Nutritional Composition, Descriptive Sensory Analysis and Consumer Acceptance of Processed Red-Billed *Quelea* Bird's Meat in Tanzania

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Abstract

Consumption of red-billed quelea birds, as an alternative affordable source of meat and proteins is common in various low-income resource communities in African countries, including Tanzania. However, information on nutritional quality, sensory profile and consumer acceptance of the processed bird's meat products is limited. Therefore, the objective of this study was to investigate the proximate composition, descriptive sensory profile and consumer acceptance of processed quelea bird meat. A total of 465 live male birds were obtained from hunters in Kelema village located in Chemba District, Dodoma region. The birds were slaughtered, and their meat was processed by boiling, deep-frying and grilling before being subjected to nutritional composition and sensory analyses using standard methods. Moisture, protein, and fat contents varied from 56.7 to 60.6, 26.9 to 31.3 and 3.0 to 4.4 g/100 g fresh weight (FW), respectively, whereas energy values ranged from 158.7 to 177.1 Kcal/g FW. Sodium was the most abundant mineral in the meat samples (505.9-546.7 mg/100g FW). There were also significant ($p<0.05$) differences in the meat samples' proximate composition parameters and mineral contents between the processing methods. Grilled meat samples had significantly ($p<0.05$) higher intensities for juiciness, tenderness, aroma and consumer acceptance than processed samples. Therefore, processed quelea bird meat is rich in nutrients with appealing sensory properties. Hence, their consumption as an alternative source of meat and proteins in the study area and country at large is recommended.

Keywords: Red-billed *quelea* bird, nutritional quality, sensory profile, consumer acceptance

Introduction

Meat is essential to a balanced diet because of its great nutritional value. It has high biological value proteins, B-complex vitamins, zinc, iron, selenium, phosphorus, and vitamin A (Ahmad *et al.,* 2018; Pereira and Vicente 2012). Tanzania mainly produces and consumes beef, mutton, hog, chicken, and goat meat. Beef accounts for about 82% of all red meat produced and consumed, with goat and mutton accounting for 4% and 14%, respectively (Ministry of Livestock and Fisheries, 2018).

However, although meat is the main source of protein for people all around the world, consumption of meat and its byproducts is low in many low-income households in developing countries, including Tanzania. One of the main challenges is poverty, which is made worse by the high cost of meat due to numerous manufacturing and marketing expenses (Kibona and Zhang, 2022). Tanzania's Ministry of Livestock and Fisheries (2018) estimated per capita consumption of red and chicken meat to be 12 kg and 0.7 kg, respectively, despite the FAO's recommendation of 50 kg of meat per year (Food and Agriculture Organization, 2019). Consequently, some low-income households in the country have been forced to hunt and eat wild animals and birds, such as Giant Cane Rats (*Thryonomys swinderianus*) and *Quelea* birds as cheaper sources of meat and animal proteins (Makupa *et al.*, 2023; Manyama *et al.*, 2014; Kilwanila *et al.*, 2023). Based on empirical evidence, different Tanzanian ecoregions and ethnic groups consume bushmeat at different rates, with the low cost and easy availability being the main factors influencing consumption (Ceppi and Nielsen, 2014; Kiffner *et al.*, 2015;

Mgawe *et al.*, 2012).

Red-billed quelea is the world's smallest wild songbird in the Ploceidae family (Cheke *et al.*, 2007). It is indigenous to Africa, with an average weight of about 20 g with a red bill (de Mey *et al.,* 2012). It is regarded as a pest because of its enormous population, which frequently destroys grain crops like wheat, sorghum, millet, and rice (Markula *et al.*, 2009, Elliott 2006). In Tanzania, large populations of birds are mostly found in Chemba District in the Dodoma region, which annually causes considerable agricultural loss (Mtobesya *et al.*, 2012; Elliott, 2006). Despite the bird's tendency to ruin crops, its meat has been reported to be a good source of several nutrients, including proteins, that may benefit human nutrition and health (Ntuli, 2022; Manyama *et al.*, 2014; Mtobesya, 2012). The birds are caught and consumed as meat by locals, and some of them are sold to customers on the streets and at Chemba and Dodoma City bus stops to raise money for their families (Makupa *et al.*, 2023; Manyama *et al.*, 2014). Makupa et al. (2023) observed that 63.4% of the local communities that are involved in bird hunting do so for food, 28% for business and 17.9% for both food and business. A similar practice of hunting and selling wild birds for food and income has long been carried out by peasants in other African countries, such as Ethiopia, Zimbabwe, Cameroon, and Chad (Ntuli, 2022: Mullie, 2000; Jaeger and Elliott, 1989). Unfortunately, information on proximate composition, mineral contents, sensory profile and consumer acceptance of processed bird meat sold and consumed in Chemba Districts and Dodoma city is limited. Therefore, the broad potential and advantages of this bird meat for human nutrition and food security are not recognized. This study was, therefore, conducted to investigate the nutritional composition, quantitative sensory profile and consumer acceptance of processed bird meat. The knowledge obtained may be used to improve the processing, marketing, and consumption of bird meat and its products to reduce food insecurity and malnutrition of children's protein and energy in the study area and the country at large.

Materials and methods

Birds samples

Four hundred and sixty-five (465) live male quelea birds were bought from hunters in Kelema village, Chemba district, Dodoma, Tanzania. The male birds were selected in order to maintain homogeneity and minimize variation that could arise from uncontrollable factors. The number of birds was determined based on parameters that were analyzed, processing methods and replication as follows: 60 birds were used for QDA (10 Judges x 3 samples x 2 sessions), 306 birds were used for the hedonic test (102 panellists x 3 samples x 1 session), 45 birds were used for proximate analysis (5 parameters x 3 samples x 3 replication) and 54 birds were used for mineral contents (6 parameters x 3 samples x 3 replications). The birds were transported in a cage to the Department of Food Science and Agro-processing Laboratory at Sokoine University of Agriculture (SUA) in Morogoro, Tanzania, for the proximate and mineral content studies. For sensory analysis, other samples were sent to the multipurpose laboratory at the University of Dodoma (UDOM) College of Medicine and Dentistry.

Experimental designs.

A completely randomized study design (CRD) was used to assess the mineral content and proximate composition of raw and processed meat samples. The main factor was the processing method (raw, boiled, grilled and deep-fried). The effect of this factor on the proximate and mineral contents of the meat samples was evaluated and compared using Equation 1.

$$Yij = \mu + \beta i + \varepsilon ij \qquad \text{.............(1)}$$

Where μ is the overall mean, βi is the ith treatment effect (processing methods), and εi is the random effect.

Additionally, a randomized complete block design (RCBD) design was used to determine the sensory profile and consumer acceptance of the processed bird's meat. The principal factors were panellists and processing methods (boiled, grilled, and deep-fried), and the effects were evaluated and compared using Equation 2.

$$Yij = \mu + \beta i + \alpha i + \varepsilon ij \qquad \text{.............(2)}$$

Where μ is the overall mean, βi is the ith treatment effect (processing method), αi is the block effect (panellists) and εijis the random effect.

Sample preparation

Birds slaughtering

Live birds were slaughtered using a neck-slathering procedure described by Zahari *et al*. (2021). The bird's necks were slashed with a sharp knife and left to bleed for around five minutes before being scalded in hot water (50-60 °C) for 20 seconds. The feathers were removed, and birds were eviscerated and cleaned using flowing water. The bird meat was packaged and stored at 4 °C before cooking and chemical analysis. Plate 1 depicts live birds and their meat.

Chemical analysis

Proximate composition of the bird's meat

The proximate composition of the bird's meat was determined using the Association of Official Analytical Chemists (AOAC) standard procedure (2015). Moisture content was determined by oven drying (Method 925.10), fat content was determined by Soxhlet extraction (Method 2003.05), ash content was determined by combustion (Method 923.03), crude fibres were determined by dilute acid and alkali hydrolysis (Method 978.0), and proteins were determined by the micro Kjeldahl method (Method 960.52). Protein content was calculated using a conversion factor of N=6.02. The difference method calculated carbohydrate content (AOAC, 2015). Each proximate parameter was analyzed in triplicate, and computations were made on a fresh weight basis.

Plate 1. Live birds and their meat

Processing of meat

The meat was separated into four groups, each with an equal number of birds. One group was used as a raw control sample, while the other three groups were either boiled, grilled or deep-fried after being submerged in a 20% salt solution for 5 minutes. Boiling was carried out using boiling water at 90 °C for 15 minutes (Olagunju and Nwachukwu, 2020) while the samples were dipped in boiling sunflower oil at 150 °C for 5 minutes for deep-frying (Rani *et al.*, 2023). Grilling was done using a charcoal stove at 150 °C for 15 minutes, as described by Chung *et al.* (2011). The processed birds' meat samples were allowed to cool at room temperature, wrapped in aluminium foil, and stored at 4 °C before chemical and sensory analyses.

Mineral analysis

The mineral content was determined using ash content following the AOAC method (2015). The ash was mixed with 20 mL of 1 N HCL, heated to between 80 and 90 °C for 5 minutes, and then the solute was transferred quantitatively to a 100 mL volumetric flask and levelled with distilled water. Potassium was determined using a flame photometer (flame analyzer) at 722 nm (AOAC, 2015). Calcium and magnesium were determined by an Atomic Absorption Spectrometer (AAS) (Unicam 919, PyeUnicam, England). Each sample was examined in triplicate, and a standard curve was made using a standard solution with known values at 0.5, 1.00, 1.5, and 2.5 ppm. To perform the quantification, the data were then compared to the standard curve and the mineral content was expressed using the formula from Equation 3.

$$Mineral\ content(Mg/100g) = \frac{R\ X\ 100\ X\ DF\ X\ 100}{S\ X\ 1000} .....(3)$$

Where R is the reading value (in mg/kg), DF is a dilution factor and S is a sample weight (g).

Sensory analysis of the processed meat samples

Quantitative descriptive analysis (QDA)

Quantitative descriptive analysis was carried out in the multipurpose laboratory of the College of Medicine and Dentistry, University of Dodoma (UDOM), as described by Lawless and Heyman (2013) and ISO 8586 (2012).

i. Panellist selection and training

Fifteen panellists were selected from students pursuing a Clinical Nutrition and Dietetics degree based on their good health, commitment and motivation. The panellists had six days of training based on the ISO 8586 Standard (2012), during which they developed sensory attributes and descriptions. Eventually, the panellists agreed on colour, aroma, tenderness, juiciness, saltiness, and chewiness as the final study attributes (Table 1). Furthermore, the panellists developed an unstructured 9-point line scale for attribute intensity rating (1 as the lowest intensity value and 9 as the highest intensity value). University of Dodoma's institutional research review committee (IRREC) granted its ethical approval (Ref no. CB.229/308/ on July 8, 2020), and the panellists provided their written consent to participate before the test began.

ii. Panel performance evaluation and final actual test

The panel's performance was evaluated to ascertain the level of agreement among panellists, the ability of individual panellists to discriminate between samples and their ability to reproduce the results. Tucker and p*MSE plots were generated by Panelcheck software VI.4.2 (Tomic *et al.,* 2010) and used in the evaluation. Panellists were given 20 grams of the actual processed meat samples, coded with 3-digit random numbers in a randomized order, and asked to score each attribute's intensity using a 9-point line scale (Civille, and Carr, 2015). Water was provided to rinse mouths between tests to prevent lingering flavours or residues from previous samples. The test was conducted in two sessions, and the mean score was computed. After evaluation, ten of the fifteen panellists were retained for the final descriptive test. The samples were coded with three-digit random numbers and served in a randomized order to each panellist. The obtained average responses were used in the univariate and multivariate analyses.

Consumer Acceptance test

The test was carried out at the multipurpose

Table 1: Sensory attributes and their description developed by assessors during training

Attribute	Description	Scale range (1- 9)
Colour	Measuring the intensity of the brown colour	1 = Weak brownish 9 = Very brownish
Cooked bird meat aroma	Aromatic associated with cooked birds' meat	1 = not aromatic 9 = very aromatic
Juiciness	Amount of liquid released during chewing	1 = not juicy 9 = very juicy
Tenderness	The force needed to masticate the meat ready for swallowing	1 = not tender 9 = very tender
Saltiness	Taste on the tongue associated with sodium chloride ions	1 = not salty 9 = very salty
Chewiness	Time and strength (energy) required to chew the sample with the molars until swallowing	1 = not chewable 9 = very chewable

laboratory of the College of Health and Allied Science (CHAS) of the University of Dodoma by 104 clinical nutrition and dietetics students using a 9-point hedonic scale as described by Lawless and Heyman (2010). The panellists were given twenty grams of the birds' meat coded with a three-digit random number in a randomized order and distilled water at approximately 10.15 a.m. The panellists were asked to rate the samples from left to right on a given scale, indicating how much they liked each one. Water was provided to rinse mouths between tests to prevent lingering flavours or residues from previous samples. Before the test began, each panellist signed a consent form agreeing to participate in the test, which was completed in a single session.

Statistical data analysis

Data were analyzed by R Commander Software (R Core Team, Vienna, Austria) for one-way and two-way analysis of variances (ANOVA) to determine significant variations between factor means. Means were separated by Tukey's Honestly Significant Difference (THSD) at $p<0.05$). Furthermore, principal component analysis was performed using LatentiX Software (version 2.13, Copenhagen, Denmark) to determine systematic variations between variables.

Results and Discussion

Proximate composition of the birds meat

Table 2 shows the results of the proximate composition of raw and processed bird meat. There were significant ($p<0.05$) differences in proximate composition parameters between the raw and processed meat samples. Raw samples had significantly ($p<0.05$) the highest moisture content and lowest energy values compared to the lowest values in fried samples. Additionally, boiled samples exhibited significantly ($p<0.05$) higher fat and protein content than others. There were no significant ($p>0.05$) differences in ash and crude fibres between the meat samples.

The moisture content of food is one of the most important and often used parameters in food processing and testing (Pomeranz and Meloan, 1994). It provides a clear indicator of the economic value, food shelf life stability, resistance to bacterial contamination, and physical and sensory qualities of the food (Moore, 2021; Ogawa and Adachi, 2014). The results have shown that quelea bird meat has a high moisture content (between 50 and 70 %), which aligns with the reported value for other animal and poultry meat (Cheke *et al.,* 2007). These high amounts of moisture imply that the bird meat has a shorter shelf life and is more susceptible to microbial growth. The variation in proximate composition characteristics between raw and cooked meat samples may be mostly caused by temperature and cooking time, which causes cooked meat to lose more moisture (Pang *et al.*, 2021; Nithyalakshmi and Preetha, 2015).

Moreover, the results demonstrated that the meat of quelea birds is high in nutrients, particularly protein, which ranges from 20 to 24% and is on par with or slightly higher than that of chicken meat (Marangoni *et al.*, 2015;

Table 2: Proximate composition and energy values of raw and processed meat (g/100 g Fresh weight (FW))

	Moisture	Protein	Ash	Fat	Crude fibre	CHO	Energy
Raw	60.6 ± 0.01	26.9 ± 0.39^{b}	3.3 ± 0.05^{a}	3.0 ± 0.05c	0.3 ± 0.03^{a}	5.8 ± 0.71^{b}	158. 7 ± 0.01^{c}
		(68.2 ± 1.34)	(8.4±0.240)	(7.7 ± 0.04)	(0.8 ± 0.09)	(14.8 ± 1.63)	(401.6 ±1.16)
Deep fried	56.7 ± 0.02	27.8 ± 0.31^{b}	3.5 ± 0.05^{a}	3.9 ± 0.07b	0.4 ± 0.01^{a}	7.7 ± 0.01^{a}	177.1 ± 0.04^{a}
		(64.1 ± 0.74)	(8.12±0.11)	(9.094 ± 0.17)	(17.7 ± 0.01)	(0.9±0.02)	(409'4 ± 3.40)
Grilled	57.8±0.64	28.4 ± 0.80^{b}	3.4 ± 0.07^{a}	4.3 ± 0.01a	0.3 ± 0.01^{a}	5.7 ± 1.48^{b}	175.5 ± 0.04^{a}
		(67.6 ± 2.88)	(8.1 ± 0.28)	(10.2 ± 0.16)	(0.9 ± 0.02)	(13.4 ± 3.31)	(415.4 ± 0.63)
Boiled	59.2±0.28	31.3 ± 0.61^{a}	3.3 ± 0.08^{a}	4.4 ± 0.04a	0.3 ± 0.01^{a}	1.5 ± 0.01^{c}	170.8 ± 0.07^{b}
		(76.8 ± 0.97)	(8.2 ± 0.23)	(10.8 ± 0.13)	(0.6 ± 0.03)	(3.5 ± 0.73)	(418.6 ± 0.41)

Values are expressed as mean ± SD (fresh weight, n=3). Values in parentheses correspond to dry matter contents. Mean values with different superscript letters along the columns are significantly different at p<0.05

Ahmed *et al.*, 2014). This suggests that low-resource households in the study area and the country may use bird meat as an inexpensive substitute for expensive animal meat and protein. Subsequent investigation revealed that 40 g of cooked meat satisfies the recommended daily allowance (RDA) for protein, which is 0.8 and 1.2 g/kg of body weight for adults and children, respectively. (Cardon-Thomas *et al*., 2012; Wu 2016). The observed differences in proximate composition values between the processed meat samples may be related to temperature and cooking time, which are important factors in developing cooked meat qualitative attributes and physicochemical changes (Suleman *et al.,* 2020). The cooking changes might also differ significantly depending on the heat treatment method used and other parameters like the cooking environment (Combes *et al*., 2004). The low level of protein in the samples may have resulted from changes in protein and loss due to the high temperature utilized in deep-frying (Suleman *et al*., 2020; Omojola *et al*., 2013).

Mineral contents of meat

The results of the mineral content of birds' meat are presented in Table 3. In the meat samples, sodium was the most abundant mineral, followed by potassium and calcium. Significant quantities of zinc were also found in the meat of the *quelea* bird. Furthermore, there was a significant difference ($p<0.05$) in the mineral levels of the processed meat samples, with the greatest values found in the fried samples compared to the other processed samples.

The results demonstrate that the meat of quelea birds has a high mineral content, which may be related to diets high in minerals derived from cereals (Ahmed *et al*., 2014). This indicates that consuming bird meat may help prevent micronutrient deficiencies and related health problems, especially for women and children in the study area. Minerals are essential for many metabolic processes and the normal functioning of biological systems (Soetan *et al.,* 2010). Sufficient amounts of sodium and potassium are crucial for maintaining the osmotic equilibrium and membrane potential of cells and controlling blood pressure (Pirahanchi *et al*., 2023). Calcium is required to grow teeth and bones in children, teenagers, and pregnant women (Cormick and Belizán, 2019; Uusi-Rasi *et al*., 2013). Additionally, zinc and iron are essential for the regular development of children, teenagers and pregnant women (Roohani *et al.*, 2013).

The results indicate that consuming between 100 and 140 g of bird meat can satisfy the recommended daily allowances (RDAs) of 1000–2300 mg/kg body weight for calcium and 700 mg/kg body weight for sodium for both adults and children (Anderson *et al*., 2012). It also shows that 40 grams of bird meat can satisfy the recommended daily requirement (RDA) for zinc, which is 8 and 11 milligrams per kilogram of body weight for adults and children, respectively. Zinc is essential for DNA synthesis, cell growth, protein synthesis, tissue healing, and immune system maintenance (US Institute of Medicine, 2001). Moreover, variations in moisture levels among beef samples may be related to the impact of cooking temperature, which can reduce moisture by up to 10% while increasing dry matter content (Marimuthu *et al*., 2012).

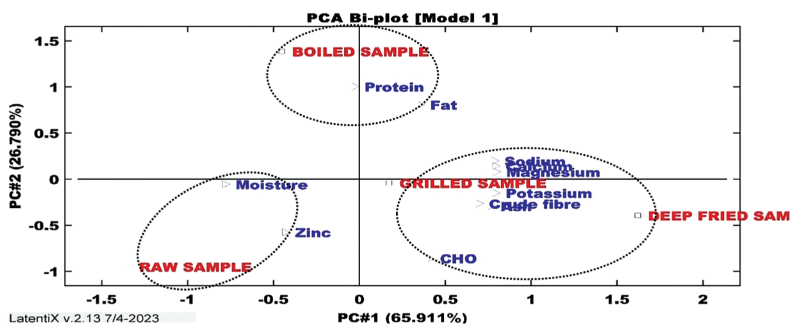

Figure 1: Systematic variations of proximate composition and mineral contents between processed meat samples

Table 3: Mineral contents of birds' meat (mg/100 g Fresh weight (FW))

Sample	Potassium	Calcium	Magnesium	Sodium	Zinc	Iron
Raw	165.6 ± 0.68[a]	147.6 ± 0.62[b]	4.0 ± 0.14[a]	505.9 ± 0.12[a]	7.4 ± 0.31[a]	29.6 ± 0.39[a]
	(420.1 ± 6.32)	(374.4 ± 7.14)	(10.2 ± 0.50)	(1283.47±20.35)	(18.7±0.59)	(75.2±2.03)
Deep fried	193.1±0.98[c]	154.1±0.92[a]	4.8±0.08[c]	546.7±1.71[d]	7.3±0.18[a]	30.6±0.60[d]
	(445.8±2.58)	(355.7±2.37)	(11.1±0.19)	(1261.97±3.06)	(16.8±0.42)	(70.7±1.34)
Grilled	177.3±0.57[b]	151.6±0.62[c]	4.5±0.03[bc]	530.7±0.63[c]	7.4±0.41[a]	37.4±0.52[c]
	(419.9±5.57)	(358.9±4.85)	(10.7±0.22)	(1256.57±19.26)	(17.5±1.25)	(88.6±1.16)
Boiled	169.9±1.64[a]	150.4±0.64[d]	4.3±0.27[ab]	525.4±0.54[bc]	7.3±0.15[a]	34.0±0.11[b]
	(416.7±6.11)	(367.8±4.67)	(10.6±0.72)	(1288.31±9.07)	(18.0±0.25)	(83.35±0/34)
RDA	3510 mg/day -	200-1200 mg/day	310-420 mg/day	< 2000 mg/day	8-11 mg/day	7-27 mg/day
	(WHO, 2013)	US Institute of Medicine, (2011)	Institute of Medicine (1997)	WHO (2013)	US Institute of Medicine, 2001)	US Institute of Medicine, 2001)

Values are expressed as mean ± SD (fresh weight, n=3). Values in parenthesis correspond to dry matter contents. Values with different superscript letters along the column are significantly different at p<0.05

Multivariate approach

The systematic variations in the nutritional composition of processed bird meat samples were further illustrated by the principal component analysis biplot (Fig. 1). Principal component 1 explains 65.9% of the total variability. It differentiates between samples that were raw and boiled (low heat treatment) and samples that were grilled and fried (High heat treatment), along with accompanying nutritional content loadings. Principal component 2 explains 26.8% of the total variability. It distinguished between samples that were boiled and samples that were deep-fried, together with the corresponding loadings of mineral contents and proximate composition. The PCA Bi-plot displays three main groups of processed meat samples together with corresponding proximate and mineral content loadings.

Sensory analysis

Sensory profile of bird's meat

Figure 2 shows the average sensory attribute intensity scores of processed meat samples. Grilled meat samples had significantly (p<0.05) higher aroma, juiciness, tenderness and chewiness intensity scores than other samples. Fried meat samples had significantly (p<0.05) higher colour and saltiness intensity scores than other samples, whereas boiled samples had significantly (p<0.05) lower intensity scores for almost all attributes tested.

Systematic variation in mean attribute intensity scores between processed meat samples was further depicted by a principal component analysis bi-plot (Fig. 3). Principal component 1 (PC 1) accounted for 61.4% of the total variability. It differentiates between grilled meat samples with high juiciness,

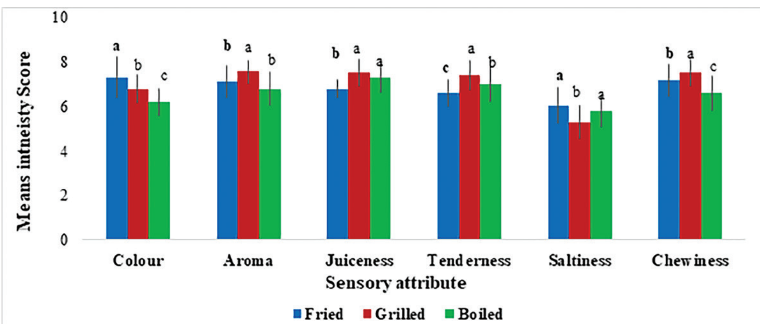

Figure 2: Mean intensity scores of processed birds' meat samples (n=10). Bars with different letters are significantly different at p<0.05

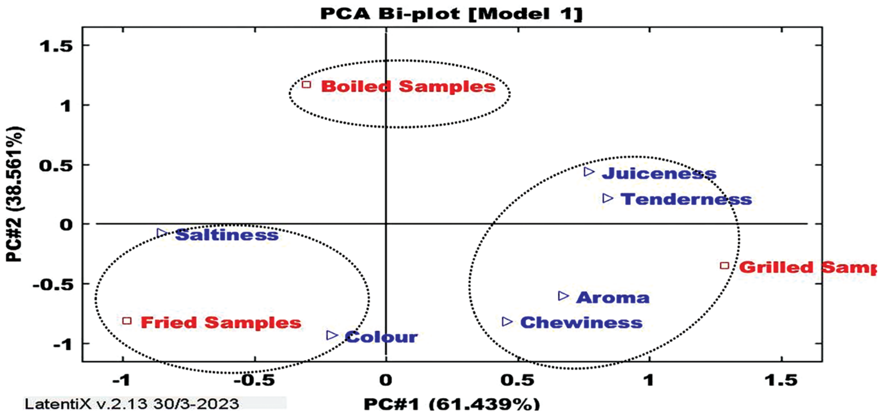

Figure 3: Bi-plot from PCA of descriptive sensory data for processed meat samples

tenderness, aroma and chewiness loadings and other processed meat samples with high colour and saltiness loadings. Principal component 2 (PC 2) accounted for 38.6% of the variability. It differentiates between grilled and deep-fried meat samples on one side and boiled samples and their associated attribute loadings on the other side. The plot shows three major groups of samples and their associated high-loaded attributes.

Cooking processes substantially impact the sensory attributes of processed bird meat samples.

It causes the meat to undergo certain chemical and physical changes, such as the dispersion of fat and water, which improves the meat's sensory properties such as flavour, colour, firmness, juiciness, and eating quality (Combes *et al.*, 2004; Hopkins, 2016; Suleman *et al.*, 2020). In line with the results of this study, Roldan *et al.* (2013) showed that different cooking methods affected the aromatic and flavour profile of lamb meat, enhancing both taste and odour. The reported higher intensities of juiciness, aroma, tenderness, and chewiness in grilled beef samples may be related to the degree of doneness and the amount of water and fat retained after the meat is cooked (Pannier *et al.*, 2018).

Consumer acceptance

Consumer panel characteristics

The consumer panel comprised of 51% women and 49% men. Most participants (89.4%) were undergraduate students, and 93% were between the ages of 15 and 30. Even though the majority of respondents (98.1%) stated they didn't often eat quelea bird meat, 83% stated they would buy and consume it if it were made available in the market

Consumer acceptance of quelea bird meat

Figure 4 shows the average hedonic scores for the processed samples of bird meat.

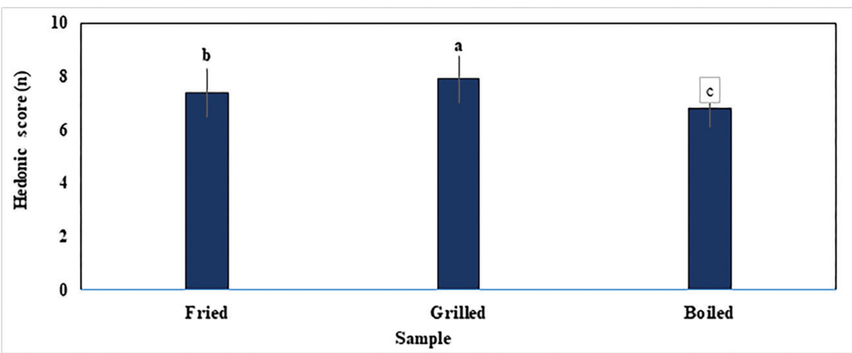

Figure 4: Mean hedonic scores of the processed birds' meat samples (n=104). Bars with different letters are significantly different at p<0.05

Consumer acceptance of grilled meat samples was significantly ($p < 0.05$) higher than that of fried and boiling meat samples.

The higher consumer acceptance of grilled meat samples may be attributed to their appealing sensory properties, such as high aroma, juiciness, tenderness and chewiness intensities, as illustrated in Figure 4. Similar influences of flavour and texture attributes on consumer liking of food products were previously reported (Mongi *et al.*, 2013; Concas *et al.*, 2019). The results suggest that the grilling method produces high-quality quelea meat products with appealing sensory properties and high consumer acceptance.

Conclusion

The red-billed quelea meat has high moisture, protein, fat, energy, sodium and zinc contents, which vary significantly with cooking methods. Raw beef samples had the highest moisture content and lowest energy content when compared to fried samples, which had the lowest and highest values, respectively. Boiled samples had the highest quantities of fat and protein compared to other samples. Sodium was the most abundant mineral in the quelea bird meat, and the mineral contents differed significantly between the processing methods. Furthermore, sensory profile and consumer acceptance of the bird meat varied significantly depending on the processing method. The grilled meat samples had higher intensity scores for juiciness, tenderness, aroma, and chewiness, and they also had higher consumer acceptance than other processed samples. Therefore, processed quelea bird meat is rich in nutrients and has appealing sensory attributes that make it acceptable to consumers. Hence, their consumption as an alternative source of meat and proteins in the study area and country at large is recommended.

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Conflict of Interest: None

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