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Evaluation of microbial and sensory quality of raw and processed poultry sausages from native poultry in Uganda

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Abstract: Despite the growing demand of poultry products across the globe, small scale poultry farmers in developing countries have increasingly found it difficult to benefit from the global markets.The most important challenge is quality and safety of their products. The study was conducted to evaluate the microbial and sensory quality of raw and processed poultry sausages from native mature drakes and toms in Uganda. Microbiological analysis was carried out on minced raw meat and fresh sausages to determine total plate count, total coliform, *E.coli* and *Salmonella*; and sensory evaluation on cooked sausages to determine quality attributes using standard methods. In microbiological analysis, a total of twenty four samples (24) comprising minced raw meat (12) and fresh sausages (12) were examined. The results revealed that in both minced raw meat and fresh sausages *Salmonella* was detected. Total plate counts and total coliforms for minced raw meat and fresh sausages were found to be 4.49$\log_{10}$cfu/g and <3.85 $\log_{10}$ cfu/g; 4.99$\log_{10}$cfu/g and <3.88 $\log_{10}$ cfu/g respectively. There was significant difference ($p<0.05$) in the total coliform levels between mean values of minced raw meat and fresh sausages. Sensory evaluation indicated that cooked sausages were highly acceptable with lowest mean rating of 6.3 and turkey sausages being extremely liked (0.59 increased odds ratio). Ordered regression analysis indicated that colour was the most liked sensory quality attribute of sausages (2.54 increased odds ratio), and it was more significantly different ($p<0.05$) for the sausage types. Combining leg and breast meat (meat ratio) especially duck meat improved the flavour (1.87 increased odds ratio) and Juiciness (0.04increased odds ratio) of the sausages. In conclusion, raw and processed products from native poultry have a relatively high risk of food borne pathogens especially *Salmonella spp*. Therefore, adequate heat treatment of the poultry sausages before consumption is necessary.

Keywords: Native Poultry, Ordered Regression, Microbial, Sensory Attributes

1. Introduction

There is rapid growth in demand and trade in livestock and livestock products in developing countries as source of income and food, especially meat products [10, 11, 40]. Poultry meat products are increasingly consumed in many forms such as dishes, processed food products, value added ready- to- cook and ready- to -eat products because it provides the most important health benefits such as protein, micronutrients, higher poly-unsaturated fatty acids and less cholesterol, which, in turn, increases popularity of poultry meat[9, 13]. However, poultry products are increasingly contaminated with micro-organism which has contributed to foodborne diseases globally [29, 49]. The global burden of food borne diseases is growing, as shown by crises of microbiological hazards in poultry products [6, 48]. As a consequence, consumer foodquality and safety concerns aboutpoultry products are increasingly becoming important [49].Moreover, international trade is increasingly governed by food safety issues, especially the food quality concern about antibiotic resistant strains of *Escherichia coli*, *Salmonella* and *Campylobacter*[48]. In the context of this research, quality is interpreted in terms of totality of features and characteristics of a product that satisfy stated or implied need (ISO, 9000:2000).The quality characteristics comprise the microbial and sensory attributes that influence a product’s value to the consumer [24].

Literature reveals that the increasing quality and safety challenges about poultry products originate from live production and processing methods [2, 3, 10, 43, 48]. The current poultry production systems and processing methods in developing countries are not based on scientifically proven methods, which inevitably compromise the quality of raw and processed poultry products. As globalization of trade and industrialization of food processing increases, the apparent consumer interest in the quality of processed poultry products with greater emphasize on microbial, nutritional and sensory characteristics of poultry products is more justified [6]. Even then sensory attributes such as texture, flavour, aroma, shape and colour are important consideration determining acceptability and choice of a product to potential purchasers [10, 14, 37]. Similarly, intangible and tangible quality attributes are crucial along the marketing and distribution chain of poultry products across the globe [23]. Regardless of the increasing importance of qualityas product acceptability and or choice factors, poultry meat value chain in Uganda have not emphasized the microbial and sensory properties of local poultry products [12, 50]. It is recognized that small scale poultry farmers contribute greater proportion of poultry products to local markets estimated at 80% [12]. Though, access of poultry products to global markets is still limited due poor quality [8]. The major challenges to access to global markets are many, of which the most important is quality and safety of their products [49].Unfortunately, Uganda has insufficient quality assurance system to assure quality and safety of raw and processed poultry product that access markets. Perhaps this is attributed to lack of effective regulations or laws, insufficient harmonized standards and unregulated market structures for enforcement of standards and quality control [12, 8]. Interestingly however, apparent ramp up of innovations and technologies in the animal industry is happening, particularly meat product value addition and meat processing. This is attributed to change in eating pattern, taste and preference for fast foods and meat products by urban dwellers. In this decade the focus of the poultry industry has shifted from marketing live bird as commodity to value added products to facilitate trade in poultry products. The ever-increasing individual preference for poultry and value added or processed products increases the public health risk from foodborne illness associated with microbiological organisms. Equally the poultry processors are increasingly interested in quality raw materials to provide products that meet international market standards and consumer quality expectations [35, 37]. In view of the above, research In Uganda to provide information on quality of raw and processed poultry products together with new innovations and technologies to add value to native poultry products are relevant now than ever. Currently, there is scanty accurate data and poorly documented information on the impact of foodborne disease attributed to microbiological organisms such as *E. coli O157: H7 and salmonella spp*, let alone microbial and sensory quality of raw and processed poultry products. However, as Uganda focuses to participate in international trade in food, she must develop science-based food safety systems to benefit from the global market. The potential of turkey and duck meat for use in value addition innovations and technologies has not been explored. Such-up-date information is important to assure safety and quality of processed poultry products for public consumption and increase trade in duck and turkey products. This study evaluated the microbial and sensory quality of raw and processed products from native duck and turkey meat. Further, I examined the possibility of value addition to duck and turkey meat.

2. Materials and Methods

2.1. Experimental Design

Experimental laboratory studies were done on the minced raw meat and processed poultry sausages. Mature health drakes and toms were procured from markets in Butaleja and Tororo districts gently caged in a basket and transported to the slaughter facility. They were rested overnight and slaughtered the following day. Thereafter, allowed to bleed for 2 minutes, scalded at 55°c, defeathered, eviscerated, dressed, packaged and chilled. The resting was considered important to mitigate the effects of glycolysis on meat quality. The chilled packaged carcass was then transported to the Department of Food technology and Nutrition (FTN) business incubation centre for preparation of minced raw and processed poultry products (fresh sausages). Transportation was done in a vehicle with in-build sterile cold chain facility, inhibiting further bacterial growth. While at FTN the chilled duck and turkey carcasses were deboned and meat packed. The raw and processed sausages were subjected to microbial and sensory quality evaluation.

2.2. Preparation of Sausages

The chilledbreast and leg meat samples from duck and turkey poultry species were each used to prepare fresh sausages according to recipe adopted after optimization. Twelve batches/lots of fresh sausages were prepared from the poultry meat types (turkey and ducks) representing two batches for each category namely duck leg, duck breast, turkey leg, turkey breast sausages, sausages from combined breast and leg meat sample (1:1). The non- meat ingredients used were bread crumbs, maize flour, monosodium glutamate, cooking oil, ice, sodium tripolyphosphate, common salt and combined spices. The process flow chart for fresh sausage preparation was as shown below:

2.3. Microbial Quality Evaluation of Minced Raw and Processed Poultry Sausages

The microbial traits of raw and prepared poultry products were evaluated using methods in Standard manual [5, 34], first to determine the total plate count and total coliforms. The study then screened for possible existence of two bacterial species (*Escherichia coli and Salmonella spp)* in the Coliform group. The description codes for raw poultry meat samples were: 1A-Duck breast meat 2A-Duck leg meat 3A-Turkey leg meat 4A-Turkey breast meat while processed sausages were: 326-duck leg sausages, 519-duck breast sausages, 420-turkey leg sausages, 914-turkey breast sausages, 618- Combined turkey leg and breast sausages, 819-combined duck leg and breast sausages. A total of twenty four samples were handled representing 12 samples of minced raw meat and 12 samples for fresh sausages.

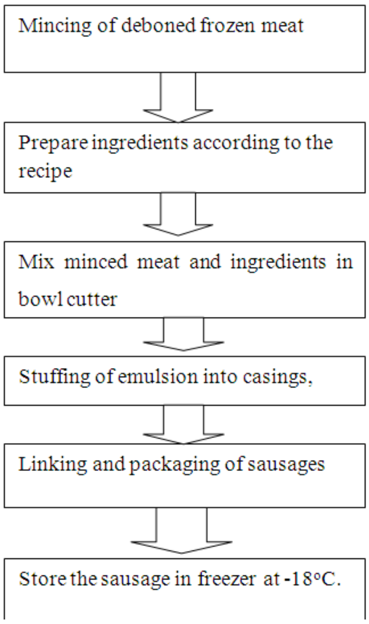


Figure 1. *Flow chart showing stages in sausage processing.*

2.4. Procedures for Microbiological Analysis

The analytical unit of 25g of either raw poultry meat or processed sausage was added to 225g of sterile peptone water a pre-enrichment media. Following the suspension of raw poultry meat and processed sausages into the peptone water, mixture was blended (homogenized) and centrifuged at 10,000 rpm for 2 minutes to concentrate the suspended micro flora in them to form a food homogenate. Thereafter, different microbial flora from homogenate was isolated using several specialized isolation culture media namely: Nutrient agar, Plate count agar, Mac Conkey agar (Oxoid, UK), Peptone water, Violent red bile lactose agar, TSI and Xylose lysine desoxycholate agar (Merck, Germany). The mainly analysed parameters were; TPC, TC, *Escherichia coli* and *Salmonella spp* and the procedures were as indicated below:

2.4.1. Procedurefor Total Plate Count (TPC)

Using separate sterile pipettes draw 1ml of the homogenate and transfer to the test tube containing 9mls of sterile diluent. By repeating the above operation procedure, prepare serial dilutions of 10^{-2}, 10^{-3}, 10^{-4}, and others as appropriate using the same diluent. Thoroughly shake the diluents in test tubes and pipette 1ml of each diluent into separate, duplicate marked petri-dishes as well as for the blank controls. Add 12-15mls of plate count agar (cooled to 45°C) to each plate. Immediately mix dilutions and agar medium thoroughly and uniformly by alternate rotation and back and forth motion of plates on flat level surface. Let agar solidify, invert solidified petri-dishes, and incubate for 48hrs at 35°C. After incubation, select normal plates (30-300) and using bacterial colony counter enumerate all colony forming units (cfu). Record the dilution(s) and the total number of colonies counted. However, TPC is reported as cfu/g, thus a standard formula is used in computation of cfu/g and the counts are represented by recording only first two significant digits. In case the counts from the duplicate petri-dishes are less than ten, counts were recorded as less than 10.

2.4.2. Total Coliforms

Using pouring plate technique, the total coliform was enumerated. The inoculums prepared by mixing the analytical unit into peptone water and later 0.1ml of the homogenised sample is pipetted on the plates and Violent red bile lactose agar (45°C) was poured into 0.1ml inoculums. The plates were incubated at 37°C for 24hrs for enumeration for total coliform. The typical colonies (red colonies) were enumerated.

2.5. Isolation of Escherichia Coli

The MacConkeyagar was inoculated with the raw poultry meat or processed sausage deposit using the streaking method as out lined by the Carter *et al.*, 1995.The inoculated plates were then incubated at 37°C and 45°C for a maximum of 48hrs. The resultant colonies on the agar surface were tentatively identified using phenotypic colonial characteristics and confirmed using biochemical tests/methods.

2.6. Identification of Escherichia Coli

Colonies that appeared pink/red (lactose fermenting), medium sized, flat convex shiny with entire margins on MacConkey plates incubated at 45°C were *E.coli* suspects. These colonies were confirmed using the characteristic IMViC pattern of reactions. The production of indole and production of sufficient acid in the methyl red test confirmed presence of *Escherichia coli.*

2.7. Isolation and Identification of Salmonella Species

The samples were isolated and identified for the *Salmonella* according to methods outlined in OIE (2010). The blended raw poultry meat or processed sausage pre-enriched was incubated at 37°C for 16- 20hrs and thereafter 0.1ml of each was enriched in 9mls of Rappaport Vassiliadis Broth (Bio lab, UK), a selective enrichment broth at 42°C for 18-24hrs. Following the enrichment, the samples were inoculated on solid selective media, solid xylose desoxycholateagar (Merck, Germany) by streaking. The inoculated plates were incubated at 37°C for a period that did not exceed 48hrs. Colonies that appeared with or without a dark centre (H_2S production) were taken to be suspects. Confirmatory identification of *Salmonella* was by biochemical tests namely composite TSI agar, urease production and citrate utilisation at 36°C for 24hrs. TSI agar was inoculated with colonies isolated from the incubated nutrient agar plates having developed colonies. Colonies that were urease negative, citrate positive and yielded an alkaline slant (red) and an acid butt (yellow) were confirmed to be *Salmonella*.

2.8. Sensory Quality Evaluation

Using a random sample of 45 trained and exposed assessors (students of Food Technology and Nutrition), the study examined the taste and preference of the processed fresh poultry sausages to determine acceptability, gauged on a 9 point hedonic rating scale adopted from Meilgaard*et al.*, (1999), with 1 for extremely dislike and 9 for extremely like. The assessors had knowledge and familiarity with quality attributes of different classes of food and could reliably identify differences and communicate their reactions in the score sheet (appendix), on account of being Food Technology Students. Prior to the evaluation, the frozen sausages were thawed at room temperature for 20 minutes, and then cooked in a food oven at 170°C for 30 minutes (appendix). Assessors were then presented with each of the six prepared sausage samples, coded with three digit numbers (to cover the identity). Nine (9) sensory parameters were evaluated (colour strength, taste intensity, hardness, juiciness, flavor, appearance, saltiness, fatty feeling of sausages and overall acceptability).The description codes were maintained as in microbial quality evaluation. The interpretation of the results was based on the standard interpretive values of 9-Point hedonic methods.

2.9. Data Analysis

Data from the laboratory sensory and microbial evaluation was captured using Microsoft Excel. The data (all sources) were exported to STATA Data Analysis System version 11. The data from microbiological analysis was transformed to $\log_{10}$values. For the sensory evaluation, the study first performed an Analysis of Variance, to examine variations in the mean rating of sensory attributes across the sausage types. To assess the preference / rating level of sausage attributes, the study employed a proportionate ordered Logistic regression (running 9 parallel regressions) to ascertain the odds ratio associated with a sausage type and treating the duck leg sausage as reference dummy. The odds ratios reported the likelihood of rating a particular attribute as being extremely liked or otherwise, assuming all other factors are constant. The constants are reported at cuts, represent the baseline odds. But they don't have much statistical information and therefore left out.

Log [pi/1-pi] = linear predictors

For the nine (9) regression equations:

$$\text{Colour}= 420\beta_1+519\beta_2+618\beta_3+819\beta_4+914\beta_5 \quad \text{(I)}$$
$$\text{Taste}=420\beta_1+519\beta_2+618\beta_3+819\beta_4+914\beta_5 \quad \text{(II)}$$
$$\text{Hardness}=420\beta_1+519\beta_2+618\beta_3+819\beta_4+914\beta_5 \quad \text{(III)}$$
$$\text{Juiciness}=420\beta_1+519\beta_2+618\beta_3+819\beta_4+914\beta_5 \quad \text{(IV)}$$
$$\text{Flavor}=420\beta_1+519\beta_2+618\beta_3+819\beta_4+914\beta_5 \quad \text{(V)}$$
$$\text{Appearance}=420\beta_1+519\beta_2+618\beta_3+819\beta_4+914\beta_5 \quad \text{(VI)}$$
$$\text{Saltiness}=420\beta_1+519\beta_2+618\beta_3+819\beta_4+914\beta_5 \quad \text{(VII)}$$
$$\text{Fatty} =420\beta_1+519\beta_2+618\beta_3+819\beta_4+914\beta_5 \quad \text{(VIII)}$$
$$\text{Overall acceptability} = 420\beta_1+519\beta_2+618\beta_3+819\beta_4+914\beta_5 \quad \text{(IX)}$$

The laboratory data from the microbial evaluation was analyzed using the non-parametric standard deviation / variance to ascertain if there could be any possible variation in the level of total plate count and total coliform among the raw and processed meat.

3. Results

3.1. Microbial Quality Evaluation

Bacteriological analysis of minced raw and processes poultry sausages reference to the selected safety indicator organism was carried out. The results showed: *Salmonella* (detected), total plate counts ($4.99\log_{10}$cfu/g) and total coliforms ($3.88\log_{10}$ cfu/g) as maximum limits and *Escherichia coli* (not detected) in table 1below:

Table 1. *Bacterial contamination load of raw poultry meat and processed meat.*

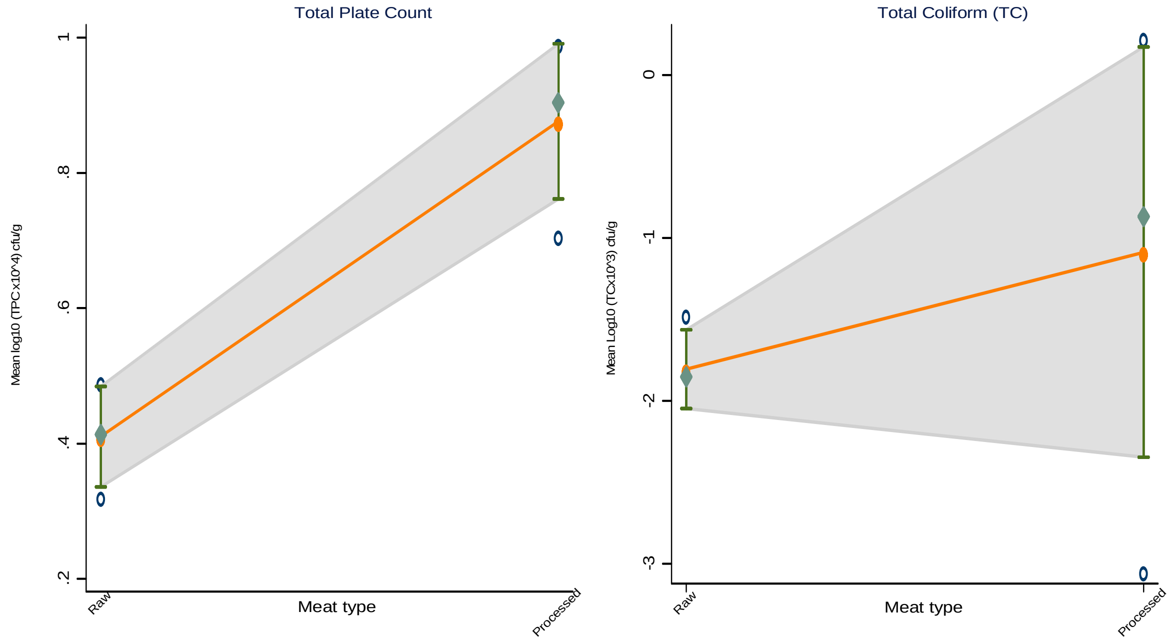
Sample Code	TPC x 10^4	TCx10^3	*E.coli*	*Salmonella*	Meat type	Log_{10} TPC x 10^4	Log_{10}TC x 10^3
1A	2.4	0.009	No	Yes	Raw	0.3802113	-2.04576
2A	3.1	0.014	No	Yes	Raw	0.4913617	-1.85387
3A	2.8	0.014	No	Yes	Raw	0.447158	-1.85387
4A	2.1	0.034	No	Yes	Raw	0.3222193	-1.46852
326	7.3	1.7	No	Yes	Processed	0.8633229	0.230449
618	9.4	0.009	No	Yes	Processed	0.9731278	-2.04576
519	6	0.0009	No	Yes	Processed	0.7781513	-3.04576
819	9.8	0.14	No	Yes	Processed	0.9912261	-0.85387
914	5.1	1.2	No	No	Processed	0.7075702	0.079181
420	8.8	0.13	No	Yes	Processed	0.9444827	-0.88606

Further, the mean $\log_{10}$ values for total plate counts in raw and processed sausages were insignificantly different ($p>0.05$) while the mean value for total coliform were statistically different ($p<0.05$). Further, the mean $\log_{10}$values for total coliform were high for processed sausages (-1.087) than in the raw (-1.806). The results were represented in the table 2 below:

The mean log10 values, median, standard deviation for TPC and TC for the raw and processed meat (Figure2).

***Table 2.** Variance (SD) ratio test on Total Plat Count and Total Coliform, grouped by meat type.*

Meat type	Mean	Std. Err.	Std. Dev.	[95% Conf. Interval]		P-value
Total Plate Count (TPC)						
Raw meat	0.410	0.037	0.074	0.292	0.529	
Processed	0.876	0.047	0.114	0.756	0.996	0.509
Total Coliform (TC)						
Raw meat	-1.806	0.121	0.242	-2.191	-1.420	
Processed	-1.087	0.515	1.261	-2.41	0.236	0.021



Note: Red dots = Means. Green dots=median. The shaded area accounts for Variability (SD) within meat type

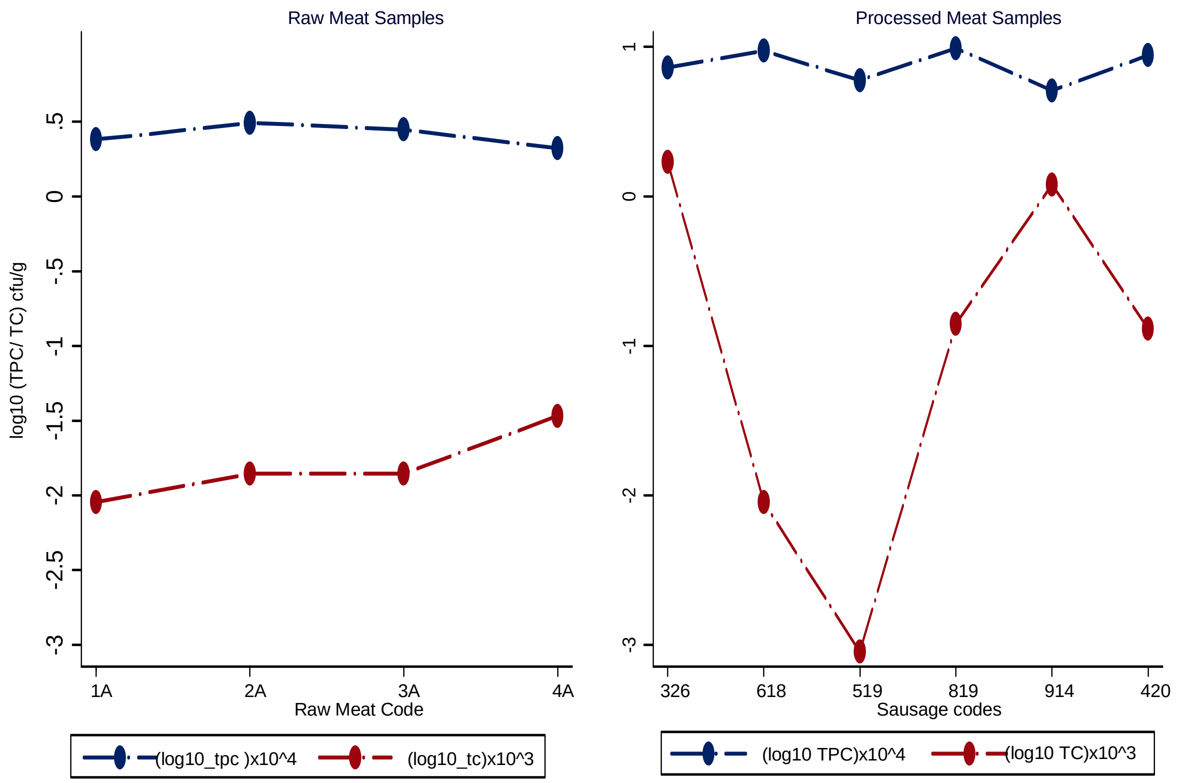
***Figure 2.**Mean Median and Standard deviation plot of TPC and TC of raw and processed poultry sausages.*

Generally, the distribution of microbial groups revealed that log_{10} values for total plate counts and total coliforms were high (greater) in the processed sausages than in the raw poultry meat except log_{10} values of total coliforms for sausage category 519 and 618 (figure3).

3.2. Sensory Quality Evaluation

The sensory quality attributes of processed poultry sausages were evaluated by assessors using hedonic scale rating.The results reported mean, standard deviation and the range/interval of responses provided by the evaluators during sensory analysis. Generally, using the hedonic rating scale evaluator rated sausages highly on most of the 9 parameters. On the duck leg sausages, the lowest mean score was on colour (a mean 6.3) and this technically meant that assessors only liked slightly the colour of duck leg sausages. For the turkey leg sausages, the assessors rated fattiness at mean score level of 6.1. In the same way, for duck breast sausages, evaluators had low rating on juiciness (mean rating of 5.8). Specifically, for this case the evaluators were almost indifferent between liking and disliking. When the combined duck leg and breast sausages were examined, the evaluators seemed uncomfortable with the colour too (mean of 6.3) and lowly rated juiciness of turkey breast sausages (mean of 6.2). The results of hedonic scale rating (table 3).

However, the study also applied an Analysis of Variance to test the null hypothesis that the mean rating level of parameters was the same on all sausages types, against the alternative of inequality of the means. In the analysis, the mean squares, degree of freedom and the probability of the F-test statistics were reported. At 5% level of significance, the mean rating on appearance was statistically significant among the sausages types (p-values<0.05). However, satisfaction of the requirement of Analysis of Variance varied considerably and in particular, results whose Bartlett’s test are satisfied at over 25% may have little statistical meaning (table 4).



Codes: (1A, 519 - Duck breast); (2A, 326 - Duck leg); (3A, 420 - Turkey leg); (4A, 914- Turkey breast) : 618 - Combined turkey leg and breast; 819- combined duck leg and breast

Figure 3. *Plot of Log$_{10}$ of Total Plate Counts and Total Coliforms.*

Table 3. *Resulting Hedonic Statistical Indices (Mean rating (SD), range) for various sausage types.*

Sensory quality attributes	**Sausage type (codes)** 326	420	519	618	819	914
Colour	5.6 (1.6)	6.8 (1.9)	6.7 (1.8)	5.8 (2.3)	6.3 (1.8)	6.5 (2.1)
	1 – 8	1 – 9	2 – 9	1 – 9	2 – 9	1 – 9
Taste	6.9 (1.5)	6.7 (2)	6.9 (1.7)	6.2 (2.1)	6.4 (2.2)	6.7 (1.9)
	2 – 9	1 – 9	3 – 9	2 – 9	1 – 9	2 – 9
Hardness	6.8 (1.7)	7.1 (1.7)	6.6 (1.7)	6.3 (2.1)	6.5 (1.8)	6.6 (1.6)
	3 – 9	2 – 9	3 – 9	1 – 9	2 – 9	2 – 9
Appearance	6.3 (1.5)	6.8 (1.6)	6.8 (1)	5.8 (2.3)	6.6 (1.8)	6.5 (1.8)
	4 – 9	2 – 9	4 – 9	1 – 9	2 – 9	2 – 9
Flavour	6.2 (1.6)	6.7 (1.5)	6.8 (1.3)	6.3 (1.9)	6.7 (1.8)	6.4 (1.9)
	2 – 9	3 – 9	4 – 9	1 – 9	2 – 9	1 – 9
Salty	7.3 (1.7)	7.2 (1.8)	7.7 (1.3)	6.9 (1.6)	7 (1.5)	6.9 (1.6)
	2 – 9	1 – 9	3 – 9	3 – 9	3 – 9	3 – 9
Fatty	6.9 (1.9)	6.1 (1.9)	6.8 (2)	5.9 (2.3)	6.5 (1.8)	6.4 (1.9)
	1 – 9	1 – 9	1 – 9	1 – 9	2 – 9	1 – 9
Juiciness	6.3 (1.8)	6.2 (1.7)	6.4 (1.7)	5.9 (2.3)	6.4 (1.9)	6.2 (1.9)
	3 – 9	2 – 9	3 – 9	1 – 9	3 – 9	2 – 9
Acceptability	6.9 (1.4)	7.4 (1.3)	7.3 (1.5)	6.5 (1.9)	7 (1.5)	7 (1.6)
	2 – 9	4 – 9	3 – 9	2 – 9	4 – 9	3 – 9

Table 4. *Analysis of variance results (Mean square, Degrees of freedom and Probability of F-Statistics).*

Between group Variations	**Sensory attributes** Colour	Taste	Hardness	Appearance	Flavour	Salty	Fatty	Juiciness	Acceptability
Mean square (MS)	10.96	2.81	3.25	6.79	2.66	2.66	4.79	1.23	4.15
Degree of freedom (df)	5	5	5	5	5	5	5	5	5
Prob>F	0.0121[a]	0.57[b]	0.4[d]	0.04[c]	0.46[b]	0.46[b]	0.01[d]	0.89[d]	0.12[a]

Note: Bartlett's test for equality of variance satisfied at a- 25%, b- 10%, c - 5%, d - >25%.
Independent variable as Sausage type (Duck leg, Turkey leg, Duck breast, Combined Turkey Leg and Breast, Combined Duck leg and Breast, Turkey Breast)

3.3. Ordered Logistic Regression

The ordered logistic regression predicated the likelihood of sensory quality attributes to influence preference for the sausage types. Ordered logistic regression output reports the proportionate odds ratios, confidence intervals and the probability. Evidently from the results, the assessors significantly had 2.54 increased odds of extremely liking the colour of a turkey leg sausages compared to a duck leg sausages, assuming all factors are held constant. Taste was rated highest on the ducks breast sausages as the assessors had 0.8 increased odds of extremely liking, compared to the duck leg sausages. However, this association was insignificant. On the other hand, the assessors also liked the hardness of a turkey leg sausage. Specifically, there were 0.4 increased odds of extremely liking the hardness of a turkey leg sausages compared to the duck leg sausages, assuming all other factors are held constant. This was as well true for appearance, although the increase in odds was higher (0.99) compared to the case of hardness. However, assessors also reported higher liking for flavour was on the combined ducks leg and breast sausages (OR=1.87) and duck breast sausages for saltiness (OR=1.38). For fattiness and ranking next to duck leg sausages were the duck breast sausages since there was only a 0.12 decreased odds of extremely liking the sausages. Comparing with other sausages types, this represented the lowest reduction in the odds ratios. On the sensory attributes/parameters of juiciness, there was a 0.04 increased odd of extremely liking the juiciness of the combined duck leg and breast sausages compared to the duck leg sausages alone. And the overall acceptability was the highest for the turkey leg sausages. Assessors had a 0.59 increased odd of extremely liking the overall acceptability of a turkey leg compared to duck leg sausages (table 5).

Table 5. *Ordered Logistic Regression Results (OR (95CI) and P>|z|.*

Sensory quality attributes	**Sausage types (dummies)** 420	519	618	819	914
Colour	3.54(1.72- 7.27) 0.001	3.20(1.56 - 6.58) 0.002	1.3 (0.64 - 2.65) 0.471	1.85(0.92– 3.72) 0.09	2.66(1.28 – 5.53) 0.009
Taste	1.06(0.52– 2.14) 0.88	1.08 (0.53 – 2.2) 0.83	0.65(0.32– 1.31) 0.23	0.79(0.39– 1.65) 0.54	0.93 (0.46 – 1.9) 0.85
Hardness	1.4 (0.68 – 2.91) 0.36	0.78(0.37– 1.61) 0.49	0.64(0.30– 1.35) 0.24	0.74(0.36– 1.54) 0.43	0.82 (0.4 – 1.67) 0.58
Appearance	1.99(0.96– 4.15) 0.07	1.58(0.78– 3.17) 0.2	0.74(0.35– 1.55) 0.42	1.56(0.75– 3.26) 0.24	1.28(0.61 – 2.69) 0.51
Flavour	1.5 (0.74 – 3.08) 0.26	1.53 (0.76 – 3.1) 0.24	1.04 (0.5-2.18) 0.91	1.87(0.89– 3.92) 0.1	1.22(0.59 – 2.52) 0.59
Salty	0.8 (0.38 – 1.69) 0.56	1.38(0.66– 2.88) 0.4	0.51(0.24– 1.07) 0.08	0.58 (0.28 – 1.2) 0.14	0.49(0.24 – 1.04) 0.06
Fatty	0.4 (0.19 – 0.84) 0.02	0.88(0.42– 1.86) 0.74	0.34(0.16– 0.74) 0.006	0.56(0.27– 1.16) 0.12	0.49(0.24 – 1.02) 0.058
Juiciness	0.88(0.43– 1.78) 0.71	0.98(0.48– 1.99) 0.95	0.77(0.37– 1.64) 0.5	1.04 (0.5 – 2.16) 0.907	0.9 (0.44 – 1.86) 0.78
Acceptability	1.59(0.78– 3.23) 0.2	1.5 (0.73 – 3.1) 0.27	0.64(0.31– 1.34) 0.24	1.17(0.57– 2.39) 0.67	1.09(0.53 – 2.24) 0.81

Note: Dependent variables as Sensory attributes: Duck leg dropped as reference category in the sausage type dummy.

4. Discussion

This study was the first of its kind in Uganda to investigate the microbial and sensory quality attributes of raw and processed sausages from duck and turkey meat. The results showed that raw poultry meat and processed sausages from the native poultry meat types have a high risk of microbial contamination especially *Salmonella spp*. This is consistent with other studies that reported poultry meat contamination with micro-organisms [29, 44]. The results concur with the fact that poultry and poultry products are increasingly associated with food-borne pathogens which cause diseases world over [1]. With the exception of the results for *Salmonella*; the total plate counts, total coliforms and *Escherichia coli* were within acceptable level of microbiological quality. These microbial count results were in agreement with microbiological standandards of raw and processed meat products [17, 16, 21, 39, 27]. These standandards recommend microbiological limits of total plate counts, total coliform, *E.coli* and *Salmonella* as: 10^6, 10^2, 10^2, and not detected respectively. The findings also concurred with other studies which gave total coliforms and *E.coli* as 4.60-4.64$\log_{10}$cfu/g and 3.89$\log_{10}$cfu/g; total coliform (1.62 to 3.63$\log_{10}$cfu/g) and *E.coli* (0.88 to 1.15$\log_{10}$cfu/g) respectively [7, 18]. On the contrary however, another study found levels of total plate count and *E.coli* above the recommended microbiological limits [19]. Whereas in this study total plate count, total coliform, *Escherichia coli* and *Salmonella* were used as indicator organisms inmicrobial quality assessment of raw and processed poultry sausages; *Escherichia coli* was the best feacal indicator organism to assess sanitation conditions during processing because of their high prevalence in the feaces of health animals [3].

Thus, failure to detect it in both raw poultry meat (minced) and processed sausages suggests that good hygienic and sanitation practices were implemented during handling, preparation of raw poultry meat and processing of sausages. In contrast, detection of *Escherichia coli* and *Salmonella spp* in both raw and processed products could suggest compromised safety of the product. In other words, indicates potential foodborne pathogens in the product and risk to public health. In the study however, *Salmonella spp* was detected in raw and processed product, implying compromised microbiological quality of the product for human consumption. The *Salmonella* pathogens could have resulted from contaminations along the production system or through cross contamination from the environment [3, 43]. More importantly, the results showed that means for total plate counts and total coliform were increasingly high in the finished processed products (sausages) than in the raw poultry meat (minced meat). The fresh sausages were reported to have higher total plate counts than minced meat [19]. Thus, increased level of microbial load in the processed products (sausages) is more likely to be associated with cross contamination and improper product handling after processing. The cross contaminations may have come from poor quality ingredients such as: non-meat materials, personels, environment, wrapping materials and equipments used [42, 45]. On the contrary, non-meat ingredients in sausages such as spices and herbs have inhibitory effect on bacterial species such as *Salmonella*, *Clostridium* and *Escherichia* [38]. The presence of *Salmonella spp* in both raw and processed product is an indication that the production line of the fresh poultry sausages lacks measures to kill or control microbial pathogens.

Focusing on consumer preference for sausage types, most of the sensory quality attributes were highly rated. This implies that their characteristics were more appealing and acceptable to the evaluators. Though, there were variations among the mean square of sensory attributes. The mean square of appearance was more statistically different for all sausage categories. As such, it’s more likely to influence decisions to make food (sausage) choice among the consumers. The appearance and or colour are important in influencing consumer preference to purchase poultry products [14]. The results of ordered regression revealed that colour, taste, appearance, flavour and hardness were the most liked sensory quality attribute of sausages to influence consumer preference. Of these, colour was more significant. Turkey sausages were perceived to be more superior to duck sausages premised on overall acceptability and increased odds of liking the sensory quality attributes of the products. Particularly, turkey leg sausage was most liked to duck sausages as presented by increased odds of the colour, hardness and appearance. These sensory attributes are determined by species variations in chemical composition of the different muscles [33, 22]. In addition, structural and physiological differences of the breast and leg muscles are significant [28, 41]. This probably explains the observed superiority in appearance and hardiness of sausages types.

The ordered regression results similarly showed that flavour and taste were among the most liked sensory attributes of duck breast sausages compared to turkey sausages. This is attributed to the fact that duck breast meat has more fat than turkey meat, which, in turn, enhances the flavour and the aroma of the duck breast sausages. As such, the effects were reflected in high rating of the flavour and taste qualities for the processed duck sausages. This observation emphasizes the fact that high fat content than protein in duck meat compared to other poultry meat types [33, 22]. Other than the peculiarity in chemical compositions of the bird muscles, physiology and the processing procedures significantly influence the sensory characteristics of the processed products [4, 2, 28, 36]. Further, the results showed low rating for juiciness of duck sausages compared to turkey sausages. It is known that juiciness is determined by the level of fat content and moisture contentsof meat, which, in turn influence hardness or tenderness of the product. Perhaps this explains the empirical results of low rating of juiciness for duck sausages. This is consistent with another study which found that duck meat has low moisture content [33]. Interestingly however, a combined duck leg and breast sausage improves the fattiness, which, in turn, enhances flavour and juiciness of the sausages as demonstrated by increased odds ratio. The combined turkey leg and breast sausages also had improved sensory quality attributes as reflected by the increased odds. Therefore, the findings suggests that combining the leg and breast part of duck and turkey meat has a positive impact on improving the sensory quality of the processed sausages. This finding re-affirms importance of structural and physiological differences in the breast and leg muscles of poultry [28, 41]. In addition, sensory quality attributes are improved on further processing [36].

5. Conclusion and Recommendations

The study established that raw and processed sausages from native poultry have a relatively high risk of microbial contamination with *Salmonella* pathogens. Presence of *Salmonella* poses a high risk of food borne illness, which, in turn, validates the recurrent quality concerns of consumers about the poultry products. The sensorial attributes of cooked poultry sausages are more appealing to consumers, and turkey sausages being extremely liked. Combining leg and breast meat (meat ratio) of the duck and turkey meat improves the flavour of sausages. Therefore, we suggest that adequate heat treatment of the sausages before consumption is necessary. Further, Indepth studies along distribution and marketing levels to establish the sources of contamination and probably the critical control points are important.

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References

[1] Bean, N.H. and Griffin, M. (1990). Foodborne disease outbreak in the United States, 1973-1987: pathogens, vehicles and trends. Journal of Food Protection, 53:804-817

[2] Biswas, S., Kandeepan, G., De', A., and Bhattacharya, D. (2009). Innovative Technologies for the quality improvement of buffalo meat. 9:250-256

[3] Byarugaba, D.K., Kisame, R. and Olet, S. (2011). Multi-drug resistance in commensal bacteria of food of animal origin in Uganda. *African Journal of Microbiology Research*, 5 (12).1539-1548. http://www.academicjournals.org/ajmr. Accessed on 5/4/2012.

[4] Bhattacharyya, D., Sinhamahapatra, M. and Biswas, S. (2005). Preparation of sausage from spent duck-an acceptability study. *International Journal of Food Science and Technology*, 42: 24-29.

[5] Carter, G.R., Chengappa, M.M. and Robert, A.W. (1995). Microbial Nutrition, Metabolism and Growth. In essentials of veterinary microbiology (5th edition).Lea and Febiger US, 35-38.

[6] CABI (2007). Animal Health and Production Compendium. International trade in Animal products- legal obligations and governing bodies.www.cabicompendium.org/ahpc. Accessed on 21/11/2013

[7] Chaiba, A., Rhazi, F. F., Chahlaoui, A., Soulaymani, B. R. and Zerhouni, M. (2007). Microbiological Quality of Poultry Meat on the Meknès Market (Morocco), *Internet Journal of Food Safety*, 9: 67-71

[8] MAAIF (2010). Development strategy and investment plan 2010/11-2014/15

[9] FAO (2002). Global Production and Consumption of Animal Source Foods. Presented at the conference "Animal Source Foods and Nutrition in Developing Countries" held in Washington, D.C.June 24-26.

[10] FAO (2004). Small-scale poultry production. Technical guide, edited by E.B.Sonaiya&S.E.J.Swan.Rome.ISSN 1810-1119

[11] FAO (2005). The state of food and agriculture. Food and Agriculture Organisation, Rome. http://apps.fao.org.page/collection. Accessed on 12/10/12

[12] FAO (2008).Poultry Sector Country Review. Uganda. FAO Animal Production and Health Division www.fao.org/avianflu//en/farmingsystems.html. Accessed on 6/3/2012

[13] FAO (2010). Poultry Meat and Eggs, agribusiness hand book. www.eastagri.org. Accessed on 4/3/2012.

[14] Fletcher, D.L. (2002). Poultry meat quality. *World's poultry Science Journal* 58(2):131-145 Doi:10.1079/WPS20020013

[15] Foley, S.L., Lynne, A.M. and Nayat, R. (2008). *Salmonella* challenges: prevalence in swine and poultry and potential pathogenicity of such isolates. *Journal Animal Science*, 86: E149-E162

[16] Food Administration Manual (1995). Microbiological Reference Criteria for Food. Vol 11, Version 2.0: 3-25

[17] Gilbert, R.J., deLouvois, J., Donovan, T., Little, C., Nye, K., Ribeiro, C.D., Richards, J., Roberts, D., Bolton, F.J.(2000). Guidelines for the microbiological quality of some ready-to-eat foods sampled at the point of sale.3:163-7

[18] Gill, C.O., Rahn, K., Sloan, K. and McMullan, L.M. (1997). Assessment of the hygienic performance of hamburger pathy production processes. International Journal of Food Microbiology, 36:171-178

[19] Gungor, E. &Gokoglu, N. (2010).Determination of microbial contamination sources at a Frankfurter sausage processing line.*Turkey Journal of Veterinary Animal Science*, 34(1): 53-59. Doi: 10.3906/vet-0805-28

[20] Groom, G.M. (1990).Factors affecting poultry meat quality. CIHEAM- Options Mediterranneennes; 206-209

[21] Health Protection Agency (2009). Draft quid lines for assessing the microbiological safety of ready to eat foods.

[22] Huda, N., Putra, A.A. and Ahmad, R. (2011). Potential Application of Duck Meat for Development of Processed Meat Products. Current Research in Poultry Science, *1:1-11*. DOI: 10.3923/crpsaj.2011.1.11

[23] Hunton, P. (2010)**.**Research is the key to prosperity.WorldPoultry.26 (05). 25.

[24] Ingr, I. (1989). Meat quality: Defining the term by modern standards. Fleisch, 69: 1268.

[25] Jing, H. & Shively, G. (2012). A review of Agriculture, Food Security and Human Nutrition Issues in Uganda. 2-10

[26] Lawless, H. (1991). The sense of smell in food quality and sensory evaluation. *Journal of Food Quality* 14:33-60.

[27] Lorraine, M. (2006). BC Centre for Disease control. Report on Food Quality Sampling Program: 3-16.

[28] Mead, G. C. (2000). Fresh and further-processed poultry. In: Microbiological Safety and Quality of food. Ed. Lund, B.M., Aspen Pub., 445-471

[29] Mead, G. C. (2004). Microbiological quality of poultry: a *review in Brazilian Journal of Poultry Science,* 6(3):135-142

[30] Meilgaard, M., Civille, G.V. and Carr, B.T. (1999)**.** Sensory Evaluation Techniques, 3rded, CBC Press Inc, Boca Raton, FL.

[31] Memon, A., Malar, M. U., Rajpat, N., Memon, A. S., Leghari, I. H. and Soomro, A. H. (2009). Consumption and cooking patterns of chicken meat in Hyderabad district. *Pakistan Journal of Nutrition* 8(4): 327-331

[32] Northcutt, J. K. (2009). Factors Affecting Poultry Meat Quality. http://www.thepoultrysite.com/articles/1312/factors-affecting-poultry-meat-quality.Accessed on /9/2012

[33] Nurul. H., Ooi.J.L.,Yong. C.P. andTina.N. (2010). Effect of Chicken and Duck Meat Ratio on the Properties of Sausages. *International Journal of Poultry Science,* 9(6).550-555.

[34] OIE, (2010).Manual of diagnostic tests and vaccines for terrestrial animals. www.oie.int/fileadmin/Home/eng/.../2.09.09_SALMONELLOSIS.pdf. Accessed on 21/5/2013

[35] Petracci, M. &Baeza (2009). Harmonization of methodology of assessment of poultry meat quality features. Working paper of WPSA Working Group 5 Poultry Meat.

[36] Sahoo, J., Samoon, A.H. and Sapcota, D.(1996). Recent developments in further processed poultry meat products.Indian Food Indust., 15(2): 30-36

[37] Santiago, A. (2002). Biological, Nutritional, and Processing Factors Affecting Breast Meat Quality of Broilers.

[38] Shalef, L. A. (2007). Antimicrobial effects of spices. *Journal of Food Safety*, 6: 29-44.

[39] Shareef, A.M., Farag, R.A. and Al-Ruthwani, E.K. (2012). Evaluation of bacterial load of frozen chicken thighs in Mosul markets.*Iraqi Journal of Veterinary Sciences*, Vol. 26, (II): 63-69). Proceedings of the 6th Scientific Conference, College of Veterinary Medicine, University of Mosul

[40] Simeon, M. (2006). Animal production food safety challenges in global markets. Sanitary and phytosanitary measures and food safety: challenges and opportunities for developing countries. Review Scientifiqueet technique. Off. Int. Epiz., 25(2): 701-712.

[41] Smith, D. M. (2001). Functional properties of muscle proteins in processed poultry products. In poultry meat processing. Edd.Sams, A.R., CRC, press.

[42] Syne, S. M., Ramsubhag, A. and Adesiyun, A. A. (2013**)**. Microbiological hazard analysis of ready-to-eat meats processed at a food plant in Trinidad, West Indies. Infection Ecology and Epidemiology, 3: 20450 http://dx.doi.org/10.3402/iee.v3i0.20450

[43] Tilman, D., Kenneth, G., Cassman, P., Matson, A., Rasamond, N. and Steven, P. (2002). Agricultural sustainability and intensive agricultural practices. Nuture,418(8).675. www.nature.com/nature. Accessed on 2/3/2012.

[44] Tsai, H. & Hsiang, P. (2005). The prevalence of antimicrobial susceptibilities of *Salmonella* and *Campylobacter* in ducks in Taiwan. *The Journal of Veterinary Medical Science/ the Japanese Society of Veterinary Science*, 67(10:7-12

[45] Walker, S.J., Archer, P., Banks, J.G. (1990**).** Growth of Listeria monocytogenes at refrigeration temperatures. *Journal of Applied Microbiology*, 68: 1365-2672.

[46] Waskar, V.S., Devangare, A.A., Gosavi, P.P., Ravikauth, K., Maini, S., Rekhe, D.S. (2011**).** Meat Quality Attributes of broilers supplemented with Herbal Toxin binders products. Published on 10/20/2011.

[47] Waskar, V.S., Devangare, A.A.1., Gosavi, P.P.1., Ravikanth, K.2., Maini, S.2.and Rekhe, D.S. (2009). Meat Quality Attributes of broilers supplemented with Herbal Toxin binder Product. Veterinary World, 2 (7): 274-277

[48] WHO (2001) .World Health Organisation surveillance programme for control of foodborne infections and intoxications in Europe. Seventh report, 1993-1998. In: Schmidt K. and Tirado C. (Ed). Federal Institute for Health Protection of Consumers and Veterinary Medicine (BgVV), Berlin, Germany, pp. 415, 422-423.

[49] WHO (2002). WHO global strategy for food safety: Safer food for better health. http://www.who.int/fsf. Accessed on 12/4/2012.

[50] USAID (2010). Parternership for Safe poultry in Kenya (PSPK) Program. Value chain analysis of poultry in Uganda.