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Original Article

The Use of Sweet Potato (*Ipomoea Batatas*) Starch as Binder in Beef and Pork Frankfurter-Type Sausages

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Abstract

This study was conducted to find an alternative ingredient for use as a binder in comminuted sausages. Sweet potato starch (SPS) was used to formulate products at three levels of inclusion (2%, 4% and 6% of minced meat) and compared with products formulated with polyphosphates (5g/kg meat) as binder, to determine the storability and sensory characteristics of the products. The single factor design was used in this study. Each treatment contained 3kg meat (2kg pork and 1kg beef). The products were formulated in duplicates, vacuum sealed in transparent polythene bags and refrigerated at 2°C for laboratory and sensory analyses. The results indicated that SPS up to 4% inclusion had no significant effect on cooking loss, meat flavour intensity, flavour liking and overall acceptability of the products. The 6% level of SPS inclusion however, significantly minimized the meat flavour intensity, flavour liking, overall acceptability and also increased cooking losses in the products. The use of SPS minimized the rate of lipid per-oxidation, but had no effect on the microbial quality of the products. It was cheaper using SPS up to 4% inclusion (US$55.12 or GH¢ 83.00) than polyphosphates (US$83.00 or GH¢125.00). SPS could be used up to 4% inclusion in meat products, to minimize formulation costs and consumers' worry over the excessive use of chemical ingredients in meat products.

Key words: Binder-substitute, polyphosphates, sweet potato starch, sausage

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Introduction

The consequence of slaughter and subsequent storage of meat is the loss of the ability to hold water due to changes in the muscle as a result of loss of adenosine tri-phosphate (Lawrie and Ledward, 2006). One method of restoring the water-holding capacity of comminuted meat products is the addition of polyphosphates, which improves the particle cohesion, and fat and water-binding capacity of the products (Troy *et al.*, 2001). Polyphosphates, when added to meat, breaks actomyosin structures into actin and myosin, which can be solubilized by salt to increase the water-holding capacity (FAO, 1991). However, the use of polyphosphates in comminuted meat products is impeded by some set-backs (Teye, 2010; Smith and Young, 2007). In Ghana, it is scarce and when available it is expensive. In addition, some consumers have concerns that being a chemical additive, polyphosphates may leave residues which can be harmful when such products are consumed over a long period (Smith and Young, 2007). There is therefore the need to find a non-chemical ingredient to serve as a binder in comminuted meat products (Means and Schmidt, 1987). One of such ingredients is sweet potato starch.

Sweet potato is a root tuber, which is being produced on large scale in Ghana. The orange-flesh sweet potato tuber is high in carotene; a precursor for vitamin A, which is necessary for good eyesight (Pond *et al.*, 1995). According to the FAO (1991), starch of tuber crops improves the water binding ability of comminuted meat products.

Several research works involving the use of yam flour and cassava flour as fillers/binders in comminuted meat products reported good level of juiciness, higher product yield and lower formulation costs; and hence greater profit margins (Annor-Frempong *et al.*, 1996; Anang *et al.*, 1999) but the FAO (1991) reported that the use of flour as binder results in lower quality products, hence the need to try the potentials of starch.

This research was therefore aimed at investigating the effects of sweet potato starch as a binder in place of polyphosphates in comminuted meat products.

Material and Methods

The study was conducted at the Meat Processing Unit and Laboratories of the University for Development Studies, Nyankpala Campus, Tamale.

Sweet potato starch extraction

Fresh sweet potato tubers were obtained from the local market, peeled, washed and grated into a fine paste, using a conventional cassava mill. The paste was diluted with water, followed by a thorough hand-mixing. The mixture was then strained with an autoclaved-cloth and the extract allowed settling in 12 hours. It was then decanted to obtain the wet starch. The starch was dried thoroughly in an oven (J.P. Selecta s.a, Incudigit) at 60°C for 24hours and then stored for later use (Daiuto *et al.*, 2005).

Sausage formulation

Fresh boneless pork and beef from the hindquarters of matured boars and bulls respectively, were obtained from the Meat Processing Unit of UDS, cut into pieces and minced separately using a 3mm-sieve table top mincer (Talleres Rommon, Spain). The single factor design was used in this study, to compare the means of the SPS products against those of the polyphosphate (control) products. The minced meat was divided into groups of 3kg each (1kg beef and 2kg pork), and used to formulate frankfurter-type sausages at four levels: Control (5g polyphosphates/kg meat), SPS1 (2% SPS of meat), SPS2 (4% SPS of meat) and SPS3 (6% SPS of meat). The other ingredients were added in equal amounts (g/kg) to the various formulations: 15.0g curing salt, 0.5g red chillies, 1.0g black pepper, 1.0g white pepper and 2g "adobo" (mixed spices). Crushed ice (1.2kg) was added during comminution to obtain the desired consistency of the meat batter in a 3-knife bowl chopper (Talleres Rommon, Spain), until a meat-batter temperature of 17°C was attained. The meat batter was immediately stuffed into natural casings, using a hydraulic stuffer (Talleres Rommon, Spain) and manually linked to similar lengths of about 10cm. The sausages were weighed, hung on smoking racks and smoked for an hour, after which they were scalded to a core temperature of 70°C. The products were formulated in duplicates. The

sausages were cooled in cold water and hung on the racks again for water to drain. They were re-weighed and vacuum-packed in transparent polythene bags, labelled and stored in a refrigerator at 2°C for sensory and laboratory analyses (FAO, 1985).

Sensory evaluation of the products

A total of 20 panellists, comprising staff members and students of the University, were randomly selected and trained according to the British Standard Institution guidelines (BSI, 1993), to evaluate the products. Sensory evaluation was conducted on days 1, 7 and 14 of storage. The sausages were thawed and warmed in an oven (Turbofan, Blue seal, UK), sliced into uniform sizes (about 2cm in length), wrapped with coded aluminium foils and presented to the panellists. Each panellist was provided with water and pieces of bread to serve as neutralizers in between tasting of the products.

An eight-point category scale as described by Keeton (1983) was used to evaluate the sensory characteristics of the products.

Colour: 1=extremely pale red; 2=very pale red; 3=moderately pale red; 4=slightly pale red; 5=slightly dark red; 6=moderately dark red; 7=very dark red; 8=extremely dark red.

Tenderness**:** 1=extremely tough, 2=very tough; 3=moderately tough; 4=slightly tough; 5=slightly tender; 6=moderately tender; 7=very tender; 8=extremely tender.

Juiciness: 1=extremely dry; 2=very dry; 3=moderately dry; 4=slightly dry; 5=slightly juicy; 6=moderately juicy; 7=very juicy; 8=extremely juicy.

Meat flavour intensity: 1=extremely bland; 2=very bland; 3=moderately bland; 4=slightly bland; 5=slightly intense; 6=moderately intense; 7=very intense; 8=extremely intense.

Flavour liking/Overall acceptability: 1=dislike extremely, 2=dislike very much; 3=dislike moderately; 4=dislike slightly; 5=like slightly; 6=like moderately; 7=like very much; 8=like extremely.

Proximate composition of the products

The sausages were analyzed for moisture, crude protein and fat contents, according to the methods of the AOAC (1999).

Aerobic plate counts

The aerobic plate counts (APC) of the products were determined on day 1, 7, 14 and 21 of storage, to determine the microbial stability in storage (AOAC, 1995).

Two grams each of thawed sausages was taken into a mortar and mashed with 1ml distilled then autoclaved water and emptied into a serial bottle to serve as a stock. Serial dilutions were then prepared from the stock. Inoculating loop was used to streak onto a commercially prepared agar, and incubated at 37°C for 48 hours. Colony counting was done using a colony counter (J.P. SELECTA, S.A. Spain) and results expressed as $\log_{10}$ CFU/g of sausage.

Data Analysis

The data obtained were analyzed using the General Linear Model (GLM) of Analysis of Variance (ANOVA) of the Minitab Statistical Package (MINITAB, 2007). Where significant differences were found, the means were separated using Tukey Pair Wise comparison, at 5% level of significance.

Results and Discussion

Cooking loss

The sausages were weighed before and after cooking to determine the cooking losses. The results are presented in Table 1. The SPS had no significant effect on the cooking losses of the SPS1 and SPS2 products, but significantly increased the cooking losses ($P<0.001$) in the SPS3 products (Table 1). It was realized that the optimum level of reduction in cooking loss was attained in the SPS2 products, though the difference was not significant.

During comminution of meat, muscle proteins form 3-dimensional matrices, which bind water, fat and any non-protein substance in the meat batter to stabilize the emulsion (Serdaroglu and Rmencioglu, 2004). The higher inclusion level of starch in the SPS3 products might be due to inadequate protein matrices available to bind the starch and water added during comminution, hence were lost during

cooking, and resulted in the greater cooking losses observed in the SPS3 products. When starch is heated it becomes jelly-like, and this aids in meat particle cohesion to trap water in the protein matrices. However, higher levels of starch results in an unstable emulsion and greater cooking losses (FAO, 1985). According to the FAO (1991), starch inclusion up to 4% improves binding in comminuted meat products, which was realized in this study. This indicates that SPS could be used as a binder at levels not greater than 4%, as recommended by the FAO (1991).

Sensory evaluation of the products

The products were presented to the taste panel for evaluation and the results are presented in Table 2. The SPS had no significant influence on colour, texture and juiciness (P > 0.05) of the sausages. The flavour intensity, flavour liking and overall acceptability of the SPS1 and SPS2 products were not significantly different from the control products, but these parameters significantly reduced (P< 0.01) in the SPS3 products.

The similar colour and flavour liking is advantageous, as meat purchasing decisions are influenced more by product appearance than any other quality factor (Lawrie and Ledward, 2006). Colour and flavour represent perceived freshness and is of vital importance to the meat industry and meat science research (Mancini and Hunt, 2005). This indicates that the SPS did not impart any colour to the products, which would otherwise cause differences between those products and the standard ones. The lower flavour intensity of the SPS3 products might have resulted in the lower flavour liking and acceptability of these products.

Table 1: Cooking losses of the sausages

Product	Control	SPS_1	SPS_2	SPS_3	SED	Sig
Cooking loss (%)	11.52^b	11.18^b	10.36^b	23.58^a	0.94	***

[ab=]Means in the same row with different subscripts are significantly different; SED=standard error of difference; Sig=significance; ***=significant (P< 0.001)

Table 2: Sensory characteristics of the products

Parameters	Control	SPS1	SPS2	SPS3	SED	Sig.
Colour	4.45	4.50	4.30	4.35	0.59	ns
Tenderness	5.60	4.85	5.30	5.35	0.85	ns
Juiciness	5.50	5.55	5.70	5.15	0.72	ns
Flavour intensity	5.50^a	4.85^a	4.65^a	4.10^b	0.70	**
Flavour liking	6.05^a	5.95^a	5.80^a	5.15^b	0.53	**
Acceptability	6.10^a	5.90^a	5.80^a	5.10^b	0.62	**

[ab=]Means in the same row with different subscripts are significantly different; SED=standard error of difference; Sig=significance; ns= not significant; **=significant (P< 0.01).

Proximate analysis of the products

The moisture, crude protein and fat contents of the products are presented in Table 3. The SPS products had significantly lower fat contents (P<0.001), but no significant effect on the crude protein content of the products.

Dietary fat plays a major role in the texture, juiciness and flavour of comminuted meat products (Crehan *et al.*, 2000). According to Drewnowski (1992), the sensory properties of fat make a diet flavourful, tender and palatable. Giese (1992) and Keeton (1994) reported that fats in meat act as reservoir for flavour compounds which improve the flavour of the products. Dietary fat reduction therefore is likely to minimize the sensory characteristics of food products (Byers *et al.*, 1993). The lower fat contents of the SPS products might have resulted in the reduced flavour intensity and flavour liking of these products (Table 2).

However, the excessive intake of dietary fats, especially the saturated fatty acids has been associated with the development of hypertension, cardio-vascular diseases, obesity, cancers of the colon, breast and prostate (Jimenez-Colmenero, 2001). A number of health organizations including

the World Health Organization, have recommended reduced daily fat intake for improved health (WHO, 1990). Since the SPS1 and SPS2 products had lower fat contents but with similar sensory characteristics as the control products, such products may minimize consumer health risks associated with the consumption of fatty meat and meat products.

Aerobic plate count of the products

The aerobic plate count of the products is presented in Figure 1. The APCs of the products ranged between 4.26 and 4.69 $\log_{10}$ CFU (colony forming units)/g of sample over the storage period. Although the values of the control products appeared higher than the SPS products, the differences were not significant. Higher microbial count in food products decreases the storability, and makes the products unsafe for consumption. In all the products, however, the APCs were lower than the maximum permissible level of 7 $\log_{10}$ CFU/g sample recommended by the ICMSF (1986), an indication that the substitution of polyphosphates with SPS in comminuted meat products would have no detrimental effect on the microbial quality of the products.

Table 3: Proximate composition of the products

Parameters (%)	Control	SPS1	SPS2	SPS3	SED	Sig.
Moisture	71.08^{ab}	70.66^{b}	71.24^{a}	69.68^{c}	0.07	***
Crude protein	17.79	17.47	17.07	16.81	0.08	ns
Fat (ether extract)	8.64^{a}	7.64^{b}	7.04^{c}	6.58^{d}	0.07	***

Means in the same row with different subscripts are significantly different. SED=standard error of difference, Sig.= significance, ns= not significant, ***=significant (P<0.001).

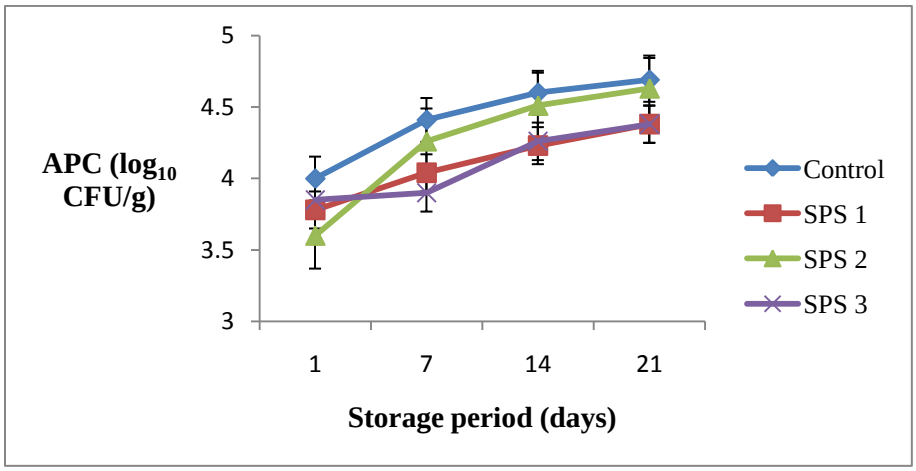

Fig. 1: Aerobic plate count of the products

Lipid per-oxidation in the products

The peroxide values (POVs) of the products ranged between 2.67 and 5.33 millequivalent/kg sausage. There POVs of the SPS products were significantly lower (P<0.05) than the control products (Fig 2).

Lipid per-oxidation in food is of importance, in that it progresses at faster rates in products with higher fat contents (Warriss, 2010). The unsaturated

and polyunsaturated fatty acids present in the fats, react with oxygen to form fatty acid hydro-peroxides. Hydro-peroxides are unstable, and breakdown into various compounds which can produce off-flavours; leading to a stale, rancid flavour in foods (Kerler and Grosch, 1996). Among the products however, the peroxide values were significantly lower than 25millequivalent/kg sausage, which is considered as the limit of acceptability in fatty foods (Evranuz, 1993; Narasimhan et al., 1986).

The relatively lower POVs of the SPS products might be due to the lower fat contents of such products, and is an indication that such products might have better storability.

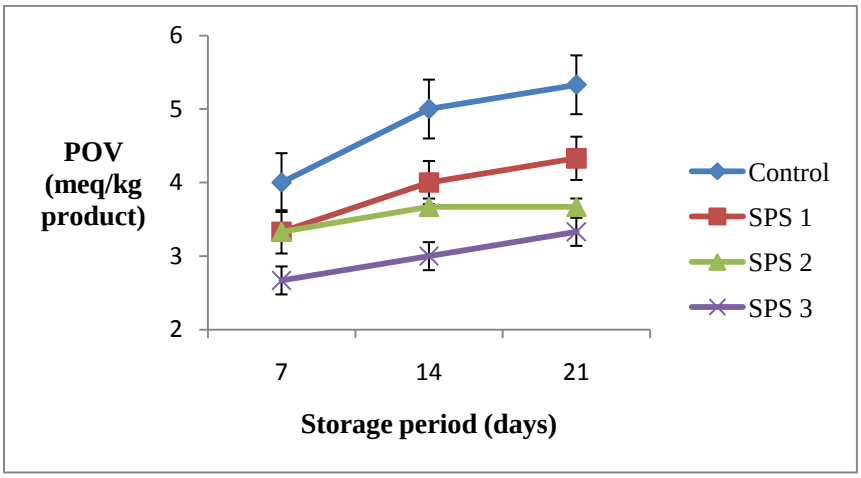

Fig. 2: Lipid per-oxidation (peroxide) in the products

Cost-benefit analysis

The costs of acquiring binders to prepare 1 tonne sausage are presented in Table 4. The cost of purchasing and transporting 5kg polyphosphates was GH¢ 125.00 (Table 4). The cost of sweet potato tubers to produce 40kg starch was GH¢ 53.00. The costs of transportation, milling and drying of the starch was GH¢ 30.00, bringing the total cost to GH¢ 83.00. Based on these, it will be cheaper to use sweet potato starch than polyphosphates in comminuted meat products.

Table 4: Cost of acquiring and processing the binders used in the experiments

Binder	Quantity (kg)	Cost of acquisition(GH¢)	Cost of Processing(GH¢)	Total Cost (GH¢)
Polyphosphates	5.00	125.00	_	125.00 (US$83.00)
Sweet potato starch	40.00	53.00	30.00	83.00 (US$ 55.12)

Conclusions

The use of SPS (up to 4% inclusion) had no effect on the cooking loss and overall acceptability of comminuted meat products. Higher levels of inclusion (6%), however, had adverse effects on the cooking losses and product acceptability. Substitution of polyphosphates with SPS reduced the fat contents, and hence, minimized the lipid per-oxidation in the products. In addition, the cost of acquiring SPS is lower than for polyphosphates, indicating that the use of SPS would minimize formulation costs than the use of polyphosphates. Sweet potato starch is recommended up to 4% inclusion in comminuted meat products to minimize

consumers' worry over the excessive use of chemical ingredients in meat products.

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