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Original article

Effects of egg albumen as binder, on yield and sensory characteristics of frankfurter sausages

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ABSTRACT

This study was conducted to find alternative binders to substitute for polyphosphate in frankfurter-type sausages. Fresh albumen (FA) at 32.5 (FA1), 49 (FA2) and 65 (FA3) g/kg meat (equivalent to 5, 7.5 and 10g dry matter/kg meat), and dried albumen (DA) at 5 (DA1), 7.5 (DA2) and 10 (DA3) g/kg meat were used to formulate the products, and compared with those formulated with polyphosphate (5g/kg meat) as binder. The Completely Randomized Design was used, and products were formulated in triplicates. They were vacuum-packed in transparent packaging bags and stored at 2°C for sensory and laboratory analyses. From the results, egg albumen had no significant (P>0.05) effects on the cooking losses of the FA1, FA2, DA1 and DA2 products, but the losses in these products were significantly (P<0.01) lower than in the DA3 and FA3 products. The FA1 and FA2 products were juicier than the FA3, control, DA2 and DA3 products. The acceptability of the products was however, not significantly (P>0.05) different. The egg albumen however, increased the crude protein and reduced fat contents of the DA and FA products. It was cheaper acquiring egg albumen for the FA1 products than acquiring polyphosphates, but it's more expensive acquiring dried albumen for the DA products, although the products had acceptable yield and sensory characteristics.

1. Introduction

The water holding capacity of meat affects its appearance before cooking, its behaviour during cooking and juiciness on mastication (Pisula and Tyburcy, 1996). However, one consequence of slaughter is the loss of water holding capacity due to changes in the muscle, as a result of depletion of adenosine tri-phosphate (Lawrie and Ledward, 2006). Comminution of meat destroys the muscle cells, and this further reduces the water holding capacity of the meat batter; but water is required in adequate quantities in comminuted meat products for improved juiciness and palatability. One way of restoring the water holding capacity of comminuted meat products is by the addition of sodium tri-polyphosphate to act as a binder to improve particle cohesion and water-binding capacity of the products (FAO, 1991; Troy *et al.*, 1999). Polyphosphates are reported to boost the water holding capacity of muscles by increasing the pH of the meat mixture (Lawrie and Ledward, 2006). The use of polyphosphates in comminuted meat products is however, impeded by some setbacks. In Ghana, it is scarce and when available it is expensive to acquire (Teye, 2010). In addition, being a chemical additive, some consumers have fears that it may leave residues which could be harmful when such products are consumed over a long period of time (McCarty, 2004; Smith and Young, 2007). There is therefore the need to find non-chemical ingredient(s) which are readily available, and can serve as substitutes for polyphosphates in comminuted meat products (Means and Schmidt, 1987). A potential ingredient for such application is egg albumen. Siegel *et al.* (1979) demonstrated that egg-albumen was a good binder for meat pieces. Egg albumen is reported to consist mainly of proteins, with negligible fat content, and forms a gel when heated, thus enabling it to serve as a binding agent in reformed meat products (Kato *et al.*, 1990; Chen and Lu, 1999). It has an added advantage of serving as a fat emulsifier and also increases the total crude protein levels of the final product (Chen and Lu, 1999). Egg albumen is also commonly used as a binder in pastries. There is however, no information on its potential as a binder in comminuted meat products. This study was therefore designed to determine the effects of egg albumen as binder, on yield and sensory characteristics of frankfurter-type sausages.

2. Materials and methods

The study was conducted at the University for Development Studies (UDS), Tamale, Ghana.

2.1. Preparation of binding substitutes

Fresh clean chicken eggs were obtained from the local market for this work. The eggs were broken and the albumen separated manually from the yolk. The albumen was then refrigerated at 1°C for later use.

The dried albumen powder was prepared according to the methods described by Kato *et al.* (1990) with some modifications. Fresh albumen was dried in an electric oven (J.P. Selecta s.a, Incudigit) at 60°C for 48hours. It was then milled with a domestic blender (model MX-X61-W, National, Japan) into powder, and stored in an airtight container for later use.

2.2. Inclusion rates of the binders

Fresh egg albumen is reported to contain about 87% moisture (USDA, 2007). Similarly, this study revealed that the moisture content of fresh egg albumen was approximately 86.3%. Therefore, the products were formulated to contain 32.5g (FA1), 49g (FA2) and 65g (FA3) of fresh albumen/kg meat, which are equivalent to 5, 7.5 and 10g dry matter respectively. Similarly, the inclusion rates of the dried albumen were 5g (DA1), 7.5g (DA2) and 10g (DA3) per kg meat respectively. The inclusion rates were based on the recommended level of polyphosphate usage, which is 5g/kg meat (FAO, 1985); hence the control products were formulated with polyphosphate at 5g/kg meat. The 7.5 and 10g/kg meat levels were to determine the effects of higher inclusions on product characteristics.

2.3. Sausage formulation

The Completely Randomized Design (CRD) was used in this study. Fresh boneless beef and pork (ratio of 1kg beef to 2kg pork) were obtained from the Meat Processing Unit of UDS, cut into smaller sizes and minced using a 5mm-sieve table top mincer (Talleres Ramon, Spain). The minced beef was apportioned into groups of 4kg, and assigned randomly to the various binders. The following ingredients were added in equal amounts (g/kg) to the various formulations of sausage meat: 13.0g curing salt, 0.5g red chillies, 1.0g black pepper, 1.0g white pepper and

2.0g "adobo" (mixed spices). Crushed ice was added during comminution of the meat, to control the temperature of the meat batter. The mixture was comminuted in a 3-knife bowl chopper (Talleres Ramon, 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 Ramon, Spain) and manually linked into similar lengths of about 10cm. The sausages were weighed and then hung on smoking racks and smoked for an hour, after which they were scalded to a core temperature of 70°C. The sausages were cooled in cold water and hung on the racks again for excess water to drain, after which they were re-weighed, vacuum-packed in transparent packaging bags, labelled and refrigerated at 2°C for sensory, chemical and microbiological analyses. The products were formulated in three (3) batches (triplicates)

2.4. Sensory evaluation of products

A total of 20 panellists, aged between 18 and 25years (12 males, 8 females) were randomly selected and trained according to the British Standard Institution (1993) guidelines of panellist selection and training, to evaluate the products. The refrigerated sausages were thawed and warmed in an oven (Turbofan, Blue seal, UK), sliced into uniform sizes (about 2cm in length) and 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 was used to rate the sensory characteristics of the products as recommended by Keeton (1983):

Internal 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

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

Texture: 1=extremely coarse; 2=Very coarse; 3=moderately coarse; 4=slightly coarse; 5=slightly smooth; 6=moderately smooth; 7=Very smooth; 8=extremely smooth

Meat flavour intensity: 1=extremely weak; 2=very weak; 3=moderately weak; 4=slightly weak; 5=slightly strong; 6=moderately strong; 7=very strong; 8=extremely strong

Flavour liking/ 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

2.5. Cooking loss determination and chemical analyses of products

The sausages were weighed before cooking and again after cooking to determine the cooking losses. The products were analyzed in triplicates for moisture, crude protein and fat contents (AOAC, 1999). Aerobic Plate Counts (APCs) of the products were conducted on days 1, 7, 14 and 21 of storage to determine their microbial quality in storage (AOAC, 1999). The pH was determined according to the methods described by Chen and Lu (1999).

2.6. Statistical analyses

The data obtained were analyzed using the General Linear Model (GLM) of Analysis of Variance (ANOVA) of the Minitab Statistical Package, version 15 (MINITAB, 2007). Where significant differences were found, the means were separated using Tukey Pair-Wise comparison, at 5% level of significance.

3. Results

3.1. Cooking losses of products

The cooking losses and sensory characteristics of the products are presented in Table 1. There were no significant ($P>0.05$) differences in the cooking losses of the FA and DA products, compared with the control. However, the cooking losses of the DA1 and DA2 products were significantly ($P<0.01$) lower than the DA3 products. Similarly, the FA1 and FA2 products had marginally lower cooking losses than the FA3 products, but the difference in this case was not significant ($P>0.05$). Generally, the egg albumen appeared to have reduced cooking losses of the products, but the losses increased with an increase in albumen inclusions.

3.2. Sensory characteristics of products

There were no significant ($P>0.05$) differences in the colour, texture, flavour liking and acceptability of the products (Table 1). The juiciness of the FA1 and FA2 products were significantly ($P<0.001$) higher than for the FA3, DA2, DA3 and control products. Lower inclusion levels of albumen improved juiciness in the products, but as the albumen inclusions increased in the products, juiciness was adversely affected. The egg flavour intensity of the FA products was significantly ($P<0.001$) higher than for the DA and control products (Table 1).

Table 1
Cooking loss and sensory characteristics of products.

Parameter	Control	DA1	DA2	DA3	FA1	FA2	FA3	SED	Sig
Cooking loss	10.41^{ab}	8.42^{b}	8.46^{b}	12.34^{a}	9.49^{ab}	10.13^{ab}	11.60^{a}	0.93	**
Colour	3.40	3.70	3.50	3.50	3.50	3.40	3.60	0.38	ns
Texture	4.60	4.50	4.60	4.50	4.70	4.50	4.50	0.39	ns
Juiciness	5.00^{b}	5.60^{ab}	4.90^{b}	4.20^{bc}	6.40^{a}	6.10^{a}	5.50^{b}	0.46	***
Egg flavour intensity	2.30^{b}	3.10^{b}	3.10^{b}	3.10^{b}	5.50^{a}	5.80^{a}	6.00^{a}	0.53	***
Flavour liking	5.40	5.20	5.20	5.50	5.90	5.70	5.70	0.40	ns
Acceptability	4.90	4.80	4.70	4.60	5.60	4.80	4.80	0.42	ns

^{abc}Means in the same row with common subscripts are not significantly different. SED=standard error of difference; Sig= significance; ns= ($P>0.05$); **= ($P<0.01$); ***= ($P<0.001$).

3.3. Proximate composition of products

The moisture, crude protein and fat contents of the products are presented in Table 2. There was no significant ($P>0.05$) difference in the moisture contents of the products. The crude protein contents of the DA and FA products however, increased ($P<0.001$) with increasing albumen inclusion, while the fat contents reduced ($P<0.001$) with increasing albumen inclusion in both the DA and FA products.

3.4. The pH of products

The pH of the products is presented in Fig. 1. The pH of the control products was significantly ($P<0.05$) higher than for the DA and FA products. There were however, no significant differences in the pH of the DA and FA products.

3.5. Aerobic plate count of products

The Aerobic Plate Counts (APCs) of the products are indicated in Fig. 2. The APCs of the control products ranged between 1.68 and 1.83 $\log_{10}$CFU/g of sausage over the storage period. The egg albumen products on the other hand had APC values between 1.61 and 1.76 $\log_{10}$CFU/g product. The APCs of the control products were quite higher than the FA and DA products, but the differences were not significant ($P>0.05$) until after 14 days in storage, when the APCs of the control products became significantly ($P<0.05$) higher than the FA and DA products.

Table 2
Proximate composition of products.

Parameter	Control	DA1	DA2	DA3	FA1	FA2	FA3	SED	Sig
Moisture	70.83	70.31	68.88	68.57	69.86	70.21	70.81	0.35	ns
Crude protein	17.94_{c}	19.44_{c}	20.15_{bc}	21.68_{a}	18.93_{c}	19.82_{bc}	20.91_{ab}	0.36	***
Fat	10.15_{a}	9.28_{ab}	8.71_{b}	8.00_{b}	9.50_{a}	8.58_{b}	8.01_{b}	0.21	***

^{abc}Means in the same row with common subscripts are not significantly different. SED=standard error of difference; Sig= significance; ns= ($P>0.05$); ***= ($P<0.001$).

3.6. Costs of acquiring the binders

The costs of each of the binders required to produce 1ton of sausage are presented in Table 3. The cost of acquiring binder for the FA1 products was lower than for the control products, but the costs of binders for the FA2, FA3, DA1, DA2 and DA3 products were in an increasing order, higher than for the control products.

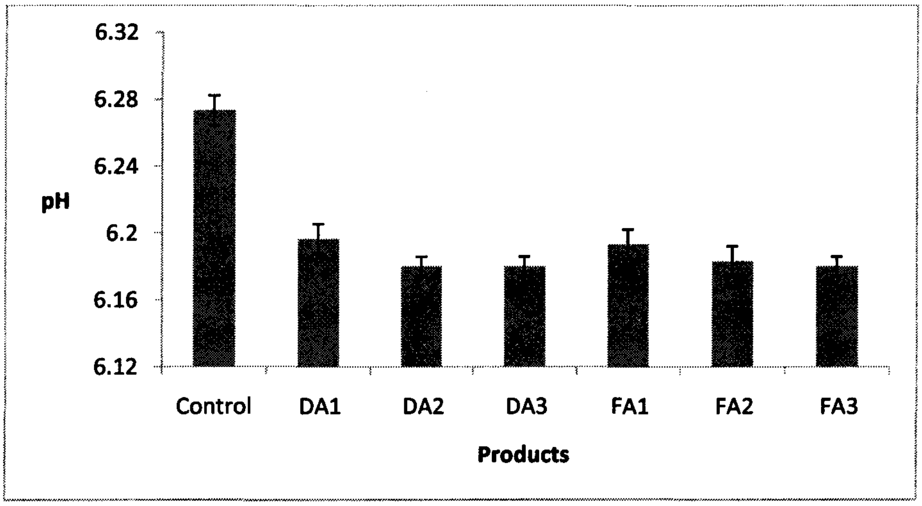

Fig. 1. pH of products.

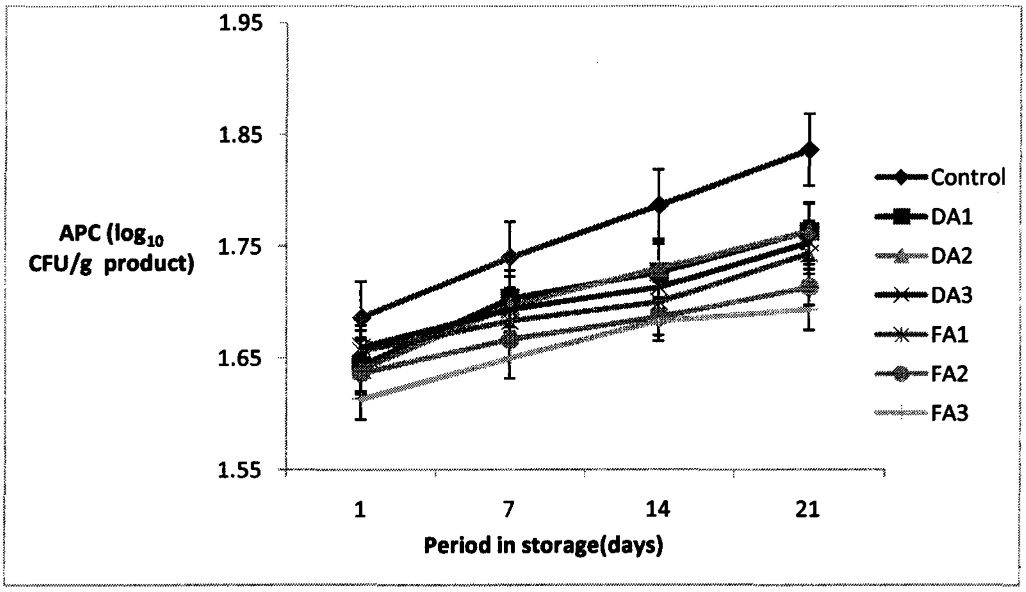

Fig. 2. Aerobic plate counts of products.

4. Discussion

4.1. Cooking losses of products

The observation in Table 1 could be explained by the following: Siegel *et al.* (1979) reported that egg albumen coagulates when heated, and therefore served as a good binder for meat pieces when used in reformed meat products. Various studies indicated that protein coagulates during thermal processing, resulting in the formation of gel-like structures which bind together the batter structural units (Acton and Dick, 1989; Kato *et al.,* 1990; Barbut, 1995; Xiong, 1997). An increase in albumen inclusion resulted in formation of egg-lumps, which did not bind the meat particles, but were separated from the meat, resulting in a poor particle-binding of products. This could have resulted in the relatively higher cooking losses observed in the DA3 and FA3 products.

4.2. Sensory characteristics of products

The similar colour of the experimental and control products is advantageous because meat purchasing decisions are influenced more by product appearance than any other quality factor (Lawrie and Ledward, 2006). Colour is an important indicator of freshness, and is of vital importance to the meat industry and meat science research (Mancini and Hunt, 2005), as consumers tend to reject products which have different colour from what they are accustomed to.

As expected, the egg flavour intensity of the FA products was significantly higher, but contrary to expectations, the egg flavour intensity of the DA products was similar to the control products (Table 1). This might be due to the evaporation of flavour compounds from the DA during the drying process. Lawrie and Ledward (2006) reported that some volatile substances are lost from food products when they are heated. The drying of the albumen might have resulted in the loss of egg flavour from it, and consequently the insignificant differences in the egg flavour intensity of the DA products. The acceptability of the products was however, not adversely affected by the use of both DA and FA, an indication that product marketability would not be impeded by the substitution of polyphosphate with egg albumen.

Table 3
Costs of binders for producing 1ton sausage.

Binder	Product	Quantity used(g)/kg meat	Quantity required(kg)/ton sausage	Cost (GH¢)	Cost of processing (GH¢)	Total cost	
						GH¢	US$
Polyphosphates	Control	5.00	5.00	125.00	-	125.00	71.43
	FA1	32.50	32.50	95.00	-	95.00	54.29
Fresh albumen	FA2	49.00	49.00	132.50	-	132.50	75.71
	FA3	65.00	65.00	170.00	-	170.00	97.14
	DA1	5.00	5.00	180.00	90.00	270.00	154.29
Dried albumen	DA2	7.50	7.50	270.00	135.00	405.00	231.49
	DA3	10.00	10.00	360.00	180.00	540.00	308.57

4.3. Proximate composition of products

The higher crude protein contents of the DA and FA products (Table 2) can be explained by reports that egg-albumen contains mainly proteins and therefore, its addition to meat products has the advantage of increasing the crude protein contents of the final product (Chen and Lu, 1999). This is of significance to the meat consumer because proteins, according to Pond *et al.* (1995), are required in higher levels in growing children and also for productive functions such as pregnancy and lactation, because of increased output of proteins in the products of conception and in milk. FAO (1991) indicated that the most valuable component of meat, from the nutritional and processing points of view is protein. Protein content is also the criterion for determining the quality and value of processed meat products (FAO, 1991). The protein content of meat and meat products also indicates their biological value, thus meat with higher protein levels are graded higher in terms of quality, than those with lower crude protein levels (Lawrie and Ledward, 2006).

Health activists are advocating a reduction in the quantity of meat consumed per person per meal, due to perceptions that meat consumption in excess could result in colorectal cancers and coronary heart diseases (WHO, 1990; Warriss, 2010; Ferguson, 2010). However, meat is a major source of proteins required by man for growth and repair of worn-out tissues (Pond *et al.*, 1995; Biesalski, 2005; Lawrie and Ledward, 2006). Therefore, with a higher crude protein content in a meat product, a small quantity would be required by consumers to meet their nutrient requirements and reduce expenditure on meat and meat products, as well as satisfy health concerns regarding the consumption of meat in excess.

The lower fat contents of the DA and FA products might be due to the albumen acting as a diluent to reduce the fat contents. This however did not adversely affect the acceptability of the products (Table 1). This is good news to the consumers, because a number of health organizations including the world health organization have recommended reduced dietary fat intake for improved health (WHO, 1990). High dietary fats especially those high in saturated fatty acids are reported to complicate coronary heart diseases (McCarty, 2004; Desmond, 2006). Since the DA and FA caused a reduction in fat contents without an adverse effect on product acceptability, their use might minimize consumer worries regarding the consumption of fatty meat products.

4.4. The pH of products

The use of polyphosphate in the control products might have resulted in their significantly higher pH values. According to Lawrie and Ledward (2006), salts of sodium are added to comminuted meat products to increase the pH, and improve the water holding capacity. Several studies reported on the significance of pH of meat and meat products on their storability. The role of lower pH of meat and meat products on the inhibition of bacterial growth and development was realized as far back in 1964 (Lawrie and Ledward, 2006). Lower pH of meat products creates an acidic medium, making it inappropriate for bacterial growth and reproduction (Warriss, 2010). The DA and FA products might therefore have better storability than the control products.

4.5. Aerobic plate count of products

Aerobic plate counts indicate the general bacterial population in the products, which provides information on the wholesomeness and product stability in storage (ICMSF, 1986). APC in products is influenced by pH among other factors (Warriss, 2010). According to Lawrie and Ledward (2006), lower pH in meat inhibits microbial activity, as the product appears acidic, and creates an unfavourable condition for bacterial dwelling. The higher APCs of the control products could be due to their higher pH values (Fig 1). The APCs in all the products were however, significantly lower than $7\log_{10}$CFU/g of product, which is considered as the maximum threshold for product acceptability (ICMSF, 1986).

4.6. Costs of acquiring the binders

The cost of FA for formulating the FA1 products was lower than for the FA2, FA3 and polyphosphate for the control products. The costs of drying and milling the DA resulted in the relatively higher costs of their acquisition, although its products were equally acceptable as those formulated with polyphosphates.

5. Conclusion

The use of egg albumen as binder at inclusion rates of 5 and 7.5% had no adverse effect on the cooking loss, acceptability and storability of the products. The egg albumen however increased the crude protein, and reduced the fat contents of the products. The costs of drying and milling the DA made its cost of acquisition higher than that for polyphosphate and FA. The FA1 products had similar acceptability as the other products, but the cost of acquiring FA for its formulation was quite lower than for the other products, an indication that its use would minimize production cost and increase profitability. Fresh albumen can be used as binder for minimized production costs, increased profitability, and especially when polyphosphate is difficult to come by.

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