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RESEARCH PAPER

PHYSICOCHEMICAL, TEXTURAL AND SENSORY ATTRIBUTES OF BEEF SAUSAGE EMULSIFIED WITH OKRA PECTIN

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ABSTRACT

Okra pectin has been found as an emulsifying agent for food systems, including meat products. In this study, the physicochemical, textural, and sensory attributes of Frankfurter sausage emulsified with okra pectin were evaluated. A completely randomized design was used for the formulations of three sausage treatments (T0, T1, and T2). Only okra pectin was varied (T0 = 0%, T1 = 0.5%, and T2 = 1.0%), whereas all other ingredients used for the formulation were kept constant. The results indicated that cooking loss increased with increasing levels of okra pectin whereas pH values were within an acceptable range (6.09-6.15). Moisture, protein, fat, ash, and fibre content varied among the samples studied. Resilience, cohesiveness, and chewiness were not significantly different ($p > 0.05$) among the samples. Hardness increased with increasing okra pectin concentration but there was no significant difference between T0 and T1 samples. There was no significant difference ($p > 0.05$) between T1 and T0 for the appearance (T0 = 7.43, T1 = 6.80), juiciness (T0 = 7.37, T1 = 6.30) and taste (T0 = 7.80, T1 = 6.93), which indicates they were either liked moderately or liked slightly. T2 (which had appearance = 5.47, juiciness = 5.10 and taste = 5.30) was however, significantly different ($p < 0.05$). T1 (6.77) and T2 (5.43) were liked moderately and liked slightly, respectively for overall acceptability. The present findings suggest that okra pectin at low levels (~ 0.5%) could be used as an emulsifier to produce acceptable sausage.

Keywords: Frankfurter, Emulsion-type sausage, Okra pectin, Emulsifier

INTRODUCTION

Sausage is a meat product that has been comminuted into various sizes and is usually stuffed into a casing (Keenan, 2015). It can be fresh, smoked, or pickled. Depending on the manufacturing procedure, sausage can be classified as fresh, emulsified, or fermented/dried (Keenan, 2015). The comminution process used in sausages is based on working with salt and water on the lean meat component of the meat to obtain the best possible binding and water retention qualities (Tonder, 2020). Emulsifiers used in sausage include egg yolks, milk and cream, and mustard. Other emulsifiers used in sausage include starch, pectin, and food gums.

The okra plant (*Abelmoschus esculentus*), is a native African plant grown in tropical, subtropical, and warm temperate areas around the world. Okra contains a polysaccharide known as pectin, which is made up of the sugars such as galactose, rhamnose, and galacturonic acid (Chandra *et al*., 2016; Ghori *et al*., 2014; Kpodo *et al*., 2017, 2018, 2021). Pectin is abundant in the mucilage found in the cell walls of okra pods (Chen *et al*., 2014). Okra pectin has shown good emulsion stability in acidic circumstances, suggesting that it could be used in fruit beverages and acidified dairy products (Alba *et al*., 2013; Kpodo *et al*., 2018; Tobil *et al*., 2020). The immature pods are always eaten as a vegetable, whereas the mature pods are occasionally used as animal feed or mucilage (Jarret *et al*., 2011; Agbenorhevi *et al*., 2020; Ofori *et al*., 2020). The high mucilage content of the okra fruit makes it ideal for making various soups and stews, especially in Ghana (Datsomor *et al*., 2019; Agbenorhevi *et al*., 2020). In traditional medicine, the immature fruits are used as a diuretic and to cure dental problems (András *et al*., 2005). Okra pectin has been demonstrated in previous research to be a natural food-grade emulsifier, thickener, and emulsion stabilizer (Chen *et al*., 2014: Bawa *et al.,* 2020; Kissiedu *et al*., 2020).

In recent years, due to dietary and health concerns, many consumers have cut back on fat and calorie intake. Meat technologists have been working to develop low-fat meat formulations with desired palatability in response to consumer demand for low-fat meat products with good economic value. Connective tissue proteins, soy proteins, and hydrocolloids are a few examples of compounds that have shown promise in the production of low-fat meat products (McArdle & Hamill, 2011). Hydrocolloids have unique properties in the creation of structure, stability, and emulsification and are of special relevance in low-fat processed meat because of their water binding and gel forming capacities (Kpodo *et al*., 2020). Hydrocolloids such as alginate, carrageenans, xanthan gum, locust bean gum, cellulose derivatives, starches, and pectin have all been extensively investigated in meat products. Pectin, which is manufactured commercially from citrus peels and apple pomace and is classified according to its degree of esterification, is principally made up of galacturonic acid and methyl ester galacturonic acid units. Pectin has been employed as a thickening, emulsifier, stabilizer, and gelling agent in a variety of food products (Candogan & Kolsarici, 2003; Tobil *et al.*, 2020; Abe-Inge *et al*., 2020; Bawa *et al.,* 2020; Kissiedu *et al*., 2020). Commercially accessible pectin is designed to act as a fat substitute and has found potential use in low-fat meals, such as processed meat, due to its qualities (Candogan & Kolsarici, 2003). With its emulsifying characteristics, okra pectin can be utilized as an emulsifier in meat products such as emulsion sausage. The objective of this study, therefore, was to evaluate the physiochemical, textural and sensory attributes of Frankfurter sausage emulsified with okra pectin.

MATERIALS AND METHODS

Materials

The Asha genotype of okra pectin (extracted and reported previously by Datsomor *et al.*, 2019), used for this study was obtained from the Department of Food Science and Technology, KNUST, Kumasi, Ghana. All other ingredients (meat, spices, sodium phosphate, sodium nitrite, and ascorbic acid) were purchased at the Kumasi Abattoir Company Limited, Kumasi, Ghana.

Sausage preparation

Three treatments (T0, T1, and T2) of Frankfurter sausage were prepared, with T0 as the control. The formulation was adopted from Pearson and Gillet (1996) with little modification. All ingredients used for the formulation were kept constant except for okra pectin and bread crumbs, which were varied in all the treatments as shown in Table 1. The process for the preparation of the sausage was adapted from Toldra and Reig (2007) as cited in Mladenoska, Temkov, and Dimitrovski (2017). Briefly, 600 g of partially thawed beef and 400 g of pork fat were minced using a Master Chef Meat grinder (MC-G1020). The minced mixture was then placed in a bowl cutter and mixed for 3 min, after which sodium nitrites, sodium erythorbate, and 1/3 of the ice were slowly added. Sodium phosphates and the remaining ice were then incorporated, and the milling continued for 2 min. All other ingredients were then added; with ascorbic acid being the last. The pectin was then added to T1 and T2, and the emulsification process was continued for another 2 min at 15°C. The meat batter was packed into cellulose casings with a Super Deal (T61) sausage stuffer, and the sausages were manually twisted to tie every 15 cm. The sausages were then linked on smoke sticks and smoked in a closed smoking room at 76°C for 45 min till 65°C internal temperature was reached. The smoked sausage was then cooked for 20 min at 60°C, then cooled for 5 min in cold water before being sealed in a Ziploc bag for storage until analysis.

Table 1. Formulations of sausage prepared with okra pectin

Ingredients (%)	Treatments		
	T0	**T1**	**T2**
Beef	48.4	48.4	48.4
Pork fat	24.2	24.2	24.2
Okra pectin	0.0	0.5	1.0
Breadcrumbs	3.0	2.5	2.0
Ice	21.8	21.8	21.8
White pepper	0.2	0.2	0.2
Nutmeg	0.04	0.04	0.04
Garlic powder	0.01	0.01	0.01
Paprika	0.15	0.15	0.15
Coriander	0.03	0.03	0.03
Ginger	0.02	0.02	0.02
Sodium phosphate	2.2	2.2	2.2
Sodium nitrite	0.01	0.01	0.01
Sodium erythorbate	0.03	0.03	0.03

T0 = 0.0% okra pectin, T1= 0.5% okra pectin and T2 = 1.0% okra pectin

Cooking loss determination

The weight differences before and after cooking were used to calculate the cooking yield for each of the samples (T0, T1 and T2) as follows:

$$\text{Cooking loss (Kg)} = \frac{\text{weight to uncooked frankfurter (Kg)} - \text{weight of cooked frankfurter (Kg)}}{\text{weight of uncooked frankfurter (Kg)}} \times 100$$

pH measurement

A pH meter (Mettler-Toledo, AG) was used to measure the pH of the sausage samples 24 h after its preparation. A homogenate made up of 5 g of the sample and 20 ml of distilled water was pulverized for 2 min before the pH was measured. All tests were carried out in triplicate.

Colour determination

A CR-400 Chroma Meter (Minolta Co., Osaka, Japan) was used to measure the colour coordinates L* (Lightness), a*(Redness) and b* (yellowness). The Chromameter was calibrated using a white tile. Colour was measured 24 h after the preparation of the sausage. The colour was measured in triplicate by taking measurements at various positions on the surface of each of the sausage samples.

Proximate analysis

The proximate analysis (moisture, ash, crude protein, crude fat and crude fibre) of the sausages was performed 24 h after their preparation according to the AOAC (1990). For protein determination, Kjeldahl (method 992.15) was used, soxhlet extraction (method 985.15) was used for fat determination, oven drying method (method 985.14) was used for moisture determination, ash (method 920.153) and crude fibre (method 985.29).

Texture profile analysis

Cooked samples of the sausage were used for all texture studies. Measurements were done twice for each sausage formulation, and the mean values were reported. Using a texturometer (TexturePro CT V1.5, Brookfield Engineering Labs. Inc.), cylindrical sausage samples (2 cm in diameter and 2 cm long) were cut and compressed twice to their original height between flat plates and a cylindrical probe. Hardness, cohesiveness, adhesiveness, springiness, gumminess, and chewiness were the parameters that were determined.

Sensory evaluation

Thirty (30) untrained consumer panelists used an affective sensory evaluation test to rate the sausage (frankfurters) samples on a 9-point hedonic scale (9 = extremely like, 1 = extremely dislike) based on attributes: appearance, taste, colour, texture, juiciness, and overall acceptance. Members of the panel were students and staff from Department of Hospitality Management at Takoradi Technical University, Takoradi, Ghana. The Frankfurter sausages were wrapped in a foil and preheated in a microwave oven for 2 minutes before being served to the panel. Three slices of each treatment sample were served on disposable plates to each panel in random order coded with three-digit numbers. Each panel was given water and crackers to be used as palate cleanser.

Statistical analysis

The Statistical Package for Social Science (SPSS) version 22 was used to analyze the data, and statistical significance was established using Analysis of Variance (ANOVA). For all analyses, Tukey HSD at $p < 0.05$ was employed to determine differences between treatment means.

RESULTS AND DISCUSSION

Cooking loss, pH and colour values of Frankfurter samples

The cooking loss in the Frankfurter samples was lowest in the control (T0), as shown in Table 2. This is consistent with the study conducted by Silva-Vazquez *et al*. (2018) in which the control sample exhibited reduced cooking loss than the other samples when pork fat was replaced with inulin and pectin in frankfurter sausage meat batters. The cooking loss increased as the amount of okra pectin used as an emulsifier in the Frankfurter samples increased, with the maximum loss in T2. This could be related to a decrease in the ability of the meat protein to create an emulsion, lowering the water-binding capacity. In a previous study, Abbasi *et al*. (2019) reported a substantial reduction in sausage cooking loss with increasing tragacanth gum concentrations. Choi *et al*. (2014) also reported a significant reduction in frankfurter cooking loss with increased makgeolli lees fibre levels. Pereira *et al*. (2010) found a reduced cooking output in pectin-containing sausage samples when soy protein was partially substituted with highly methyl esterified pectin, which contradicts the findings of this study.

Table 2. Cooking loss, pH and colour values of Frankfurter samples

	Treatments		
	T0	T1	T2
Cooking loss (%)	0.00 ± 0.00^{a}	5.26 ± 0.00^{b}	21.05 ± 0.00^{c}
pH	6.09 ± 0.01^{a}	6.14 ± 0.01^{a}	6.15 ± 0.05^{a}
Lightness (L*)	78.60 ± 0.01^{a}	79.75 ± 0.05^{b}	80.85 ± 0.05^{c}
Redness (a*)	0.80 ± 0.00^{b}	1.00 ± 0.00^{c}	0.65 ± 0.05^{a}
Yellowness (b*)	17.45 ± 0.05^{c}	16.85 ± 0.05^{b}	15.85 ± 0.05^{a}

$^{a-c}$Mean ± SD with different superscript in the same row indicates significant differences ($p < 0.05$).
T0: control (0.0% okra pectin); T1: 0.5% okra pectin; T2: 1.0% okra pectin.

In Table 2, the pH analysis of the Frankfurter sausage samples reveals that there was no statistically significant ($p > 0.05$) difference between the samples. However, the results show that when the level of okra pectin in the Frankfurter sausage samples grew, the pH value increased; hence, T0 had the lowest pH (6.09) and T2 had the highest pH (6.15). The results obtained in this study supports Feiner's (2006) assertion that most beef products have a pH range of between 4.6 to 6.4. Méndez-Zamora *et al*., (2015) found the opposite results, with a decrease in pH as the concentration of inulin and pectin increased. When Pereira *et al*. (2010) emulsified sausage by partially substituting soy proteins with highly methyl-esterified pectin, the pH again degreased.

The instrumental colour analysis revealed that L* (lightness) values increased with increasing okra pectin concentrations, whereas a* (redness) and b* (yellowness) values decreased with increasing okra pectin concentrations, as shown in Table 2. Although Ayo *et al*. (2008) stated that when the fat content of Frankfurter is reduced, L* and b* values decrease and a* increases, the results obtained in this study were the opposite.

This is because even though T1 had the least amount of fat, L* values increased and a* values decreased, but there was a decrease in the b* values. Choi *et al*. (2014) observed that the redness (a*) and yellowness (b*) of cooked Frankfurters increased as makgeolli lees fibre increased, which is the opposite of the findings in this study.

Proximate composition

Table 3 shows the proximate analysis of a frankfurter sausage made with okra pectin as an emulsifier. The moisture, crude protein, and crude fat contents of sample T1 and the other samples, thus T0 and T2, were significantly different ($p < 0.05$). The moisture, crude protein, and crude fat contents of sample T1 and the other samples, thus T0 and T2, were significantly different ($p < 0.05$). However, there was no significant difference between the samples T0 and T2. In the case of the crude fibre content of the sausage samples, all three samples showed a substantial difference. T1 had the highest moisture content followed by T0. However, there was no significant difference ($p > 0.05$) between samples T0 and T2. This might be due to the fact that okra is abundant in water, which increases moistness, as well as the addition of ice for frankfurter manufacturing.

The protein content of T2 and T0 (control) Frankfurter samples were high but not significantly different ($p > 0.05$) whereas that of T1 was lowest among the three samples (Table 3). The findings of the study were consistent with those of Choi *et al*. (2010) and Choi *et al*. (2014), who found that fibre in frankfurter samples had no effect on protein concentration.

Table 3. Proximate composition of Frankfurter samples

	Treatments		
Proximate (%)	**T0**	**T1**	**T2**
Moisture	66.29 ± 0.64^b	67.12 ± 0.19^a	62.87 ± 0.70^b
Ash	2.05 ± 0.10^b	1.66 ± 0.06^a	1.57 ± 0.02^a
Crude Protein	48.93 ± 0.84^b	46.71 ± 1.02^a	50.44 ± 0.11^b
Crude Fat	32.98 ± 0.22^b	31.83 ± 0.47^a	33.53 ± 0.05^b
Crude Fibre	0.19 ± 0.00^a	0.48 ± 0.00^b	0.31 ± 0.00^c

$^{a-c}$Mean ± SD with same superscripts in the same row indicates no significant difference (p>0.05) and values with different superscript in the same row indicate significant differences (p<0.05). T0: control (0.0% okra pectin); T1: 0.5% okra pectin; T2: 1.0% okra pectin.

Texture profile

Table 4 shows the textural properties of Frankfurter sausage emulsified with various concentrations of okra pectin. With the exception of resilience, cohesiveness and chewiness that were not significantly different ($p < 0.05$) in all the samples; all the other Texture Profile Analysis (TPA) parameters of the samples differed significantly ($p < 0.05$).

Table 4. Textural attributes of Frankfurter sausage samples

	Treatments		
TPA Parameters	**T0**	**T1**	**T2**
Hardness cycle 1	47.18 ± 0.57[a]	49.18 ± 1.15[a]	76.87 ± 3.27[b]
Hardness cycle 2	66.84 ± 0.58[a]	77.50 ± 4.42[ab]	85.21 ± 10.40[b]
Adhesiveness	0.86 ± 0.01[a]	1.10 ± 0.07[b]	1.29 ± 0.03[c]
Resilience	0.03 ± 0.00[a]	2.15 ± 1.82[a]	0.05 ± 0.00[a]
Cohesiveness	1.61 ± 0.06[a]	2.65 ± 1.43[a]	1.13 ± 0.06[a]
Springiness	10.99 ± 0.57[b]	4.36 ± 3.68[a]	9.99 ± 0.85[b]
Gumminess	72.87 ± 0.59[b]	49.52 ± 1.34[a]	84.62 ± 0.83[c]
Chewiness	6.79 ± 0.58[a]	6.48 ± 2.11[a]	8.27 ± 0.81[a]

[a-c] Mean ± SD with same superscripts in the same row indicates no significant difference ($p<0.05$) and values with different superscript in the same row indicate significant differences. TPA: Texture Profile Analysis. T0: control (0.0% okra pectin); T1: 0.5% okra pectin; T2: 1.0% okra pectin.

Hardness of the samples increased with increasing concentrations of okra pectin but statistically there was no significant difference between T1 and T0. The findings of the current study contradicted those of Henning *et al*. (2016), who found that when sausage was formed with fibre, lower hardness values were obtained. In a study by Pereira *et al.* (2010), hardness levels were found to be decreased in sausage samples when partially emulsified with high methyl esterified pectin. However, the findings of this study are similar to those of Choi *et al.* (2014), who found that increasing the amount of makgeolli lees fibre considerably enhanced the hardness of frankfurter. The significant increase in hardness is attributable to fibre's binding ability and water retention capacity; which is possibly the case with okra pectin as in this study.

The springiness and cohesiveness of the samples in this study are similar to those reported by Henning *et al*. (2016), who found that sausage samples containing fibre had lower springiness and similar cohesiveness values when compared to the control sample (Table 4). Since the springiness was minimal, it indicates that chewing will require less energy.

Sensory attributes

Table 5 shows the sensory evaluation scores for frankfurter sausage samples produced with okra pectin as an emulsifier and the control sample. According to the findings, at least two of the three sausage formulations had significant ($p < 0.05$) differences in sensory evaluation scores for the following qualities: appearance, texture, juiciness, taste, and overall approval.

The color of the three sausage formulations, however, did not differ significantly ($p < 0.05$). T1 was not significantly different ($p < 0.05$) from the control sample when it came to the sensory qualities of appearance, juiciness, and flavour (T0). Hence, based on the nine-point hedonic scale used by the panelist for the evaluation, appearance, juiciness, and taste were either liked moderately or liked slightly with mean scores for T0 being 7.43 (appearance), 7.37 (juiciness), and 7.80 (taste), while T1 obtained mean scores of 6.80 (appearance), 6.30 (juiciness), and 6.93 (taste).

Table 5. Sensory attributes of Frankfurter sausage samples

	Treatments		
Sensory Attributes	**T0**	**T1**	**T2**
Appearance	7.43 ± 1.073[b]	6.80 ± 1.495[b]	5.47 ± 1.756[a]
Texture	7.33 ± 0.959[c]	6.30 ± 1.803[b]	5.30 ± 1.784[a]
Colour	7.07 ± 1.639[a]	6.53 ±1.613[a]	6.17 ± 1.440[a]
Juiciness	7.37 ± 1.639[b]	6.30 ± 1.745[b]	5.10 ± 2.006[a]
Taste	7.80 ± 1.349[b]	6.93 ± 1.507[b]	5.30 ± 1.860[a]
Overall Acceptance	7.97 ± 0.850[c]	6.77 ± 1.654[b]	5.43 ± 2.046[a]

[a- c]Mean ± SD with different superscripts in the same row indicate significant differences ($p < 0.05$) on a 9-point hedonic scale (1-dislike extremely; 9 -like extremely). T0: control (0.0% okra pectin); T1: 0.5% okra pectin; T2: 1.0% okra pectin.

Similar results were observed by Mendez-Zamora *et al*. (2015) in terms of the appearance when Frankfurter samples were formulated with pectin and inulin.

In terms of the sensory attribute texture, all of the Frankfurter sausage samples were found to be significantly different, with T0 being the most accepted in terms of texture, with a mean value of 7.33 representing moderately on the hedonic scale used for evaluation; and T2 being the least accepted in terms of texture with a mean value of 5.30 representing neither liked nor disliked on the hedonic scale. The results show that the texture of T2 was the least liked because of a larger level of okra pectin, which made it a little firmer. In terms of the sensory attribute colour, all samples were not significantly different. However, T0 had the highest mean value (7.07), followed by T1 with a mean value of 6.53 and T2 with a mean value of 6.17. This indicates that T0 which is the controlled sample was liked moderately whilst T1 and T2 which contained the okra pectin were liked slightly.

The overall acceptance of the Frankfurter sausage samples varied significantly, with T0 being the most accepted and T2 being the least accepted. Even though the control sample was mainly accepted by the panel, T1 was the second most accepted sample, with panels citing its taste, juiciness, and appearance as reasons for its acceptability.

CONCLUSION

The results suggest that it is possible to reduce the fat content in emulsion-type beef sausages by replacing pork backfat with okra pectin by up to 0.5% without affecting the textural, and physicochemical properties, and consumer acceptability of the sausage. Moisture, protein, fat, ash and fibre content varied among the samples studied. Resilience, cohesiveness, and chewiness were not significantly different among the samples. Consumer acceptability of okra pectin emulsified sausages, however, decreased with increasing levels of pectin inclusion. The present findings suggest that okra pectin at low levels could be used as an emulsifier to produce acceptable sausage.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

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