



Nutritional Composition, Physiochemical Analysis, Sensory Properties and Economics of Raw and Roasted “Niri” (*Citrullus vulgaris*) Chaff Extended Beef Sausages

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Abstract | There are increasing incidences of obesity, cardiovascular and other dietary related diseases as a result of the crave for ready-to-eat and processed foods. These foods lack adequate dietary fiber which contributes to these diseases. This study investigated the effects of “niri” chaffs (raw and roasted) as an extender on the nutritional, physiochemical, sensory and economics of beef sausages. All treatments were randomly assigned to minced beef by a completely randomized design. Raw and roasted “niri” chaffs were incorporated at 0, 5, 15 and 25% to minced beef. The Association of Official Analytical Chemist and the British Standard Institutes procedures were used to determine the proximate and sensory characteristics of the beef sausages, respectively. The results revealed significant ($p < 0.05$) differences in some of the parameters determined. Raw and roasted “niri” chaffs extended beef sausages (extended products) generally had an improved ($p < 0.05$) effect on fat (1.5–3.28%), ash (1.31–2.19%) and carbohydrate (2.06–20.81%) contents as compared to control. A decline ($p < 0.05$) was observed in moisture content of beef sausages (62.34–21.52%) by the treatment of raw and roasted “niri” chaffs as compared to control. The protein contents of RaC 5% and RaC 15% (5% and 15% raw “niri” chaff beef sausages, respectively) were better ($p < 0.05$) than the rests of the products. Extended products exhibited significantly ($p < 0.05$) high calcium, iron and magnesium than control products; while potassium and zinc contents of beef sausages were improved by the treatment of 5% raw “niri” chaff than the control. pH values of products were in the range of 5.76–6.00. Raw chaffs extended products had higher grilling loss (5.4–25%) than roasted products (4–13.95%). Lipid peroxidation values showed that all “niri” chaffs extended products had exceedingly high ($p < 0.05$) values than the control within the storage period with raw products being the most affected. The formulation cost saw an average cost reduction of Gh¢ (Ghanaian Cedi) 2.25 using raw and roasted “niri” chaffs for the sausages. This study reveals that raw and roasted “niri” chaffs have the potential for use as an extender in beef sausages.

Keywords | *Citrullus vulgaris*, Economics, Raw/roasted, Sausage

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INTRODUCTION

Humans have recognized the indispensable role of meat and meat products to the growth and healthy life of mankind. The prime components of meat are water, proteins and fats, with a considerable amount of minerals and vitamins (America Meat Science Association, 2016; Ahmad et al., 2018). Meat also has a high degree of bi-

oavailability making it better available to the body (Bhat & Hina, 2011; Ahmad et al., 2018). Meat and its related products can be tailored by the addition of ingredients that are considered valuable for health through the elimination or reduction of ingredients that are considered detrimental to human health (Bhat & Hina, 2011; Talukder, 2015). Rapid urbanization coupled with altered life styles increased the demand for more nourishing and set to eat

meat products (Deogade et al., 2008) like sausages. However, consumers of meat and meat products are increasingly becoming aware that dense energy foods like meat are associated with many chronic diseases (Bhat & Hina, 2011; Qian et al., 2020). It has been established that there is a positive association between meat eating and colorectal cancer (Sadri & Mahjub, 2006), cardiovascular diseases, obesity and many other disorders (Mozaffarian, 2016; Neuenschwander et al., 2019; Qian et al., 2020). The addition of dietary fibre in daily diet is highly recommended (Dhingra et al., 2012; Song et al., 2016; Anonymous, 2020) in reducing the health effects of consuming highly dense energy foods like meat and meat products.

The addition of fiber to meat products improves the characteristics of the products and increase the profit margins of the processors (Bhat & Hina, 2011). The inclusion of fiber in meat products also improves cooking yield, enhances texture and reduces formulation cost (Dhingra et al., 2012; Talukder, 2015). Dietary fiber consumption through meat incorporated with vegetables, fruits and certain grains is linked to the reduction in plasma and low density lipids (LDP) like cholesterol as well as reduction in the risk of major dietary diseases like obesity, coronary diseases, diabetes, gastrointestinal disorders, including constipation and inflammatory bowel diseases (Song et al., 2016; Anonymous, 2020).

Dietary fiber can be incorporated to meat and meat based products through various sources such as vegetables, cereals, fruit, tubers and legumes in the form of extenders, fillers and binders (Bhat & Hina, 2011; Teye et al., 2015; Food and Agriculture Organization, 2020; Ossom et al., 2020). The high cost of meat products has made it impossible for consumers to regularly include them in their daily diets. Processors are now resorting to the use of locally available ingredients as extenders in meat products to reduce cost of products. One local feed ingredient with the potential for inclusion in meat products is “niri” (*Citrullus vulgaris*), a member of the melon family (Adua et al., 2020). Adua et al. (2019) also reported that, raw “niri” chaff has 8.34% protein, 16.98% fat and 69.85% carbohydrate, while roasted chaff has 9.95% protein, 38.18% fat and 47.12% carbohydrate making “niri” potential candidate as an extender in beef sausages. This study was conducted to determine the pH, nutritional, sensory, oxidation and formulation cost of beef sausages extended with raw and roasted “niri” chaffs.

MATERIALS AND METHODS

EXPERIMENTAL DESIGN

All trials were done using completely randomized design. Equal amounts of spices were added to minced beef (1kg). The treatments (raw and roasted “niri” chaffs) were each randomly added to minced beef at 0, 5, 15 and 25% inclu-

sion rate.

“NIRI” CHAFFS PREPARATION

Raw and roasted “niri” chaffs were collected separately onto 50×35 cm² trays and oven dried at 60°C for 8 hours in an electric oven (Turbofan Blue seal, UK), cooled for 6 hours at 26°C and blended using kitchen blender (Philips) for 8 minutes. Samples were then collected, cooled, sealed and stored in a freezer for further use (sausage preparation). Figure 1 shows “niri” plant with a fruit, while Figure 2 shows “niri” seeds.



Figure 1: “Niri” (*Citrullus vulgaris*) plant with a fruit on it



Figure 2: “Niri” (*Citrullus vulgaris*) seeds

FORMULATION OF “NIRI” BEEF SAUSAGES

Thirteen (13) kg of frozen boneless beef was bought from University for Development Studies (UDS) Meats Unit and thawed at 4°C. The meat was cut into smaller pieces and minced with a 5mm sieve table top mincer (Tallers Ramon, Spain). The chaffs (raw and roasted) were incorporated at 0, 5, 15 and 25% inclusion per 1 kg minced meat. The incorporation levels were selected to determine the optimum level of inclusion without going beyond the 25% maximum inclusion limit for non-meat ingredients in sausages (Ismed, 2016). Spices; 0.5g red pepper, 15g curing salt, 2.0g adobo®, 0.5g of polyphosphate and 1g each of black and white pepper were added to each treatment.

Each level was comminuted with one hundred and fifty grams (150g) of ice cubes. A hydraulic stuffer (Tallers Ramon, Spain) was used to stuff comminuted paste in natural casings and linked into equal lengths of about 10cm manually. The samples were then smoked (Laint Smoker, Spain) at a temperature of 105°C for 30 minutes and scalded at 55°C for 20 minutes. The products were cooled in water, packaged and stored in a deep freezer (-18°C) awaiting sensory and nutritional analysis.

PROXIMATE, pH AND MINERAL ANALYSES OF “NIRI” BEEF SAUSAGES

Crude protein, crude fat, moisture, carbohydrates, ash and mineral contents were analyzed to determine the nutritional values of extended products using the procedures in the International Association of Official Analytical Chemist (2005). Crude protein and crude fat were analyzed using the Kjeldhal and Soxhlet extraction methods, respectively. Moisture was determined through oven drying of samples (5g) at 105°C for 5 hours. The ash content was determined by completely burning 5g of sample in a muffle furnace at 600°C for 2 hours. Carbohydrate was determined by difference [100% - (%ash + % crude protein + % crude fat + % moisture)]. Mineral (iron, magnesium, calcium, zinc and potassium) content was determined by digesting a gram of sample in 5.0ml of doubled distilled water. This was followed by addition of 4.0ml of $\text{NHO}_3\text{-HClO}_4$. The samples were mixed with 5ml of concentrated sulphuric acid and heated at 200°C until the solution was clear. The solution was allowed to cool and topped with distilled water to 50 ml mark. The solution was then ran using ASPECT LS software using Atomic Absorption Spectrometer (AAS). The pH of products was determined by grinding 10g of sample using laboratory mortar and pestle and homogenized with 10ml of deionized water for 30 minutes prior to taking readings using a pH meter (CpH METER BASIC 20, Spain).

GRILLING LOSS

Each sausage sample was weighed (using Sartorius CP224S Analytical Balance, USA) after being thawed for 4 hours, and grilled to a core temperature of 70°C using an electric oven (Turbonfan, Blue seal, UK). The cooked sausages were allowed to cool to room temperature and reweighed. Grilling loss was calculated as the difference between the weight before grilling and the weight after grilling.

Percentage grilling loss = (initial weight – weight after grilling) / initial weight × 100%

SENSORY ANALYSIS OF BEEF SAUSAGES

A total of 15 panelists were randomly selected from the students of UDS Nyankpala Campus and trained based on the British Standard Institution (1993) procedures for

the evaluation of products. The panelists evaluated the beef sausages for aroma, colour, flavour intensity, flavour liking, juiciness, tenderness, texture, taste and overall liking using a 5-point hedonic scale as described by Adua et al. (2020).

LIPID PEROXIDE VALUE DETERMINATION

Five (5) grams of sample was weighed into a 250 ml glass stoppered Erlenmeyer flask and heated in a water bath at 60°C for 3 minutes to melt the fat. Thirty (30) milliliters of acetic acid – chloroform solution (480 ml Acetic acid and 320 ml Chloroform) was added to the sample in the flask and thoroughly swirled for 3 minutes to dissolve the fat. Meat particles were filtered using Whitman filter paper. Saturated potassium (0.5 ml) was added to filtrates with addition of 0.5 ml 1% starch solution as an indicator. The filtrates were titrated against 0.01 N Sodium thiosulphate standard solution until the blue-gray disappeared in aqueous solution. The volume was recorded to two decimal places as the sample titre value.

Calculations:

V_s = Sample (s) titre value, V_B = Blank titre value

Peroxide value = $(V_s - V_B) \times 1000 / \text{Weight of sample}$

FORMULATION COST OF “NIRI” EXTENDED BEEF SAUSAGES

The cost of a kilogram minced beef was recorded and used as the basis to determine each percentage inclusion level (0, 5, 15 and 25%). There was no cost for a kilogram of “niri” chaff except processing cost. This is because the chaffs are by-products which would have hitherto been thrown away. The cost of spices, curing salt and ice cubes for processing a kilogram of beef sausage was added equally across treatments. Transportation cost was not included since chaffs were collected on site.

STATISTICAL ANALYSIS

Data were analyzed by One-way Analysis of Variance (ANOVA) in Genstat Discovery 4th edition. Tukey studentized range test at 5% significant level was used to separate means that were significantly different ($P < 0.05$).

RESULTS AND DISCUSSION

PROXIMATE COMPOSITION OF RAW AND ROASTED “NIRI” CHAFFS EXTENDED SAUSAGES

There was significant difference ($P < 0.05$) in all proximate parameters measured as illustrated in Table 1. The control products had higher moisture (78.68 %) than chaff products (62.34 – 75.11%). The reduction in moisture content means “niri” chaffs cannot retain much water as the control. The reduction was observed as the inclusion level of chaffs increased even though water in the form of ice was added on equal

Table 1: Proximate composition of raw and roasted “niri” chaffs extended sausages

Parameter	Control	RaC 5%	RaC 15%	RaC 25%	RoC 5%	RoC 15%	RoC 25%	S.e.d.	P-Value
Moisture (%)	78.68 _a	75.11 _b	72.19 _d	66.54 _f	73.69 _c	69.67 _e	62.34 _g	0.428	<0.001
Ash (%)	1.39 _c	1.31 _c	1.84 _b	2.07 _{ab}	1.51 _c	1.90 _a	2.19 _a	0.1115	<0.001
Carbohydrate (%)	0.25 _e	2.95 _d	2.90 _d	8.21 _b	2.06 _d	6.57 _c	20.81 _a	0.542	<0.001
Fat (%)	0.42 _e	1.50 _d	2.07 _{bc}	2.64 _b	1.71 _{cd}	2.44 _b	3.28 _a	0.2185	<0.001
Protein (%)	19.15 _b	21.52 _a	20.53 _a	18.59 _c	19.86 _{ab}	19.86 _{ab}	11.67 _d	0.423	<0.001

RaC - Raw Chaff, RoC- Roasted Chaff, S.e.d.- Standard error of difference, Means in a row with the same subscripts are not significantly different (P>0.05) and vice versa

Table 2: Mineral (mg/g) results of raw and roasted “niri” chaffs extended sausages

Parameter	Control	RaC 5%	RaC 15%	RaC 25%	RoC 5%	RoC 15%	RoC 25%	S.e.d.	P-Value
Calcium	2.67 _f	2.94 _e	3.98 _d	4.15 _c	4.22 _c	4.91 _b	9.55 _a	0.0664	<0.001
Iron	0.24 _g	0.29 _f	0.39 _d	0.41 _c	0.34 _e	0.44 _b	0.64 _a	0.007	<0.001
Potassium	29.89 _b	30.48 _a	27.96 _c	25.28 _g	29.60 _c	28.60 _d	27.15 _f	0.0815	<0.001
Magnesium	14.99 _g	17.55 _d	17.31 _e	18.50 _c	17.01 _f	19.32 _b	20.67 _a	0.2196	<0.001
Zinc	0.61 _a	0.62 _a	0.42 _d	0.39 _e	0.58 _b	0.50 _c	0.36 _g	0.0100	<0.001

RaC - Raw Chaff, RoC- Roasted Chaff, S.e.d.- Standard error of difference, Means in a row with the same subscripts are not significantly different (P>0.05) and vice versa

amount across treatments. The findings of this study disagrees with Aleson-Carbonell et al. (2004) as they reported an increase in moisture as lemon albedo fiber content increased in non-fermented dry-cured sausages. A low moisture level is likely to make products less juicy and tougher. Ash content determines the amount of minerals in a material. This study reveals a significant difference (P<0.001) in ash content between the control and the “niri” extended chaff products (RaC 15%, RaC 25%, RoC 15% and RoC 25%). There was an increasing ash content as inclusion increased with high values generally in roasted products. This agrees with Aleson-Carbonell et al. (2004) who reported increasing ash content as dry and cooked dehydrated lemon albedo fibre increased in non-fermented dry-cured sausages. The high ash content in extended products means a high mineral content of these products than the control.

The results also showed a high carbohydrate content (2.06 – 20.81%) in extended chaff products than the control (0.25%). This is because chaffs are largely cell wall material which have a greater proportion of carbohydrate to other nutrients. This is contrary to the decreasing energy levels when 12 % soluble dietary fiber was incorporated in reduced-fat sausages (Caceres et al., 2004). Plant materials have high carbohydrate content than animal products hence the large differences between extended products and control. The significant amount of carbohydrate in roasted products implies that roasting did not negatively affect energy level of chaffs.

Fat improves eating quality as well as energy supply to the

body. Fat content increased as inclusion levels increased in all treatments, similar to the findings of Aleson-Carbonell et al. (2004) where an increase in albedo fiber increased fat content of non-fermented dry-cured sausages. The content was high in roasted “niri” chaff sausages than the raw and control products. This implies that the heat used in roasting caused the extraction of fat which is insoluble in water and could not be removed during preparation of chaffs.

Products with “niri” chaffs had appreciable amount of protein (11.67 - 21.52%). Products with 25% raw and 25% roasted chaffs had 18.59% and 11.67% protein, respectively which were lower than the control (19.19%). This means the 25% chaff products were low in protein and their addition will reduce the protein content as their inclusion increases. A similar trend was reported by Aleson-Carbonell et al. (2004) when albedo fiber was incorporated in non-fermented dry-cured sausages. This confirms the findings of Asgar et al. (2010) that incorporation of ingredients low in protein consequently leads to a reduction in protein content of products. Raw “niri” chaff products had higher protein values than roasted chaff extended products. This means the roasting temperature negatively affected protein content of the roasted chaffs hence the low values.

The addition of “niri” chaffs into beef sausages did not reduce nutritional levels below acceptable levels using the control as benchmark and some parameters were improved. This agrees with Fernandez-Gines et al. (2003) who reported that nutritional values of dry-fermented sausages were improved by the addition of orange fibre powder (0.5

- 2%). It also supports the findings that dietary fibre from cereals and fruits at 1.5% in sausages increased nutritional and sensory properties of products (Garcia et al., 2002).

MINERAL COMPOSITION OF “NIRI” CHAFF EXTENDED BEEF SAUSAGES

Table 2 shows the calcium, iron, potassium, magnesium and zinc contents of the beef sausages extended with “niri” chaffs (raw and roasted). The results showed a high potassium content (25.28 - 30.48 mg/g) in extended products. The mineral with the least value in the products was zinc (0.36 - 0.62 mg/g). There was high calcium content in roasted chaff products (4.22 - 9.55 mg/g) than raw products (2.94 - 4.15 mg/g). This suggests that the difference was as a result of the roasting. The calcium values of all extended products were significantly ($P < 0.001$) higher than the control. Again, the calcium values of extended products were higher than the calcium value of 4.5 mg/g for beef (Williams et al., 2002). This is an indication that “niri” chaff beef sausages could be a good source of calcium for humans.

All extended products were significantly ($P < 0.001$) higher than the control in terms of iron content. Higher values were recorded in roasted products than the raw products. The values also increased as the inclusion levels of chaffs increased in products. This high iron content in the extended products implies that raw and roasted “niri” chaff beef sausages are better source of iron. This could help improve iron content of humans when consumed.

There was high potassium content in products than other minerals. This supports the assertion by Hamdallah (2004) that potassium is high in plants, animals and fish. There were decreases in potassium values as the inclusion level increased. This is because, chaffs (roasted chaff, 14.91 mg/g and raw chaff, 23.35 mg/g) have lower potassium values than that of pure beef (167, 193, or 142 mg/g) and replacing meat with chaffs will naturally reduce the potassium levels (Ahmad et al., 2018; Adua et al., 2019). However, raw and roasted “niri” chaff beef sausages have appreciable level of potassium. Pohl et al. (2013) indicated that the consumption of foods containing potassium improves heart performance, and improve smooth muscles and skeletal contractions.

The extended products had significantly ($P < 0.001$) high magnesium values than the control. The values increased as inclusion level of chaffs increased across treatments. This implies that more “niri” chaffs addition to a product will lead to high magnesium level in diets. The high values of magnesium in extended products confirms the conclusion drawn by Gröber et al. (2015) that seeds contain more magnesium than meat. Roasted products also had high values than raw products. This suggests that heat

treatment by roasting causes better extraction and release of magnesium from cell walls (chaffs). Magnesium helps to reduce hyperactivity, stress anorexia and vomiting among consumers (Gröber, 2009).

Zinc content of the control was significantly ($P < 0.001$) higher than all treatments, but similar to 5% raw chaff products. The zinc content of the control (0.61 mg/g) was however lower than that of beef (1.7, 3, or 3.7 mg/g) which could be due to the processing of meat into sausages (Ahmed et al., 2018). There was a reduction in zinc content as inclusion of test materials increased. This is due to the low zinc content in “niri” chaffs (0.1767 and 0.2367 mg/g for roasted and raw chaffs, respectively) (Adua et al., 2019). This caused much reduction as more of the low zinc material (chaffs) replaced high zinc material (beef). Despite these low values in extended products in comparison with the control, “niri” chaff beef sausages are potential sources of zinc. Nriagu (2007) reported that zinc helps boost spermatozoa production and maturation in males. Zinc also boost the immune system, aid metabolism and plays a role in wound healing, and sense of smell (Anonymous, 2017).

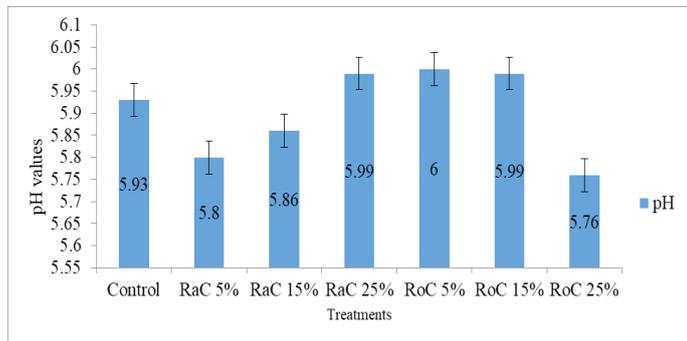
ACIDITY (pH) OF “NIRI” EXTENDED BEEF SAUSAGES

The pH of “niri” extended beef sausages is shown in Figure 3. The pH increased as inclusion level increases in raw chaff products, the reverse was observed in roasted products. The work showed that, the use of “niri” chaffs did not alter the pH from what is characteristic of meat (5.6 - 6.2) according to Dilbaghi & Sharma (2007). The pH of products (“niri” extended beef sausages) is consistent with the mean values of 5.85 - 6.10 for sausages marketed in different food markets in São Paulo (Ferrari and Torres, 2002). The results, however, disagree with Caceres et al. (2004) who found no significance in pH of sausages extended with indigestible oligosaccharides and the control. According to FAO (2007), a pH of 5.08 - 5.6 gives meat its characteristic flavour and improves water binding abilities of products. The results in this study are relatively similar to the FAO range and could have better flavour liking. Low pH values restrict microbial growth thereby prolonging shelf life of products (Dilbaghi & Sharma, 2007). The slightly acidic nature of products in this study means the products can be preserved for longer periods.

GRILLING LOSS OF “NIRI” CHAFFS EXTENDED BEEF SAUSAGES

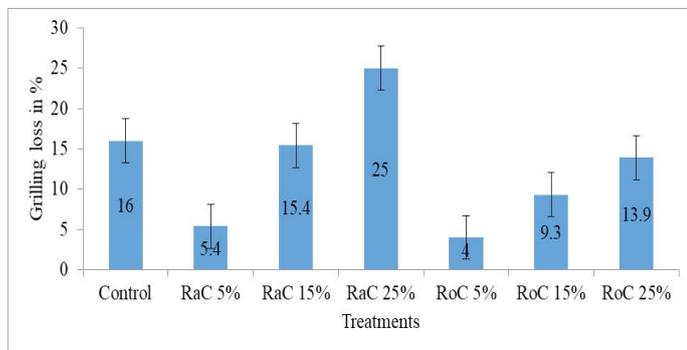
Figure 4 shows the percentage grilling losses of the products. With the exception of 25% raw chaff inclusion level, the other inclusion levels had lower grilling losses than the control. Roasted chaff products also had lower losses than raw chaff products. This indicates that the chaffs are capable of retaining soluble components of products than the control thus the reduced grilling losses in extended chaff products. The relatively low moisture contents might have

also accounted for the reduced losses as water would have leached out during grilling. The swelling property of chaffs as a fiber (Haluk et al., 2014) might have also accounted for the reduced losses.



RaC - Raw Chaff, RoC- Roasted Chaff

Figure 3: pH of “niri” chaffs extended beef sausages



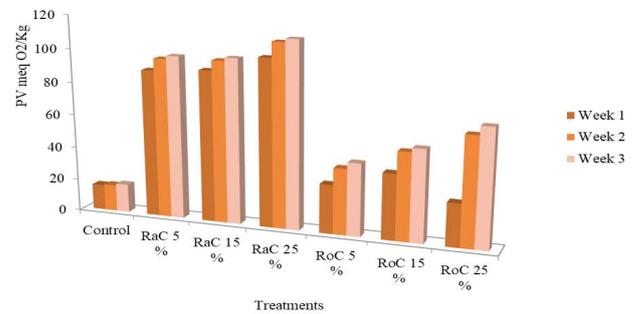
RaC - Raw Chaff, RoC- Roasted Chaff

Figure 4: Grilling loss of “niri” chaffs extended beef sausages

LIPID PEROXIDATION VALUES OF “NIRI” CHAFF SAUSAGES

Peroxide values were determined each week for three weeks to determine the ability of “niri” chaffs to halt oxidation of products. The results as shown in Figure 5 revealed that peroxide values of “niri” extended chaff products were significantly higher ($P < 0.05$) than the control in each week of study. An increase in oxidation was also observed as inclusion was increased and as storage period was extended. The raw chaff products had higher values than the roasted products. This implies that roasting has a significant impact in reducing the rate of oxidation of “niri” extended products. The peroxide values observed in this study exceeded the 25 meq/kg permissible level for food products (Evranuz, 1993). This means “niri” extended product cannot be stored for extended periods. The high values could be due to the unsaturated nature of the fats of raw “niri” chaff products (1.5-2.64%) and roasted “niri” chaffs products (1.71-3.28%) which was significantly ($P < 0.05$) higher than the fat content of control products (0.42%) as well as the iron contents; 0.24, 0.29-0.41 and 0.34-0.64 mg/g for control, raw and roasted “niri” chaff products, respectively.

These two agents (unsaturated fat and iron) are precursors for lipid oxidation hence the high values. The results disagree with Aleson-Carbonell et al. (2004) who reported peroxide values (10 - 12 meq/kg) lower than the maximum permissible level when lemon albedo was incorporated in non-fermented dry-cured sausages. This means “niri” chaffs do not have antioxidant property and this could result in rancid flavour of products when stored over extended period. Products will therefore have to be vacuum packed to reduce the rate of rancidity. The exceedingly high values did not however, affect sensory level of products. This suggests that secondary oxidation which is responsible for nutritional and sensory losses (Jayasena & Jo, 2014) had not set in which would have caused off odour and colour changes in products.



RaC - Raw Chaff, RoC- Roasted Chaff

Figure 5: Lipid peroxidation values of “niri” chaffs extended products

SENSORY RESULTS OF RAW AND ROASTED “NIRI” PUREE SAUSAGE PRODUCTS

Dietary fibre is the remains of edible portion of plants and related carbohydrates that are indigestible and non-absorbable in the small intestine of humans (Lunn & Buttriss, 2007). Its addition helps in freeing of bowels, decrease colorectal cancers and increase in bulk of feed (Dhingra et al., 2012; Anonymous, 2020). Meat products containing dietary fibres are good from nutritional point of view. This is because of their characteristic nutritional and functional effects (Kumar et al., 2010; Hur et al., 2009) hence the addition of “niri” chaffs (raw and roasted) in the extended beef sausages. Table 3 shows the sensory results of “niri” chaffs (raw and roasted) extended beef sausages. The results showed no differences ($P > 0.05$) in all sensory parameters during the period of study except ($P < 0.05$) for colour and tenderness. Though there were no differences in most sensory parameters, however, increasing inclusion levels of chaffs resulted in numerical increases in most of the parameters. The results disagree with Turhan et al. (2005) who reported a decline in flavour, juiciness, colour and appearance scores, as levels of hazelnut pellicle in beef burgers increased. The addition of fruits (apple, orange and

Table 3: Sensory results of “niri” chaffs (raw and roasted) extended beef sausages

Parameter	Control	RaC 5%	RaC 15%	RaC 25%	RoC 5%	RoC 15%	RoC 25%	S.e.d.	P-value
Aroma	2.73	3.00	2.67	2.73	2.60	2.87	2.60	0.418	0.960
Colour	2.53 _b	3.53 _a	3.60 _a	3.46 _a	2.66 _b	2.26 _b	1.73 _{bc}	0.357	<0.001
Flavour intensity	3.03	2.93	3.07	3.07	3.60	3.27	3.07	0.452	0.727
Flavour liking	2.48	2.93	3.00	3.13	3.00	2.93	3.00	0.410	0.757
Juiciness	2.68	2.80	2.93	3.40	3.20	3.27	2.87	0.363	0.399
Tenderness	2.60 _b	2.60 _b	3.13 _{ab}	3.53 _a	3.66 _a	3.06 _{ab}	3.20 _{ab}	0.333	0.017
Texture	2.59	3.06	3.20	3.53	3.40	3.20	3.00	0.293	0.252
Taste	3.10	3.26	3.26	3.40	3.40	3.20	2.73	0.315	0.296
Overall liking	2.87	3.07	3.33	3.20	3.13	3.20	2.87	0.356	0.841

RaC - Raw Chaff, RoC- Roasted Chaff, S.e.d.- Standard error of difference, Means in a row with the same subscripts are not significantly different (P>0.05) and vice versa

Table 4: Formulation cost for raw and roasted “niri” chaff products

Ingredient	Rate Ghana cedis/Kg	Control	RaC 5%	RaC 15%	RaC 25%	RoC 5%	RoC 15%	RoC 25%
Minced beef	19	19	18.05	16.15	14.25	18.05	16.15	14.25
“Niri” chaff cost	-	-	-	-	-	-	-	-
Drying of chaff	3	-	0.15	0.45	0.75	0.15	0.45	0.75
Milling of chaff	1	-	0.05	0.15	0.25	0.05	0.15	0.25
Spice mix	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Curing salt	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Ice cubes	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Total (Gh¢/kg)		20.1	19.35	17.85	16.35	19.35	17.85	16.35

RaC - Raw Chaff, RoC- Roasted Chaff

peach) and cereals (oat and wheat) above 3% inclusion level in dry fermented sausages decrease sensory quality significantly (Garcia et al., 2002). The results also agree with findings of Gringelmo-Miguel et al. (1999) that the addition of 17 and 29% peach dietary fibre suspension had no significant effect in sensory quality of frankfurters. The colour decline was much observed in the roasted chaff products. This is because roasting led to browning of chaffs. The chaffs were obtained from roasted “niri” after extraction of puree and further blending which caused darkening of chaffs hence the subsequent impact on products. The colour scores decreased as inclusion level of roasted chaffs increased, but increased as the inclusion of raw chaffs increased in products. Tenderness of “niri” chaffs (raw and roasted) extended beef sausages were generally better than the control. This was unexpected since the control had high moisture content. Nonetheless, we postulate that “niri” chaffs (raw and roasted) helped in better water retention during grilling as compared with the control. The sensory results suggest that “niri” chaffs could be included in beef sausages as the differences in colour and tenderness, and the insignificant differences in other sensory attributes did not impact negatively on overall acceptability of products.

FORMULATION COST OF RAW AND ROASTED “NIRI” CHAFFS EXTENDED BEEF SAUSAGES

Formulation cost of chaff products was lower than the control (Table 4). The higher inclusion levels cost much lower than the 5% and control. A cost reduction of Ghanaian Cedi (Gh¢) 0.75, Gh¢ 2.25 and Gh¢ 3.75 was respectively realized for 5, 15 and 25% inclusion rate of raw and roasted “niri” chaffs. The low cost of chaff products is on account of the fact that, the chaffs are considered waste after the extraction of purees and would have been disposed-off. The only cost incurred, is the cost of drying and milling hence the low cost of products. Marichu et al. (2014) reported that, the inclusion of 75% banana pseudo stem core in scrapple reduced production cost by 31.30% making them more affordable than the control. The use of pineapple dietary fibres NPS 0, NPS 60, NPS 100 and NPS 200 in beef sausages led to a formulation cost of R 34.23, R 32.88, R 32.96 and R 32.89, respectively (Tshalibe, 2014). This implies that the addition of the fibres did not only increase bulk but led to a reduction in formulation cost of products. This will invariably lead to low cost of the extended products making them more affordable than the control.

The inclusion of “niri” chaffs generally led to an improved fat, ash and carbohydrate content of beef sausages. The protein content of the 25% raw and roasted “niri” extended beef sausages had the lowest protein content. Calcium, iron and magnesium contents of “niri” chaff extended products were also improved except potassium and zinc with the extension of beef sausages with “niri” chaffs. “Niri” extended chaff products could be stored for long period since their pH values were slightly acidic. With the exception of 25% raw inclusion level, all “niri” extended products had lower grilling loss than the control. The lipid peroxidation values of “niri” extended products exceeded the maximum permissible limit thus “niri” chaffs do not have antioxidant property. Colour and tenderness qualities were generally better for “niri” chaff beef sausages than control sausages. The incorporation of “niri” chaffs led to a reduction in formulation cost of extended products. “Niri” chaffs could be used as a dietary fiber in extending beef sausages, however, the addition of an antioxidant is recommended.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHORS CONTRIBUTION

Edward Ayinbila Adua: Involved in the experimental design, data collection, data analysis, funding and revised this manuscript. Frederick Adzitey: Conceptualized the idea, involved experimental design, data analysis, funding and drafted this manuscript. Nurul Huda: Conceptualized the idea, provided funding and revised this manuscript. All authors read and approved this manuscript.

REFERENCES

- Adua EA, Adzitey F, Teye GA, Abu A (2020). Nutritional composition and sensory properties of raw and roasted “Niri” (*Citrullus vulgaris*) puree extended beef sausages. Ghana J. Sci. Technol. Develop. 7: 1-12. <http://www.gjstd.org/index.php/GJSTD/article/view/216>.
- Adua EA, Adzitey F, Abu A (2019). Nutrient composition of whole grain and processed “niri” (*Citrullus vulgaris*) seeds. Int.

J. Food Sci. Nutr. 4: 76-79. <http://www.foodsciencejournal.com/archives/2019/vol4/issue2/4-2-21>.

- Ahmad RS, Imran A, Hussain MB (2018). Nutritional composition of meat. Retrieved from: <https://www.intechopen.com/books/meatscience-and-nutrition/nutritional-composition-of-meat>; accessed on 7/8/2020.
- Aleson-Carbonell L, Fernández-López J, Sendra E, Sayas-Barberá E, Pérez-Alvarez JA (2004). Quality characteristics of non-fermented dry-cured sausage with lemon albedo. J. Sci. Food Agric. 84: 2077-2084. <https://doi.org/10.1002/jsfa.1912>.
- America Meat Science Association (2016). Nutrients in meat. Retrieved from: <https://meatscience.org/TheMeatWeEat/topics/meat-in-the-diet/nutrients-in-meat>; accessed on 7/8/2020.
- Angnihotri MK, Pal UK (2000). Quality of chevon sausages in refrigerated storage. Int. J. Anim. Sci. 15:69-73.
- Anonymous (2020). Nutrition and healthy eating. Retrieved from: <https://www.mayoclinic.org/healthy-lifestyle/nutrition-and-healthy-eating/in-depth/fiber/art-20043983>; accessed on 7/8/2020.
- Anonymous (2017). Zinc. Retrieved from: <https://www.mayoclinic.org/drugs-supplements-zinc/art-20366112>; accessed on 7/8/2020.
- Asgar MA, Fazilah A, Huda N, Bhat R, Karim AA (2010). Nonmeat protein alternatives as meat extenders and meat analogs. Comprehensive Reviews in Food Sci. Food Safety. 9: 513-529. <https://doi.org/10.1111/j.1541-4337.2010.00124.x>.
- British Standard Institute (1993). Assessors for sensory analyses. Guide to selection, training and monitoring of selected assessors. British Standard Institute, London, United Kingdom.
- Caceres E, Garcia ML, Toro J, Selgas MD (2004). The effect of fructooligosaccharides on the sensory characteristics of cooked sausages. Meat Sci. 68: 87-96. <https://doi.org/10.1016/j.meatsci.2004.02.008>.
- Deogade AH, Zanjad PN, Raziuddin M (2008). Value added meat products. Vet. World. 1: 88-89.
- Dhingra D, Michael M, Rajput H, Patil RT (2012). Dietary fibre in foods: a review. J. Food Sci. Technol. 49(3): 255-266. <https://doi.org/10.1007/s13197-011-0365-5>.
- Dilbaghi N, Sharma S (2007). Food spoilage, food infections and intoxications caused by microorganisms and methods for their detection. Corpus ID: 4650369.
- Evranuz OE (1993). The effects of temperature and moisture content on lipid peroxidation during storage of unblanched salted roasted peanuts: shelf life studies for unbranched salted roasted peanuts. Int. J. Food Sci. Technol. 28: 193-199. <https://doi.org/10.1111/j.1365-2621.1993.tb01264.x>.
- Fernandez-Gines JM, Fernandez-Lopez J, Sayas-Barbera E, Sendra E, PerezAlvarez JA (2003). Effect of storage conditions on quality characteristics of bologna sausages made with citrus fiber. J. Food Sci. 68:710-714. <https://doi.org/10.1111/j.1365-2621.2003.tb05737.x>.
- Ferrari CKB, Torres EAFS (2002). Lipid oxidation and quality parameters of sausages marketed locally in the town of São Paulo (Brazil). Czech J. Food Sci. 20:144-150. <https://doi.org/10.17221/3525-CJFS>.
- Food and Agriculture Organization (2020). Meat products with high levels of extenders and fillers. Retrieved from: <http://www.fao.org/tempref/docrep/fao/010/ai407e/ai407e07.pdf>; accessed on 7/8/2020.

- Food and Agriculture Organization (2007). Meat processing technology for small to medium scale producers. Retrieved from: <http://www.fao.org/docrep/010/ai407e/ai407e00.htm>; accessed on 26/09/2016.
- Garcia ML, Dominguez R, Galvez MD, Casas C, Selgas MD (2002). Utilization of cereal and fruit fibres in low fat dry fermented sausages. *Meat Sci.* 60: 227-236. [https://doi.org/10.1016/S0309-1740\(01\)00125-5](https://doi.org/10.1016/S0309-1740(01)00125-5).
- Gröber U (2009). Magnesium. In *Micronutrients: Metabolic Tuning-Prevention-Therapy*, 1st ed.; Gröber, U., Ed.; MedPharm Scientific Publishers: Stuttgart, Germany, 159-166.
- Gringelmo-Miguel N, Abadies- Seros MI, Martin-Belloso O (1999). Characterisation of low- fat high dietary fiber frankfurters. *Meat Sci.* 52: 247-256. [https://doi.org/10.1016/S0309-1740\(98\)00173-9](https://doi.org/10.1016/S0309-1740(98)00173-9).
- Haluk E, Tolga A, Meltem S (2014). The effects of potato puree and bread crumbs on some quality characteristics of low fat meatballs. *Korean J. Food Sci.* 34: 561-569. <https://doi.org/10.5851/kosfa.2014.34.5.561>.
- Hamdallah G (2004). Plant, animal and human nutrition: An intricate relationship. Expert consultation on land degradation and plant, animal and human nutrition, ACSAD, Damascus.
- Hur SJ, Lim BO, Park GB, Joo ST (2009). Effect of various fiber additions on lipid digestion during in vitro digestion of beef patties. *J. Food Sci.* 74: 653-657. <https://doi.org/10.1111/j.1750-3841.2009.01344.x>.
- Ismed (2016). Colour properties, pH value and sensory evaluation of commercial beef Sausages. *Journal of Pharmaceutical, Chem. Biolog. Sci.* 4: 450-454. https://www.jpccbs.info/2016_4_3_14_Ismed.pdf.
- Kumar V, Biswas AK, Chatli MK, Sahoo J (2010). Effect of banana and soybean hull flours on vacuum packaged chicken nuggets during refrigeration storage. *International J. Food Sci. Technol.* 46:122 – 129. <https://doi.org/10.1111/j.1365-2621.2010.02461.x>.
- Lunn J, Buttriss J (2007). Carbohydrates and dietary fibre. *British Nutrition Foundation Nutr. Bull.* 32:21-64. <https://doi.org/10.1111/j.1467-3010.2007.00616.x>
- Marichu TC, Alma II, Lelisa JT, Celedonia RH, Eduardo GS, Perlita SI (2014). Banana (*Musa sp.*) Pseudostem core as meat filler in scrapple preparation. *Int. J. Curr. Microbiol. Appl. Sci.* 3: 859-873. <https://www.ijemas.com/vol-3-2/Marichu%20T.%20Calizo,%20et%20al.pdf>.
- Mozaffarian D (2016). Dietary and policy priorities for cardiovascular disease, diabetes, and obesity: a comprehensive review. *Circulation.* 133:187–225. <https://doi.org/10.1161/circulationaha.115.018585>.
- Neuenschwander M, Ballon A, Weber KS, Norat T, Aune D, Schwingshackl L, Schlesinger S, (2019). Role of diet in type 2 diabetes incidence: umbrella review of meta-analyses of prospective observational studies. *Brit. Med. J.* 366: 12368. <https://doi.org/10.1136/bmj.12368>.
- Nriagu, J. (2007). Zinc deficiency in human health. *School of Public Health. University of Michigan, USA*, p. 1-5.
- Ossom RN, Teye GA, Adzitey F (2020). Sensory and nutritional qualities of frankfurter sausages with sweet potato as extender. *African J. Food Agric. Nutr. Develop.* 20: 15222-15235. <https://doi.org/10.18697/ajfand.89.18720>.
- Pohl HR, Wheeler JS, Murray HE (2013). Sodium and potassium in health and disease. *Metal Ions Life Sci.* 13:29-47. https://doi.org/10.1007/978-94-007-7500-8_2.
- Qian F, Riddle MC, Wylie-Rosett J, Hu FB (2020). Red and processed meats and health risks: How strong is the evidence? *Diab. Care.* 43:265-271. <https://doi.org/10.2337/dci19-0063>.
- Sadri GH, Mahjub H (2006). Meat consumption is a risk factor for colorectal cancer: meta-analysis of case-control studies. *Pakistan J. Nutr.* 5: 230-233. <https://doi.org/10.3923/pjn.2006.230.233>.
- Jayasena DD, Jo C (2014). Potential application of essential oils as natural antioxidants in meat and meat products: A Review. *Food Rev. Int.* 30:71-90. <https://doi.org/10.1080/87559129.2013.853776>.
- Song M, Fung TT, Hu FB, Willett WC, Valter D, Longo VD, Chan AT, Giovannucci EL (2016). Association of animal and plant protein intake with all-cause and cause-specific mortality. *JAMA Internal Med.* 176:1453-1463. <https://doi.org/10.1001/jamainternmed.2016.4182>
- Talukder S (2015). Effect of dietary fiber on properties and acceptance of meat products: A review, *Crit. Rev. Food Sci. Nutr.* 55:1005-1011. <https://doi.org/10.1080/10408398.2012.682230>
- Teye GA, Adzitey F, Bawah J, Takyi F (2015). Dawadawa (*Parkia biglobosa*) pulp as an extender in beef sausage. *UDS Int. J. Develop.* 1:30-35. <http://www.udsijd.org/index.php/udsijd/article/view/6>.
- Tshalibe P (2014). Effects of different pineapple dietary fibres on the quality parameters and cost of beef species sausage. Master of Technology (Food Technology), Theses. Cape Peninsula University of Technology, South Africa.
- Turhan S, Sagir I, Ustun NS (2005). Utilization of hazelnut pellicle in low-fat beef burgers. *Meat Sci.* 71: 312-316. <https://doi.org/10.1016/j.meatsci.2005.03.027>
- Williams PG, Droulez V, Levy G, Stobaus T (2002). Composition of Australian red meat. *Nutrient Profile.* 2002 – 2003.
- Bhat ZF, Hina B (2011). Fiber based functional meat products. *Asian J. Food Agro-indus.* 4: 261-273. <https://www.cabdirect.org/globalhealth/abstract/20123386967>.