sample after drying
% moisture content = moisture /sample weight x100/1

Ash content: 1 gram of each sample was weighted from the dried samples; this was placed in a muffle furnace (Model No SXL) and then allowed to ash for a period of 3hrs at 550°C and then placed in a desiccator where it was allowed to cool for 3 minutes and then weighted. The percentage of residue weight was expressed as ash content.

Calculation:

Weight of sample = (weight of + sample – weight of empty crucible)

Weight of ash= (weight of crucible +ash – weight of empty crucible)

% ASH = weight of ash/sample weight * 100/1

Protein determination: First, 0.5 g of the weighted samples was placed into the Kjeldahl digestion flask and 0.3 g of copper sulphate (CuSO₄). 3 g of sodium sulphate (NaSO₄), serving as a catalyst, was added into the Kjeldahl flask containing the samples, then 12ml conc. H₂SO₄ was introduced and mounted into kdn -04 c digest furnace. This was allowed to digest for 1hr at 420oC (formation of clear solution). The second phase which is the distillation proceeded and also the final stage of titration which resulted in a pink coloured solution was seen.

Carbohydrate determination: The carbohydrate content was determined using the mathematical equation: Available carbohydrate (%) = 100-[Protein (%) + Moisture (%) + Ash (%) + Fibre (%) + Crude fat (%)]

Fat/lipid determination: Two gram (2 g) of the samples were used for fat determination; the 2 g weighted samples in a thimble was transferred into a Soxhlet extractor, 150 ml of hexane was added and placed on the extraction unit which extracted for 3 hours. The thimble was taken away and the solvent covered. Finally, the extraction flask was placed in an oven and allowed to evaporate resident solvents at 105oC for 30 minutes and placed in a desiccator to cool down. The duplicate samples were used to achieve duplicate values and the mean were calculated.

Calculation: Weight of fat = [weight (wt) of flask + fat] – [weight (wt) of empty flask]

% fat = weight of fat /sample weight x100/1

Crude fiber determination: A total of 0.5 g of moisture-free samples was extracted for 3hours with petroleum ether using Soxhlet apparatus. The fat-free sample was put in a 100 ml beaker where 25 ml of 1.2% of sulphuric acid was introduced; and covered with watch glass. The content was gently heated on a Gehard hot plate for approximately 5 minutes and later filtered under vacuum through a Buchner funnel fixed with filter paper and washed with boiling water until the

Comparative Effects of Various Frog Meat Processing Methods on Quality, Nutrition, and Sensory Attributes

washings were no longer acidic to the litmus. The residue was then washed again into the beaker with 1.25% NaOH and covered with the glass which was allowed to boil for 5 minutes.

Calculation: Crude fibre (%) = weight of fibre/weight of same x100/1

Mineral Analysis: Mineral content of both frog will be analyzed using atomic absorption spectrophotometer (AOAC, 2000). The minerals Ca, Mg, Fe, and k were investigated for all the four different processing samples. Samples were acid-digested (wet digestion); Aqua Regia (HNO₃ and H₂SO₄ in ratio of 3:1) in the fume-cupboard until a clear mixture was obtained. This was then diluted and filtered into 100ml volumetric flask and made up to 100ml mark with distilled water. The sample so prepared was then taken for the mineral analysis in the atomic absorption spectrometer machine.

Statistical Analysis

The data was analyzed using the statistical package for social science (SPSS) to conduct independent t-tests on the frog meat samples

RESULT AND DISCUSSION

Proximate evaluation:

The chemical composition of frog meat used in this study for deep frying, the following results were obtained: moisture 6.30%, protein 47.59%, fat 23.29%, texture 2.19%. Ash 17.88% and CHO 2.76%. Grilling method obtained the following results: moisture 10.50%, protein 56.12%, fat 10.28% , texture 0.95%, ash 21.66% and CHO 0.35%. Shallow fried samples results were: moisture 17.70%, protein 38.05%, fat 13.77%, texture 0.58%, ash 14.03% and CHO 15.97%. The results obtained from smoked samples were as follows: moisture 9.60%, protein 53.51%, fat 8.01%, texture 1.71%, ash 21.80% and CHO 5.5%. The results of proximate analysis of the smoked frog are shown in Table 1.

Table 1: Proximate composition of frog meat

Parameters	Deep frying 65%	Grilling 65%	Shallow frying 65%	Smoked 65%	p-values
Moisture	6.30±0.05d	10.50±0.08b	17.69±0.04a	9.60±0.02c	
Protein	47.57±0.06c	56.11±0.09a	38.05±0.004d	53.51±0.09b	
Fat	23.29±0.02a	10.28±0.05c	13.77±0.07b	8.01±0.05d	
Fibre	2.19±0.08a	0.95±0.05c	0.58±0.05d	1.71±0.04b	
Ash	17.88±0.04b	21.66±0.20a	14.03±0.07c	21.80±0.06a	
Nitrogen free extract	2.76±0.6c	0.35±0.07d	15.97±0.03a	5.51±0.08 ^b	

Values in the same row with same superscripts are not significantly different at 0.05 level of probability.

Table 2: Sensory evaluation

Parameters	Deep frying 65%	Grilling 65%	Shallow frying 65%	Smoked 65%	p-values
Colour	7.80±1.32 ^a	7.80±1.23 ^a	7.60±1.21 ^a	4.30±1.34 ^b	
Aroma	8.00±1.05 ^a	7.20±1.40 ^a	8.10±1.1 ^a	5.40±1.84 ^b	
Taste	8.40±0.42 ^a	7.50±1.18 ^b	7.80±1.23 ^b	5.30±0.82 ^c	
Texture	7.80±0.98 ^a	7.30±1.03 ^a	7.90±1.29 ^a	6.20±1.40 ^b	
General acceptability	8.00±0.85 ^a	7.45±1.25 ^b	7.85±0.79 ^a	5.30±1.47 ^c	

These values are the 9-point Hedonic scale of 10 man/woman panel response to each attribute. The Hedonic scales are: 1 = Dislike extremely, 2 = Dislike very much, 3 = Dislike moderately, 4 = Dislike slightly, 5 = Neither like nor dislike, 6 = Like slightly, 7 = Like moderately, 8 = Like very much and 9 = Like extremely. Values in the same column with same superscripts are not significantly different at 0.05 level of probability.

Sensory evaluation

The results of sensory evaluation of frog meat samples used in this study, are shown in table 2 above. The results revealed that the sensory analyses for deep fried samples parameters were: color 7.8 ± 1.25 , aroma 8 ± 1 , taste 8.4 ± 0.4 , texture 7.8 ± 0.98 , general acceptability 8.00 ± 0.81 , Grilled sample had, colour $7.80 \pm 1.23a$, aroma $7.20 \pm 1.40a$, taste $7.50 \pm 1.18a$, texture $7.30 \pm 1.03a$, general $7.45 \pm 1.25bS$, shallow fried sample color 7.6 ± 1.43 , aroma 8.1 ± 1.04 , taste 7.8 ± 1.67 , texture 7.9 ± 1.22 , general acceptability $7.85 \pm 0.79a$ and smoked sample, color $4.30 \pm 1.34b$, aroma $5.40 \pm 1.84b$, taste $5.30 \pm 0.82c$, texture $6.20 \pm 1.40b$, general acceptability $5.30 \pm 1.47c$. The mean general acceptability of all the methods of processing showed values of $8.00 \pm 0.85a$, $7.45 \pm 1.25b$, $7.85 \pm 0.79a$, $7.85 \pm 0.79a$, indicating that deep fried samples were most preferred, while smoked samples were least liked. The result from Table 2 also showed that there is no significant difference between deep fried, grilled and shallow fried samples in general acceptability. But differences exist between these samples and smoked samples in terms of colour, aroma and texture. Taste attribute showed that there are differences in the taste of all the methods of processing used. However, all the methods were accepted by the panelist.

Table 3: Mineral analysis of frog meat processed with different methods

Parameters	Deep frying 65%	Grilling 65%	Shallow frying 65%	Smoked 65%	p-values
Calcium mg/kg	19950.32 ± 0.03 c	35762.53 ± 0.03 a	$34741.54 \pm 0.04b$	$35750.00 \pm 0.03a$	
Potassium Mg/kg	$5260.12 \pm 0.04c$	$5306.57 \pm 0.03b$	$4428.45 \pm 0.03d$	$5376.88 \pm 0.03b$	
Magnesium Mg/kg	$1005.62 \pm 0.04d$	$1279.63 \pm 0.03b$	$1142.53 \pm 0.02c$	$1288.44 \pm 0.03b$	
Iron Mg/kg	$45.84 \pm 0.03b$	$49.75 \pm 0.04a$	$41.29 \pm 0.03c$	$49.75 \pm 0.04a$	

Values in in the same column with same superscripts are not significantly different at 0.05 level of probability

Table 3 showed the mineral parameters of the processed frog meat indicated that there is a significant difference in the calcium content of the the samples processed with different methods. The calcium content of the deep fried frog meat is far lower than the proceed with other methods. The value of calcium in the deep fried samples (19950.32) is reportedly lower than values of (35762.53, 34741.54, and 35750.00) grilled; shallow fried and smoked samples respectively. Lower calcium content of fried samples might be attributed to chemical metabolism of calcium in the hot oil cooked at 1800C. The potassium, magnesium, and iron content of deep fired samples are also generally lower than those of other processed methods. However, a difference does not exist between deep and fried sallow fried samples in all the minerals analyzed ($p \leq 0.05$).

CONCLUSION

Smoking method is the most popular method of processing frog meat in Gashua but based on the findings of this research, different methods of processing is now made available, and are generally accepted. Deep fat frying is the most generally accepted from the sensory evaluation. However, the cost of oil for frying it discourages the people as it adds extra cost to the processing method. The next most acceptable with least processing cost is grilling therefore, through the help of this

Comparative Effects of Various Frog Meat Processing Methods on Quality, Nutrition, and Sensory Attributes

research, grilling method of processing will also enhance frog meat variety. Based on the findings and conclusion drawn above the following recommendation were made viz: There should be varieties in frog meat by processing it using different methods, again since Beef, chicken and other meat is now very expensive a kilo is #6.000, Frog meat can be used to supplement all the necessary nutrient since the frog meat is generally accepted, cheap and affordable with optimum nutrient

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