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Sensory and Physicochemical Characteristics of Semi-dry fermented Beef Sausages produced with Fresh Ripe Plantain

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A B S T R A C T

Fermented sausages are stable meat items typically prepared from comminuted mixtures of meat, spices, and salts and permitted to ripe under controlled conditions, where bacteria produce lactic acid quickly and reliably from added sugars in the form of dextrose. This study assessed the possibility of using fresh ripe plantain (FRP) in semi-dry fermented beef sausages. FRP was used at 0% (T0), 5% (T1) and 10% (T2). A fourth treatment with 0.5% dextrose without any FRP (T3) was produced. The products were evaluated for proximate compositions, pH, cooking loss as well as sensory attributes. No significant differences existed between T0, T1, T2 and T3 in terms of appearance, flavor, aftertaste and texture, however significant differences were recorded in tenderness, juiciness and acceptability. Cooking loss and water holding capacity ranged between 31.83 (T0) to 36.53 (T3) and 4.40 (T3) to 14.74 (T2) respectively. The pH recorded after 36 hours of fermentation ranged from 4.20 (T3) to 5.36 (T0). Using FRP resulted in appreciable decreases in costs of producing semi-dry fermented beef sausages from 20.50 to 16.46 Ghana Cedis per kg. It was concluded that fermented beef sausages could be made with 5% fresh ripe plantain without any adverse effects on consumer acceptability.

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Introduction

The rise in world populations as well as increased affluence in numerous nations across the globe has prompted increasing interests for animal products as reflected in the rapidly developing animal industries. But as lifestyles have become more fast-paced, recent patterns have seen an increase in consumers' interest for more shelf stable items that are safe for consumption. Also consumers are increasingly becoming health-conscious and are more stringent on the quality of foods they eat. Consequently, there has been an increasing demand for natural additives in animal flesh utilized as food (Lawrie and Ledward, 2006). Animal protein sources, as suggested by Bastin (2007) contain all key amino acids, which makes them complete in satisfying all requirements for human needs. In recent years there has been a tendency to avoid the use of chemical additives in food production and preservation. Food fermentation is regarded as one of the oldest ways of processing and preservation, and such food products play an important role in cultural uniqueness and the local economy (Toldra, 2007). Some of the benefits of fermented food are destruction of bacteria (Raes *et al.*, 2014), an improvement on appearance, aroma, flavour and texture, production of new products and enhancement of health (Katz, 2012) as well as preservation of food through improved shelf life and safety (Van Boekel, *et al.*, 2010). Fermented sausages are stable meat items and are typically prepared from comminuted mixture of meat, spices, fats and salt which are permitted to ferment under controlled temperature and humidity conditions (Toldra, 2007). The significant part of lactic acid bacteria is to produce lactic acid quickly and reliably from added sugars (Lücke, 1998) in the form of dextrose. Fermented sausage is popularly known as ''Salami'' in Southern Europe and ''Kielbasa'' in Central Europe, is not a common type of sausage in Ghana. Fermentation by desirable microorganisms' impact good fragrance and acceptable texture to the product, adds to their nutritive value, and could influence other different qualities associated with edibility (Shelhub *et al.*, 2014).

According to Stanley and Adam (2009) dextrose is refined sugar from corn starch, is around 70% as sweet as sucrose and has the advantage of being directly fermented into lactic acid and is the quickest acting sugar for bringing down pH. In general, 0.3 to 0.7 percent of dextrose is frequently prescribed in prepared meats (Stanley and Adam, 2009). Plantain (*Musa acuminate*) belongs to the family of banana and is popularly called "cooking banana" since it is rarely eaten raw. Adeniyi *et al*. (2006) indicated that ripe plantains have high carbohydrate content, are good sources of vitamins and minerals in addition to being low in fat. The USDA (2005) suggested that there are about 26.85g sugars in one medium size ripe plantain. Also, the fruit contains moderate levels of folates, niacin, riboflavin and thiamin (Rudrappa, 2014). Textural, physico-chemical and sensory properties of vegan sausages produced with different combinations of raw jackfruit (RJF) and banana floret (BF) have been reported (Priya et al., 2022).

However, the use of fresh ripe plantain in fermented sausages has not had enough attention in the meat processing industry. This study therefore aimed at evaluating the potential of using ripe plantain in the production of fermented beef sausages. The specific objectives included the determination of sensory characteristics and costs of production, proximate compositions, cooking loss, water holding capacity, moisture and fat retentions, and acidity.

Materials and Methods

Production of Sausages

This study was conducted at the Meat Science and Processing Unit of the Department of Animal Science, Kwame Nkrumah University of Science and Technology (KNUST), Kumasi. Ripe plantain and all spices used in product formulations were obtained from the Ayeduase market in Kumasi, Ghana. Dextrose was obtained from the Department of Food Science and Technology, KNUST. Fresh boneless beef, and natural hog casings were obtained from Kumasi Abattoir Company Limited, Ghana. The beef was trimmed of visible adipose and connective tissues, and transported on ice to the location of the experiment and stored in a freezer at -18°C.

Ripe plantain was peeled, sliced into smaller pieces and washed under running tap water to remove any unwanted materials. The boneless beef was also cut into smaller pieces and minced using a table top grinder (MADO Super wolf, Germany) with a grinding sieve of 5.00 mm after overnight freezing -18 °C. Two kg of the minced beef was used without ripe plantain to produce the control treatment (T0), while treatments T1 and T2 were produced by substituting the portions of beef in T0 with 5% and 10% of fresh ripe plantain respectively. A fourth treatment (T3) was produced by using 0.5% dextrose in 2 kg minced beef. Each treatment was thoroughly mixed with spices in a bowl to improve sensory qualities (Hagan, 2000) and manually stuffed, linked and fermented at room temperature (27 °C) for 36 hours as determined by a preliminary study, packaged, labelled and frozen for further studies. Linked sausages were hung of wooden racks under a ceiling fan over the duration of fermentation. The fermentation process was achieved through natural microflora available within the meat processing room of the Department of Animal Science. The ingredient formulation used in the study are shown in Table 1.

Table 1 Ingredients used in sausage formulations

Ingredient (g)	Treatment			
	T0	T1	T2	T3
Beef	2000	1900	1800	2000
FRP	0	100	200	0
Water	60	60	60	60
Hot pepper	10	10	10	10
Garlic	6	6	6	6
Curing salt	20	20	20	20
*Dextrose	0	0	0	10

FRP = fresh ripe plantain; *not an ingredient

Parameters Measured

Sensory quality was performed by thirty (30) consumer panelists made up of nine (19) females and eleven (11) males. Samples were evaluated by 10 panelists in one session to minimize communication. The panelists were recruited from the Animal Science Department of KNUST, according to sensory evaluation procedure by Carr *et al*. (1999). Sausages were cooked in a microwave oven at 200°C for 1 min. Cooked fermented sausage samples were cut into equal pieces (2cm) and placed on plates coded with random numbers and presented to the panel at the same time in a randomized order. The panelists were asked to assess samples for appearance, mouth feel, texture, appearance, flavor and overall acceptability using a 9-point hedonic scale (1 = dislike extremely, 9 = like extremely). Panelists were instructed to rinse their mouths with water before starting and between sample evaluations. The ratings of each sensory attribute were converted to numerical scores for statistical analysis. Costs of producing the sausages were calculated based on the prevailing market retail prices of all ingredients used in product formulations.

The Association of Official Analytical Chemists (AOAC, 2012) procedures of analysis for moisture, protein, ash and fat were used to determine proximate compositions of cooked sausages.

The procedure used in determination of pH was as described by Kim *et al.* (2010). Five (5) g of blended samples of each treatment was mixed thoroughly with 10ml distilled water in separate 50ml centrifuge tubes. The mixtures obtained were allowed to stand for 15 min after which a syntax pH meter (Schott Instruments, Lab 860) was lowered into each to read and record the pH. Cooking loss was calculated as the weight of the cooked sausage sample divided by the weight of uncooked sample multiplied by 100.

The water holding capacity of the various treatments were obtained by the procedure described by Lee et *al.* (2008). Samples of each treatment were mashed and 5g of the mashed sample was mixed thoroughly with 10 ml of distilled water in separate 50 ml centrifuge tubes. The mixture was then centrifuged using Centrikon T-42-K at 2000 rpm at 15°C for 15min. The resulting supernatant was carefully decanted and pellet obtained was weighed. WHC (%) was calculated as follows:

$$\text{WHC}=\frac{\text{(final pellet weight (W0) - initial weight (W1))}}{\text{initial weight (W1)}}\times 100$$

Moisture and fat retentions were determined according to equations by El-Magoli *et al.* (1996) as follows:

Moisture retention (%) = (% yield × % moisture) × 100

Where % yield = cooked weight/fresh weight × 100

$$\text{Moisture\%}=\frac{\text{(fresh weight- oven dry weight)}}{\text{fresh weight}}\times 100$$

$$\text{Fat retention\%}=\frac{\text{Cooked weight}\times\text{\% fat in cooked product}}{\text{Raw weight}\times\text{\% fat in raw product}}$$

Statistical Analysis

Statistical analyses of the data were performed by one-way Analysis of variance (ANOVA) with SPSS (2013) version 20.0 for Windows. Significant differences were obtained by Duncan's Multiple Range Test at 5%.

Results and Discussion

Sensory Attributes

Table 2 shows the results for the sensory test conducted for appearance, tenderness, juiciness, flavor, texture, aftertaste and acceptability of sausages with and without fresh ripe plantain or dextrose. No significant differences (P>0.05) were found between T0, T1, T2 and T3 in terms of appearance, flavor, aftertaste and texture, however significant differences (P<0.05) existed in tenderness, juiciness and acceptability. The tenderness, juiciness and acceptability of the control was however not different from ripe plantain-treated sausages. Increasing levels of ripe plantain usage resulted in some increases in juiciness, with T3 having lower values (P>0.05) than T0, probably because of the higher moisture retention in the plantain-treated products (Table 2). The dextrose-based product was least accepted by consumers because it was less tender compared to all the other treatments. These findings contradicted the observation of Gyimah (2015) who had significant differences in flavor and juiciness when sausages were fermented for 24 hours using ripe plantain. These contradictions could be attributed to the differences in the hours of fermentation.

Proximate Composiion and Cost of Production

Results obtained for percentage contents of moisture, crude protein, crude fat, ash and costs of production are shown in Table 3.

Moisture content

Moisture content increased significantly with increasing levels of FRP from 30.45 (T3) to 40.39 (T2). The observed increasing moisture contents with higher levels of FRP used was due probably to the ability of FRP to bind and retain water in the extracellular spaces to prevent purge of fermented sausages during cooking (Table 3). Grigelmo-Miguel *et al. (*1999) reported that when extenders and fillers were added to meats, they serve as binders by physical entrapment of water and fat. The dextrose-based product recorded lower moisture values probably due to its low pH, and this manifested in low water holding capacities (Table 4). Aberle *et al.* (2001) reported that meat with low pH will normally exhibit low moisture contents.

Ash content

There were significant differences (P<0.05) in the ash contents of the control (T0), ripe-plantain and dextrose-based sausages respectively (Table 2). Increasing levels of ripe plantain usage significantly resulted in reduced the ash content of the sausages (P<0.05). However, T3 (dextrose-based) had the highest ash value of 1.91%. This agrees with findings observed by Akwetey *et al.* (2012) who reported a decrease in ash contents with increasing levels of whole cowpea flour as filler in frankfurter-type sausages.

Table 2. Sensory attributes

Parameter	Treatment				SEM
	T0	T1	T2	T3	
Appearance	6.11	5.86	5.83	6.32	0.30
Tenderness	5.62^{b}	5.37^{b}	5.20^{b}	4.89^{a}	0.35
Juiciness	5.56^{ab}	6.09^{b}	6.13^{b}	5.26^{a}	0.37
Flavour	5.54	5.66	5.69	5.78	0.35
Aftertaste	6.29	5.99	5.78	5.60	0.18
Texture	5.91	5.65	5.67	5.09	0.26
Acceptability	5.54^{b}	6.03^{b}	5.21^{a}	5.61^{b}	0.35

^{ab}Means in the same row with different superscript are significantly different. (P<0.05). T0 = 0% FRP; T1=5% FRP; T2 = 10% FRP and T3 = 0% FRP + 0.5% dextrose. Sensory scale: 1=Dislike extremely to 9=Like extremely.

Table 3. Proximate composition and cost of production

Parameter	Treatment				SEM
	T0	T1	T2	T3	
Moisture	32.27^{a}	35.23^{b}	40.39^{c}	30.45^{a}	0.74
Crude protein	23.31	23.01	22.10	22.30	0.33
Fat	4.67^{b}	3.01^{a}	3.07^{a}	4.61^{b}	0.41
Ash	1.81^{a}	1.86^{a}	1.83^{a}	1.91^{b}	0.01
Cost (GHS/kg)	20.50	17.20	16.46	15.52	

^{abc}Means in the same row with different superscript are significantly different. (P<0.05). T0 = 0% FRP; T1=5% FRP; T2 = 10% FRP and T3 = 0% FRP + 0.5% dextrose; GHS= Ghana Cedi.

Table 4. Percentage cooking loss, water holding capacity, fat and moisture retention and pH

Parameter (%)	Treatment				SEM
	T0	T1	T2	T3	
Cooking loss	31.07[a]	30.23[a]	32.72[b]	36.53[c]	0.023
WHC	8.73[b]	10.66[bc]	14.47[c]	4.43[a]	0.074
Fat Retention	1.67[a]	1.73[a]	2.67[b]	4.43[c]	0.052
Moisture Retention	21.81[b]	24.04[c]	27.02[d]	19.04[a]	0.035
Acidity (pH)	5.36[c]	5.29[bc]	5.31[bc]	4.20[a]	0.124

[abc]Means in the same row with different superscript are significantly different. (P<0.05). T0 = 0% FRP; T1=5% FRP; T2 = 10% FRP and T3 = 0% FRP + 0.5% dextrose.

Fat content

Significant differences (P<0.05) were observed in crude fat levels however, T1 and T2 were similar in crude fat while T0 and T3 were also not different. Treatment, T0 (0% ripe plantain) had the highest crude fat value, and this was attributed to the release of long-chain fatty acids from neutral lipids and phospholipids in meat during fermentation (Roncales *et al.*, 1989). This results agree with findings by Akwetey and Yamoah (2013) who reported decrease in fat in pork patties with increasing levels of solar dried plantain flour. This observation is related to the fat content of the meat. Plantain was used instead of meat in formulating T1 and T2 so fat contents of their samples were lower compared to T0(0%FRP) and T3(0.5% dextrose).

Crude Protein and cost of production

The protein content recorded were not significantly (P>0.05) different across treatments. Observed values ranged from 22.10% (T2) to 23.31% (T0). Increasing levels of FRP resulted in reduced costs of production apparently because fresh ripe plantain is relatively cheaper compared to meat.

The costs of production reduced from 20.50 to 15.52 Ghana Cedis per kg for sausages without FRP and those produced with the highest level of plantain respectively.

Cooking loss, water holding capacity (WHC), fat and moisture retentions, and pH

The results obtained for cooking loss, water holding capacity, fat and moisture retention and pH of cooked sausages produced are shown in Table 4.

Cooking loss

There were significant differences (P<0.05) in the cooking loss of control, fresh ripe plantain and dextrose treated-products as shown in Table 4. The dextrose-treated sausages lost 36.53% after cooking while sausages produced with ripe plantain lost up to 32.72% (T2) of their fresh weights while the lost in weight for T0 samples was 31.07%. The observed higher losses in weight during cooking was related to pH and water holding capacity. Generally, pH increases with water holding capacity and cooking yield (Lawrie and Ledward, 2006). Thus a lower pH will ultimately result in higher cooking loss due to the inability of the product to retain inherent moisture, which will be lost through purging during cooking.

Water holding capacity

There were significant differences (P<0.05) between the control, fresh ripe plantain and dextrose based-product as shown in Table 4. However, T3 (dextrose based products) recorded the least water holding capacity as a results lower pH recorded for the product. Bertram *et al.* (2004) reported that higher pH favored water binding capacity in meat systems probably due to their effects on the microstructure of meats.

Fat and Moisture retention

There were significant differences (P<0.05) between the control, fresh ripe plantain and dextrose based-product in terms of moisture and fat retentions as shown in Table 4. The fat and moisture retentions increased with increasing levels of FRP and the control recorded significantly (P<0.05) lower fat retention compared with T2 and T3. Treatment T3 (dextrose) had the highest ability to retain fat during cooking, but the least capacity to retain moisture; an observation which was attributed to the inverse relation with water and fat content in meat (Aberle *et al.*, 2001).

pH of the fermented sausage

Table 4 shows treatment effects on the pH of fermented sausage with or without FRP or dextrose. There was significant (p<0.05) effects on the pH values of treatments. Treatment T0, T1 and T2 were significantly higher (p<0.05) than T3, and the use of FRP in fermented sausages seemed to affect pH, though not statistically different. The lower pH in T3 corroborates suggestions by Stanley and Adam (2009) that dextrose has the advantage of being directly fermented into lactic acid and is the quickest acting sugar for bringing down pH, for which reason 0.3 to 0.7 percent dextrose is frequently prescribed in meat formulations.

Conclusions and Recommendations

The results obtain from this study suggested that sensorial appearance, flavor, aftertaste and texture of semi-dry fermented beef sausages were not affected by using fresh ripe plantain in product formulations. Moisture contents increased in the sausages with 5-10% plantain compared to the control without using fresh ripe plantain. Conversely, the fat content in the control sausage samples were higher than those containing 5-10% FRP. Also, the use of fresh ripe plantain resulted in appreciable reductions in the costs of producing fermented sausages. It was concluded that 5% fresh ripe plantain could be used in producing fermented beef sausages in order to reduce production costs without any adverse effect on most of their eating characteristics as well as crude protein contents. It is recommended that further studies be conducted to assess the effects of fresh ripe plantain in the production of other processed meat.

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