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Sensory and nutritional qualities of beef sausages prepared with sweet potato puree as extender

Ossom, R.N.,[1] Adzitey, F. ,[1,2]* Teye, G.A.,[1] Abu, A.[1] and Amagloh, F.K.[3]

[1]Department of Animal Science, [2]Department of Veterinary Science, [3]Department of Food Science, Faculty of Agriculture, University for Development Studies, P.O. Box TL 1882, Tamale, Ghana.

***Corresponding Author: email:** adzitey@yahoo.co.uk; **Telephone Number:** +233249995310*

***Target Audience:** Food consumers, food processors, stakeholders*

Abstract

This study investigated the effects of three varieties of sweet potato purees, that is orange-fleshed sweet potato (OFP), purple-fleshed sweet potato (PFP) and white-fleshed sweet potato (WFP) on the sensory and nutritional qualities of beef sausages. A complete randomized design was used to assign the sweet potato purees to the meat. The sweet potato purees were added to 2kg meat at 0% (TO 0%), 10% (OFP1 10%, PFP1 10% and WFP1 10%), and 15% (OFP2 15%, PFP2 15% and WFP2 15%) inclusion levels. The British Standard Institute procedure was adopted for sensory analysis. The official methods of analysis of the Association of Official Analytical Chemists was used for nutritional analysis. There were no significant differences (P>0.05) in sensory attributes of beef sausages except tenderness which were generally improved in the sweet potato beef sausages on day 14. The pH of the sweet potato beef sausages varied significantly (P<0.05) among the various inclusion levels. It was observed that whole beef sausages (TO 0%) had the lowest value and the values increased as inclusion level of sweet potato puree was increased. The moisture, protein and ash contents ranged from 63.60 ± 0.42 to 69.10 ± 0.42, 17.98 ± 0.24 to 19.79 ± 0.24 and 6.74 ± 0.18 to 8.71, respectively, and differed significantly (P<0.05) among the various inclusion levels. There were no significant differences (P>0.05) in fat content of the beef sausages. Cooking loss ranged from 8.0 ± 4.0 to 25.0 ± 13.0 and differed significantly (P<0.05). The peroxide values were not different (P>0.05) on day 7, but increased with storage time. The iron (0.1949-0.3181 mg/kg), selenium (0.0305-0.1088 mg/kg) and zinc (0.0017-0.0670mg/kg) contents of the beef sausages differed significantly (P<0.05). The inclusion of sweet potato puree as an extender did not negatively affect the sensory and nutritional qualities of the beef sausages.

***Keywords:** Beef sausages, meat, nutrient composition, sensory properties, sweet potato varieties*

Description of Problem

Meat is the flesh obtained from a slaughtered animal that is eaten as food, and this may include skeletal muscle, fats and other tissues (1). It is rich in proteins and other nutrients required by man for growth and repair of worn out tissues (1, 2). Meat can be processed by the addition of ingredients and/or mechanical action to convert it into specific products such as beef sausages, pork sausages, frankfurters, burgers among others to meet the desires of consumers (3-9). In the meat processing industry, the inclusion of non-meat ingredients such as sweet potato is considered an important strategy for reducing overall production cost while maintaining nutritional and sensory qualities of end products (10-12). Extenders such as sweet potato is used in meat products to improve meat particles cohesion, increase processing yield and increase dietary fiber to improve texture and reduce cost (10).

As in the quest of reducing cost of production, sweet potato which is readily available and relatively cheaper than meat can serve as an extender in sausages. Several varieties of sweet potato exist with various phenotypic appearances (ranging from white, cream, yellow, orange and purple fleshed), sensory, physicochemical and nutritional characteristics (13). Sweet potatoes are rich source of energy, antioxidants and vitamins which is of a high value to humans (13, 14). They are excellent source of fibre and minerals which are important in reducing blood cholesterol and aiding digestion (15, 16). Department of Agriculture, Health and Human Services (17) also reiterated that sweet potatoes have a percentage of insoluble fibre which is capable of preventing colon cancer, diverticular disease and constipation.

The use of sweet potatoes as an extender in meat products is limited despite its nutritional importance. In addition, the short shelf life of sweet potatoes and high cost of meat are among the major challenges of food processing even though they both have major nutrients for human development and maintenance. Using sweet potatoes in meat processing could contribute to solving the afore-mentioned challenges. Therefore, this study was conducted to investigate the use of sweet potato puree as an extender in beef sausages.

Materials and Method

Study Site

The study was conducted at University for Development Studies (UDS), Tamale. Products (beef sausage) formulation took place at the Meat Processing Unit of UDS, while chemical and microbiological analyses were carried out at laboratories of University for Development Studies, Nyankpala Campus and Kwame Nkrumah Science and Technology, Kumasi, Ghana.

Experimental Design

Completely randomized design was used in all the trials. The sweet potato purees were randomly assigned to the minced meat with spices and each treatment was triplicated.

Processing of Sweet Potato Purees

The orange, white and purple-fleshed sweet potatoes used for the experiment were purchased from farmers in Kumbugu. Sweet potato purees were processed according to Ossom *et al.* (12). Briefly, the sweet potatoes were peeled chopped into smaller sizes (4mm) and cooked at 100^{o}C for 15min. They were then allowed to cool down, blended into puree and stored frozen at -2^{o}C.

Preparation of Beef Sausages

The beef sausages were prepared according to Teye *et al*. (12). Fourteen kilogram of lean beef was used for the experiment. The meat was thawed for 3h at a temperature of 1°C and minced using a 5mm-sieve table top mincer (Taller Ramon, Spain). The minced beef was divided into one kilogram each. Each kilogram was mixed with 1.0g black pepper, 1.0g white pepper, 0.5g red pepper, 2.0g mixed spice (Adobe®) and 15g curing salt. The spices were measured into a container and mixed thoroughly before adding it to the minced beef. Sweet potato purees were included at 0, 100 and 150 (g/kg) to the various sausage formulations to obtain 0% (TO 0%), 10% [(orange-fleshed sweet potato (OFP1 10%), purple-fleshed sweet potato (PFP1 10%) and white-fleshed sweet potato (WFP1 10%)], and 15% [(orange-fleshed sweet potato (OFP2 15%), purple-fleshed sweet potato (PFP2 15%) and white-fleshed sweet potato (WFP2 15%)] beef sausages, respectively. The minced meats, spices and sweet potatoes at the various inclusion levels were comminuted in a 3-knife, 30 litres capacity bowl chopper (Tallers Ramon, Spain) into a meat. The meat butter was then stuffed into natural casings, using a hydraulic stuffer (Tallers Ramon, Spain) and manually linked into equal lengths of about 10cm. The linked sausages were hung on smoking racks (Laint smoker), smoked for 45 minutes and scalded to a core temperature of 70°C. They were then cooled in cold water, packaged and stored in deep freezer for sensory evaluation.

Cooking Loss of Sweet Potato Beef Sausages

Cooking loss for sweet potato beef sausages was determined by following the procedure as described by Adzitey *et al*. (6). In brief, fresh sweet potato beef sausages were weighed (W1) and cooked to an internal temperature of 75ºC for 15 minutes. After cooking, the weight was retaken and recorded (W2). Cooking loss was calculated as [(weight of sausages before cooking (W1) -weight of sausages after cooking (W2) ÷ weight of sausages before cooking (W1)] X 100.

Sensory Analysis of Beef Sausages

A total of 12 panelists were selected from the students and staff of UDS Nyankpala Campus and trained according to the British Standard Institution guidelines for the evaluation of the products (18). The panelists were made up of 6 females and 6 males. The panelists evaluated the beef sausages for colour, aroma, flavour liking, juiciness, texture, taste and overall acceptability. A 9-point hedonic scale (*1= Extremely dislike to 9 = Extremely like*) was used. Sensory evaluation was carried out on day 1, 7 and 14 of storage to determine the effect of storage period on the sensory characteristics of the products. Stored beef sausages were removed from the refrigerator and allowed to thaw under room temperature. They were then grilled in an electric oven (Turbonfan, Blue seal, UK), sliced into 2cm thickness and wrapped with coded aluminium foil.

Nutritional Analyses of Beef Sausages

Proximate composition was conducted by following the procedures of the methods of Association of Official Analytical Chemists (19). The determination of pH, peroxide values and minerals (iron, zinc and selenium) were done as described by Adzitey *et al.* (6), Abu *et al*. (8) and Adua (20), respectively. All analyses were done in triplicates. All reagent used were also of analytical grades. For the determination of pH, 10g beef sausage of each treatment was ground with laboratory mortar and pestle, homogenized with 50ml distilled water and pH values were measured with digital pH-meter (CRISON, Basic 20, Spain).

Table 1: Sensory characteristics of sweet potato beef sausages on day 1

Parameters	TO 0%	WFP1 10%	WFP2 15%	OFP1 10%	OFP2 15%	PFP1 10%	PFP2 15%	S.e.d	P value
Colour	5.25	5.42	5.33	4.67	5.25	5.17	5.75	0.854	0.941
Aroma	6.17	6.50	6.50	7.00	6.58	6.25	6.50	0.717	0.945
Flovour liking	6.00	5.83	6.67	7.08	7.08	7.08	6.92	0.648	0.239
Tenderness	5.00	5.83	6.33	5.58	6.33	5.83	5.92	0.838	0.730
Texture	5.42	6.08	5.83	6.17	6.00	6.17	6.58	0.744	0.837
Taste	6.67	6.67	7.17	6.75	6.83	7.33	6.92	0.502	0.790
Overall liking	7.08	7.00	7.00	7.08	7.00	7.00	7.00	0.513	1.000

Sed = standard error of difference. Means on the same row with the same superscript are not significantly different (P>0.05). TO 0%: whole beef or control; WFP1 10%: white-fleshed sweet potato; WFP2 15%: white-fleshed sweet potato; OFP1 10%: orange-fleshed sweet potato; OFP2 15%: orange-fleshed sweet potato; PFP1 10%: purple-fleshed sweet potato; and PFP2 15%: purple-fleshed sweet potato.

Table 2: Sensory characteristics of sweet potato beef sausages on day 7

Parameters	TO 0%	WFP1 10%	WFP2 15%	OFP1 10%	OFP2 15%	PFP1 10%	PFP2 15%	S.e.d	P value
Colour	6.53	6.13	5.93	5.60	5.80	6.20	5.40	0.586	0.529
Aroma	5.60	5.93	6.40	5.73	6.27	7.00	6.60	0.653	0.331
Flovour liking	6.27	7.20	6.93	6.60	6.33	6.87	7.00	0.580	0.622
Tenderness	5.53	6.47	6.40	5.47	6.13	6.67	6.53	0.594	0.246
Texture	5.60	6.13	5.93	5.87	6.07	6.80	7.07	0.604	0.176
Taste	6.93	7.40	7.00	6.73	6.80	7.40	7.00	0.454	0.660
Overall liking	7.13	7.27	6.53	6.33	6.40	7.00	6.87	0.605	0.612

Sed = standard error of difference. Means on the same row with the same superscript are not significantly different (P>0.05). TO 0%: whole beef or control; WFP1 10%: white-fleshed sweet potato; WFP2 15%: white-fleshed sweet potato; OFP1 10%: orange-fleshed sweet potato; OFP2 15%: orange-fleshed sweet potato; PFP1 10%: purple-fleshed sweet potato; and PFP2 15%: purple-fleshed sweet potato.

Table 3: Sensory characteristics of sweet potato beef sausages on day 14

Parameters	TO 0%	WFP1 10%	WFP2 15%	OFP1 10%	OFP2 15%	PFP1 10%	PFP2 15%	S.e.d	P value
Colour	6.91	5.82	4.91	5.73	6.18	6.27	5.73	0.691	0.163
Aroma	4.91	5.00	5.45	5.18	5.82	5.27	5.91	0.664	0.671
Flovour liking	6.00	5.55	6.55	6.09	5.91	6.09	6.64	0.743	0.802
Tenderness	3.27[a]	4.55[ab]	5.00[ab]	4.91[ab]	5.64[b]	5.36[b]	5.18[ab]	0.689	0.028
Texture	5.82	6.00	6.09	6.18	6.82	6.27	6.27	0.692	0.869
Taste	6.00	6.18	6.82	6.27	6.55	6.82	7.00	0.529	0.421
Overall liking	5.91	6.00	6.55	6.18	6.36	6.91	6.73	0.556	0.500

Sed = standard error of difference. Means on the same row with the same superscript are not significantly different (P>0.05). TO 0%: whole beef or control; WFP1 10%: white-fleshed sweet potato; WFP2 15%: white-fleshed sweet potato; OFP1 10%: orange-fleshed sweet potato; OFP2 15%: orange-fleshed sweet potato; PFP1 10%: purple-fleshed sweet potato; and PFP2 15%: purple-fleshed sweet potato.

Statistical Analysis

Data collected was analyzed using Analysis of Variance (ANOVA) of the Genstat Statistical Package, Edition 4. Differences were separated at 95% significant level.

Results and Discussion

Sensory Characteristics of Sweet Potato Beef Sausages

There were no significant differences (P>0.05) in the sensory characteristics of sweet potato beef sausages throughout the storage period except tenderness which was significantly different (P<0.05) on the 14th day of storage as shown in Table 1, 2 and 3. In general, beef sausages formulated with sweet potatoes were tender (P<0.05) than the control.

The addition of sweet potato purees did not have any negative impact on the beef sausages. The colour of sweet potatoes was expected to have impacted on the final product and customer's preference but that was not observed. The inclusion of sweet potato puree in the products did not cause any repulsion by consumers. The tenderness improvement became evident on day 14 and was relatively in favour of the test products. The moisture content of sweet potato puree could have contributed to moisture content of the test products. Lorenzen *et al*. (21) demonstrated that 51% of consumers rated tenderness as the most important sensory trait they look for in meat and meat products. The insignificant differences (P>0.05) among the various treatments for most sensory attributes (colour, aroma, flovour liking, texture, taste and overall liking) indicate that beef sausages prepared by the addition of sweet potato purees were equally preferred as the control by consumers.

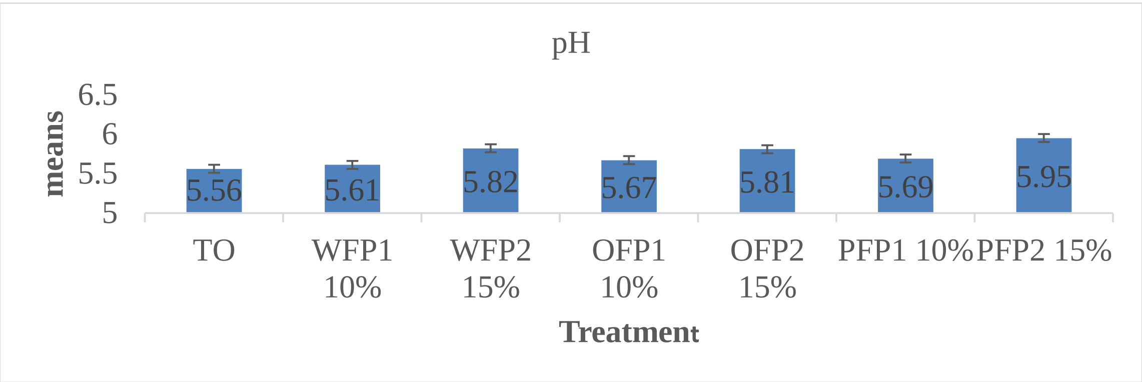
Proximate Composition of Sweet Potato Beef Sausages

The results for proximate composition of sweet potato beef sausages are presented in Table 4. All proximate parameters were significantly different (P<0.05) among the various formulations except for the crude fat content. The moisture content of beef sausages with and without sweet potato purees ranged from 63.60-69.10%. Agnihotri and Pal (22) stated that the moisture content of sausage is about 66.7% which agrees with this study. The moisture content as found in sweet potato beef sausages with low inclusion level of sweet potato puree indicates that, sausages with 10% inclusion level (WFP1 OFP1 and PFP1) has high water holding capacity than products with 15% inclusion level (WFP2 OFP2and , PFP2). The protein content ranged from 18.35-19.21% while the fat and ash contents ranged from 14.71-16.18% and 6.74-8.71%, respectively. It was realized that higher inclusion levels of sweet potato (OFP2 15% and PFP2 15%) puree significantly (P<0.05) lowered the protein content of the products which agrees with the findings by Asgar *et al.* (23). Asgar *et al.* (23) reported that adding substances which are low in protein will result in low protein content of which sweet potato is one of such as compared with beef. The addition of sweet potato did not affect (P>0.05) the fat content of the sweet potato beef sausages which agrees with the findings of Tamakloe (24). Tamakloe (24) reported that using orange-fleshed sweet potato puree as extender in beef sausages did not affect the fat content of the sausages as compared to the control. However, the inclusion level of orange-flesh sweet potato puree as used by Tamakloe (24) was higher than this current study. Ash content represents the total mineral content in foods. Significant amount (P<0.05) of ash was found in sweet potato sausages which indicates presence of mineral in products. The white-flesh sweet potato beef sausages were relatively better in ash content than the rest of the sausages.

The pH of Sweet Potato Beef Sausages

Figure 1 shows that, the pH of the sweet potato beef sausages varied remarkably (P < 0.001) among the beef sausages. Control (TO 0%) and 10% purees had lower pH as compared to the treatments with high (15%) puree products.

It was observed that whole beef sausages (TO), had the lowest pH as compared to the sweet potato beef sausages. The role of lower pH in meat and meat products on the inhibition of bacterial growth and development is known since antiquity (1). Lower pH of meat products creates an acidic medium, making it inappropriate for bacterial growth and reproduction (25, 26). This implies that the inclusion of sweet potato purees up to 10% would enhance storability of the products.



TO 0%: whole beef or control; WFP1 10%: white-fleshed sweet potato; WFP2 15%: white-fleshed sweet potato; OFP1 10%: orange-fleshed sweet potato; OFP2 15%: orange-fleshed sweet potato; PFP1 10%: purple-fleshed sweet potato; and PFP2 15%: purple-fleshed sweet potato.

Figure 1: pH of sweet potato beef sausages

Table 4: Proximate composition of sweet potato beef sausages

Parameter	TO 0%	WFP1 10%	WFP2 15%	OFP1 10%	OFP2 15%	PFP1 10%	PFP2 15%	P value
Moisture	66.10± 0.42^{b}	69.10 ± 0.42^{a}	65.50 ± 0.42^{bc}	66.30 ± 0.42^{b}	64.50 ± 0.42^{bc}	64.90 ± 0.42^{bc}	63.60 ± 0.42^{c}	0.001
Protein	19.79 ± 0.24^{a}	18.94 ± 0.24^{ab}	19.18 ± 0.24 ^{ab}	19.07± 0.24^{ab}	17.98 ± 0.24^{b}	19.21± 0.24^{ab}	18.35± 0.24^{b}	0.014
Fat	16.47 ± 0.47	15.88 ± 0.47	15.29 ± 0.47	16.18 ± 0.47	14.71 ± 0.47	16.18 ± 0.47	15.88 ± 0.47	0.264
Ash	7.60 ± 0.18^{bc}	8.71 ± 0.18^{a}	8.21 ± 0.18^{ab}	6.75 ± 0.18^{c}	6.83 ± 0.18^{c}	7.70 ± 0.18^{bc}	6.74 ± 0.18^{c}	0.000

Values are means ± standard error of means; Means in the same row with the same superscript are not significantly different (P > 0.05). TO 0%: whole beef or control; WFP1 10%: white-fleshed sweet potato; WFP2 15%: white-fleshed sweet potato; OFP1 10%: orange-fleshed sweet potato; OFP2 15%: orange-fleshed sweet potato; PFP1 10%: purple-fleshed sweet potato; and PFP2 15%: purple-fleshed sweet potato.

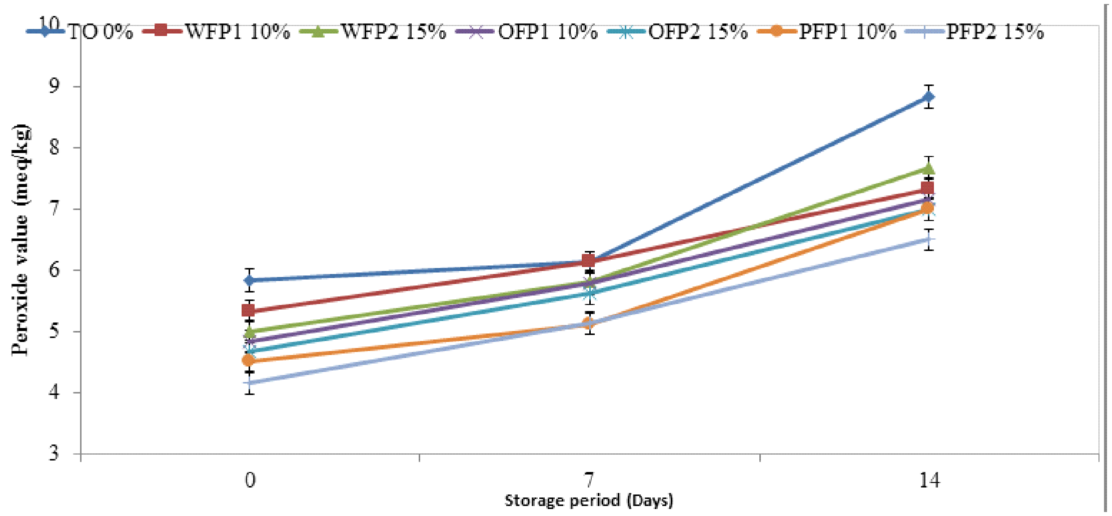
Table 5: Cooking loss of sweet potato beef sausages

Treatment	TO 0%	WFP1 10%	WFP2 15%	OFP1 10%	OFP2 15%	PFP1 10%	PFP2 15%	P value
Means	11.0 ± 1.0[ab]	11.5 ± 3.50[ab]	8.0 ± 4.0[b]	13.0 ± 1.0[ab]	15.0 ± 3.0[ab]	25.0 ± 13.0[a]	12.0 ± 0[ab]	0.043

Means (± standard deviation); Means in the same row with the same superscript are not significantly different (P < 0.05). TO 0%: whole beef or control; WFP1 10%: white-fleshed sweet potato; WFP2 15%: white-fleshed sweet potato; OFP1 10%: orange-fleshed sweet potato; OFP2 15%: orange-fleshed sweet potato; PFP1 10%: purple-fleshed sweet potato; and PFP2 15%: purple-fleshed sweet potato.

Cooking Loss of Sweet Potato Beef Sausages

There were significant differences (P<0.05) in cooking loss for beef sausage with sweet potato purees. PFP1 10% and WFP2 15% had the highest and the lowest value for cooking loss (25.0 and 8.0%), respectively as shown in Table 5. The inclusion of sweet potato puree in beef sausages significantly affected (P<0.05) the cooking loss of the sausages. There was no trend that can be attributed to the effect of the addition of the sweet potato puree on cooking loss. However, inclusion of the various test materials up to 10% generally did not affect the cooking yield of the products. This finding agrees with Tamakloe (24) who included sweet potato puree up to 20% in beef sausage.



TO 0%: whole beef or control; WFP1 10%: white-fleshed sweet potato; WFP2 15%: white-fleshed sweet potato; OFP1 10%: orange-fleshed sweet potato; OFP2 15%: orange-fleshed sweet potato; PFP1 10%: purple-fleshed sweet potato; and PFP2 15%: purple-fleshed sweet potato.

Figure 2: Peroxide value of sweet potato beef sausages

Table 6: Mineral composition of sweet potato beef sausages

Treatments	Iron (mg/kg)	Zinc (mg/kg)	Selenium (mg/kg)
TO 0%	0.2637[c]	0.0670[a]	0.0784[b]
WFP1 10%	0.3181[a]	0.0349[c]	0.1088[a]
WFP2 15%	0.1949[f]	0.0017[e]	0.0427[e]
OFP1 10%	0.2205[e]	0.0573[b]	0.0571[c]
OFP2 15%	0.2370[d]	0.0350[c]	0.0305[f]
PFP1 10%	0.2205[e]	0.0542[b]	0.0565[c]
PFP2 15%	0.3009[b]	0.0117[d]	0.0438[d]
Pooled standard error of means	0.00	0.00	0.00
P value	0.0001	0.0001	0.0001

Means (± standard error) Means in the same column with different superscript are significantly different ($P<0.0001$). TO 0%: whole beef or control; WFP1 10%: white-fleshed sweet potato; WFP2 15%: white-fleshed sweet potato; OFP1 10%: orange-fleshed sweet potato; OFP2 15%: orange-fleshed sweet potato; PFP1 10%: purple-fleshed sweet potato; and PFP2 15%: purple-fleshed sweet potato.

Peroxide Value of Sweet Potato Beef Sausages

The peroxide value of whole beef (TO 0%) was significantly higher ($P<0.05$) than the sweet potato beef sausages on day 14, but on days 1 and 7, the beef sausages were relatively stable (Figure 2). The peroxide values of the beef sausages ranged from 4.16 to 8.833meq/kg throughout the storage period.

The values obtained throughout the storage period were below the maximum permissible limit of 25meq/kg of active oxygen/kg of product (27). The sweet potato sausages had significantly ($P<0.05$) lower values. This could be attributed to the presence of sweet potato as extender which served the role of antioxidant to halt lipid oxidation. Pigmented potatoes contain a variety of substances with antioxidant potential (28). Potatoes are also known to contain water-soluble antioxidants that act as free radical acceptors, e.g. glutathione, ascorbic acid, quercetin and chlorogenic acid (29). Diets rich in antioxidants, such as carotenoids, have been associated with lower risk of stomach, kidney and breast cancers (30).

Mineral Composition of Sweet Potato Beef Sausages

Table 6 shows the results of the mineral content of beef sausages as prepared with sweet potato puree. Among the formulations, all minerals considered were significantly different ($P<0.05$) from each other except OFP1 10% and PFP1 10% which were not different ($P>0.05$) from each other in iron, zinc and selenium. The sweet potato sausage (WFP1 10%) had the highest value of iron content. Therefore, sweet potato sausages can serve as source of iron for humans when consumed. The sweet potato sausages were significantly ($P<0.05$) lower in zinc compared to the whole beef sausage. The importance of zinc to humans cannot be over-emphasized as zinc plays a role in the body's defense system, involved in cell division, growth and wound healing. Potato purees were lower in zinc than beef and that could have accounted for the lower zinc content in the beef sausages prepared with sweet potato purees compared to the control. The selenium content of the sweet potato beef sausages was also highest for WFP1 10%. Selenium works with vitamin E in production of glutathione to protect cells from damage that may lead to cancer, heart related diseases and other health problems (32).

Selenium also has the ability to stimulate the formation of antibodies which help to fight infections in the body (32). Although, the zinc, and selenium contents of the sweet potato beef sausages were generally lower than the whole beef sausages, they contained appreciable amounts of these minerals that will be available to humans when consumed.

Conclusion and Applications

1. The inclusion of sweet potato puree as an extender did not negatively affect the sensory characteristics of the beef sausages but rather improved the tenderness of the beef sausages.
2. The beef sausages were not influenced negatively in terms of their proximate compositions.
3. Lipid peroxidation process was slowed by the sweet potato puree inclusion in the sausages.
4. The sweet potato beef sausages were also sources of micro minerals (zinc, iron and selenium).
5. Sweet potato purees showed potential for use as extenders in meat products to reduce production cost since the price per kilogram of meat is expensive than a kilogram of sweet potato.
6. It is recommended that further research should determine the cost of production and carotenoid levels in the products.

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