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Effect of okra pectin on the quality and consumer acceptability of tigernut milk and fried yam

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Abstract: The objective of this study was to investigate the effect of okra pectin as a stabilizer and a texturizer on the quality and consumer acceptability of tigernut milk and fried yam, respectively. Okra pectin concentrations 0% (control), 0.2%, 0.4% and 0.6% were used in the preparation of tigernut milk as well as to pretreat yam slices before deep frying. The viscosity and microbial quality of the tigernut milk samples were evaluated, whilst the moisture content, oil uptake and colour of fried yam were also determined. Consumer acceptability test was conducted on both the tigernut milk and fried yam using 50 semi-trained panelists. The viscosity of the tigernut milk samples which ranged from 4.67 cP to 10.50 cP increased with increasing concentrations of okra pectin. The microbial load of all tigernut milk samples were within the acceptable limits. With the exception of sample appearance, okra pectin also had no significant effect ($p > 0.05$) on the sensory quality of tigernut milk. On the other hand, okra pectin treatment in the fried yam samples resulted in significantly different moisture (54.33–56.71%), oil uptake/fat content (4.00–5.50%) and colour (L*a*b*) values. Results showed that okra pectin had no significant effect ($p > 0.05$) on all sensory quality parameters of fried yam samples though 0.2% okra pectin treated yam had the highest mean overall acceptability. The findings suggest that treatment with okra pectin can be exploited to make appreciable impact on the quality and consumer acceptability of fried yam.

Subjects: Food Additives & Ingredients; Food Chemistry; Beverages; Sensory Science; Food Analysis

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PUBLIC INTEREST STATEMENT

Okra is a common vegetable in the tropics. Its use is mostly limited to soups and stews. However, some studies have indicated the potential application of okra pectin in food systems. The suitability of okra pectin extracted from the *asha* genotype as a stabilizer and a texturizer in the tigernut milk and fried yam, respectively, was studied. It was shown that okra pectin increased the viscosity of tigernut milk at all concentrations and also enhanced the crispness of fried yam at a concentration of 0.2%. This highlights the potential application of okra pectin as a stabilizer in tigernut milk and a texturizer in fried yam.

Keywords: Okra pectin; fried yam; tigernut milk; texturizer; stabilizer; consumer acceptability

1. Introduction

Okra (*Abelmoschus esculentus*) is a vegetable that is produced for its fruits/pods. It is cultivated in regions that are warm to hot and moist all year round, as well as in regions of moderate temperatures. There is little diversity in the utilization of okra in Ghana where it is mainly used in the forms of soups and stews (Agbenorhevi et al., 2020) due to its mucilaginous nature. This mucilaginous nature of okra is conferred by its pectin content. Okra pectin, which consists of galactose, galacturonic acid and rhamnose, has been reported to function as a lecithin substitute in chocolate (Datsomor et al., 2019). Besides its function as an emulsifier, other popular uses of pectin include its use in gelling, clarifying, thickening, stabilizing and binding (Tobil et al., 2020). Pectin has also been reported to function as a fat substitute in cookies, frozen desserts and chocolate (Maxwell et al., 2012). Due to its functions as a stabilizer, okra pectin could be utilized as a stabilizing agent in food systems including non-dairy tigernut milk.

Tigernut (*Cyperus esculentus*) is a food crop that belongs to the class *Liliopsida*, the order *Cyperades*, the family *Cyperaceae* and the division *Magnollophyta* and is a rhizome tuber (Adejuyitan, 2011; Gambo & Da'u, 2014). According to Nyarko-Mensah (2018) "*atadwe*" is the local name for tigernut among the Akans of Ghana and is commercially produced in the Eastern and Central regions of Ghana. Tigernut is known for its nutritional and energetic qualities. It contains Vitamins E and C, protein, glucose, potassium and phosphorus (Nyarko-Mensah, 2018; Suleiman et al., 2018). It can be consumed either fresh, dried or prepared into beverages (Adejuyitan, 2011). Popular among the tigernut beverages is tigernut milk. Tigernut milk is said to be less expensive hence accessible to all groups of persons in society as well as suitable for lactose intolerant persons (Asante, 2018). Despite the beneficial qualities of tigernut milk, it is unstable due to its colloidal nature hence has a great tendency to undergo phase separation. This necessitates the addition of hydrocolloids such as okra polysaccharides to tigernut milk to serve as stabilizers as well as thickening agents (Bahrami et al., 2013).

Okra polysaccharides also pose as hydrocolloids which are useful in enhancing firmness and consistency fried yam (Agbenorhevi et al., 2015). However, limited information is available on its influence on the quality of fried white yam slices. Fried yam slices are commonly prepared from the white yam variety *(Dioscorea rotundata*) due to its excellent taste (Tortoe et al., 2014). In Ghana, fried yam is commonly vended along the streets and is consumed either as a snack or a main meal replacer. Textural properties and gustatory attributes are the key attributes that influence the quality of fried yam slices, as well as influence consumers' choices. Amongst the textural properties are firmness, chewiness and crispiness. Textural properties together with colour and flavour have been reported to be enhanced by cooking methods such as deep frying (Chen & Moreira, 1997; Mallikarjunan et al., 2009). Although okra polysaccharides have been reported to enhance the firmness of fried yam snacks, its impact on the sensory quality and physiochemical characteristics of deep-fried yam has not been well investigated.

Considering the potential influence of okra pectin on the quality of tigernut milk and deep-fried yam, the main objective of this study was to investigate the effect of okra pectin as a stabilizer and texturizer on the quality of tigernut milk and fried yam, respectively.

2. Materials and methods

2.1. Materials

Okra pectin from Asha genotype was obtained from the Department of Food Science and Technology, KNUST-Kumasi. The Asha okra pectin had 86% total carbohydrate, 5.5% protein, 17.2% Degree of methylation (DM), 39.3% Degree of Acetylation (DA) and Molecular weight (Mw) of 1202×10^3 g/mol

(Kpodo et al., 2017, 2018). Oil (Frytol), yam *(Dioscorea rotundata*), tigernut (*Cyperus esculentus*) and salt were obtained from the local markets in Kumasi. A Master Chef & Crown Star deep fryer (model no.: MC-DF 1018, China) was also obtained from Melcom, Kumasi, Ghana.

2.2. Tigernut milk preparation

Tigernut samples were sorted to ensure the exclusion of poor quality (rotten, severely mechanically damaged and poorly developed) nuts. About 500 g of tigernut was washed thoroughly till it was clean and free of filth. The tigernut was then soaked in 1 L of water for 24 h to soften the nut. The water was drained from the tigernuts and washed again. The obtained soaked tigernut was blended with 1 L of water into a fine puree using the warring mechanical blender. It was sieved to obtain the milk extract. The pectin was then added in different concentrations, that is 0.0% (control), 0.2%, 0.4% and 0.6% by mixing 100 mL of tigernut milk with 0.0 g, 0.2 g, 0.4 g and 0.6 g okra pectin, respectively. The mixtures were homogenized to ensure uniformity.

2.2.1. Microbial load determination of okra pectin treated tigernut milk

2.2.1.1. Aerobic plate count. The aerobic plate count of tigernut milk samples was determined using ISO 4833:2003 (2003) procedure. Serial dilutions were done to the sixth power using bacteriological peptone diluent, in which 10 g of the tigernut milk was weighed into 90 mL of sterile diluent to attain the stock from which successive dilutions were prepared. 0.1 mL volume ofinoculum of the dilution was injected unto the sterile plates of plate count agar (OXOID CM0325) incubated for 72 h at 30ºC by means of the spread plate technique. The colonies were recorded in colony-forming units (cfu).

2.2.1.2. Escherichia coli. The *Escherichia coli* (*E. coli*) content of the tigernut milk samples was determined using ISO 7251:2005 (2005) procedure. Serial dilutions were performed to the sixth power using bacteriological peptone diluent, in which 10 g of the tigernut milk was weighed into 90 mL of sterile diluent to attain the stock from which successive dilutions were prepared. 0.1 mL volume of inoculum of the dilution was injected unto the sterile plates of tryptone bile agar (OXOID CM0325) incubated for 24 h at 44ºC by means of the spread plate technique. The colonies were recorded in colony forming units (cfu).

2.2.1.3. Bacillus cereus. The *Bacillus cereus (B. cereus)* content of the tigernut milk samples was determined using ISO 7932:2004 (2004) procedure. Serial dilutions were done to the sixth power using bacteriological peptone diluent, in which 10 g of the tigernut milk was weighed into 90 mL of sterile diluent to attain the stock from which successive dilutions were prepared. 0.1 mL volume of inoculum of the dilution was injected on to the sterile plates of plate count agar (OXOID CM0325) incubated for 48 h at 37ºC by means of the spread plate technique. The colonies were recorded in colony forming units (cfu).

2.2.2. Determination of viscosity of okra pectin treated tigernut milk samples

The viscosity of the tigernut milk samples was determined using the Ubbelodhe capillary viscometer (PSL Rheotek OB. C 80,705). This was done for all the concentrations of okra pectin treated samples (0.0%, 0.2%, 0.4% and 0.6%) at least in triplicate. The viscosity was calculated using the formula:

$$V = \frac{ds \times ts}{dw \times tw} \times 1.0020$$

where d_s and d_w are the density of sample and water, respectively, whereas t_s and t_w are the time taken for the sample and water to flow through the thin capillary, respectively.

2.3. Yam sample preparation

White yam (*Dioscorea rotundata*) tubers of an average weight of 1.5–2.0 kg devoid of bruises/ infestations were obtained from the local market at Ayigya, Kumasi. Yam was peeled using a sharp knife and cut into uniform sizes. It was then washed with clean water twice to remove any dirt and other surface substances like starch. It was cut vertically into uniform sizes/slices of 50 mm x 12 mm x 10 mm. The cut yams were again washed in clean water. The cut slices of yam were dipped in 0.4 % brine solution; after which it was subjected to okra pectin pretreatment. Yam slices were dipped in 0.0%, 0.2%, 0.4% and 0.6% okra pectin solutions for 1 h at room temperature. The pectin solutions were drained off and yam slices were air dried for 10–12 min in a clean flat pan before deep frying.

2.3.1. Deep frying of okra pectin treated yam slices
The yam slices were fried in a 1.7 L capacity deep fryer with oil volume of 1 L. The working temperature of the fryer was kept constant at 170°C. Fresh vegetable oil (Frytol) was used for frying. Once the temperature of the oil was achieved, the samples were loaded in a perforated basket. Each batch of 500 g yam slices was fried in 1 L of oil. The perforated basket loaded with yam slices was immersed in the hot oil for about 20 min during which the yam slices developed a golden yellow colour. Subsequently, the perforated basket together with the fried yam slices was taken out and drained for 15 min using a wire screen; when the surface was well drained, it was transferred to an absorbent towel. This was to prevent moisture adhesion to the surface of the slices. The samples were stored at room temperature in a plastic container for further analysis.

2.3.2. Moisture content of okra pectin treated fried yam
The moisture content of deep-fried yam slices was determined by the gravimetric method (AOAC, 2005). Moisture content was calculated by weight loss after 2 g of finely blended sample was dried in an oven at 105°C for 4 h to constant weight. Cooled samples were weighed and moisture content was calculated as follows:

$$\%\ Moisture = \frac{Weight\ of\ sample\ before\ drying\ \text{-}\ Weight\ of\ sample\ after\ drying}{Weight\ of\ sample\ before\ drying} \times 100$$

2.3.3. Oil uptake of okra pectin treated fried yam
Total oil content of fried yam samples was determined by weighing 2.0 g of each finely ground sample into a folded filter paper. The weighed sample was hot air oven-dried for 45 min and transferred into a thimble. A ball of cotton was placed to prevent the loss of the sample. About 150 mL of petroleum ether (B.P 60–80°C) was put into clean dried round bottom flasks of known weights and placed into the heating mantles and assembled with the Soxhlet extractor and the Quick fit condenser. The samples were then refluxed for 8 h under medium heat conditions. The petroleum ether was recovered from the extracted fat in the flask. Flasks together with oil extracts were further heated for 30 min in a hot air oven at 105°C to ensure the removal of remnant solvents, then cooled in a desiccator for 30 min and weighed. This was done in duplicates for each sample. The fat content expressed in percentage as follows:

$$\%\ Fat = \frac{mass(g) of\ the\ extracted\ matter}{mass(g) of\ the\ tested\ sample} \times 100$$

2.3.4. Colour determination of okra pectin treated fried yam
The colour of the yam chips was measured using Chroma meter (CR-410, Konica Minolta Inc., Japan) which was calibrated using white and black standard ceramic tiles. The measurements were taken with D-65 illuminant and 10° observer. Colour was measured on finely blended yam chips and two readings were taken at different locations on the surface of the yam chips for each experimental condition. The colour was expressed in terms of L, a* and b* values.

2.4. Sensory evaluation of okra pectin treated fried yam and tigernut milk samples
The consumer acceptability test was used to evaluate the sensory attributes of samples. Fried yam slices and tigernut milk samples were both evaluated by a semi-trained panel of 50 members using the 9-point hedonic scale. Panelists were mainly individuals with a scientific work

background and were trained in the use of attributing rating scale for the characteristics examined. The scores were assigned from dislike extremely (1) to like extremely (9) (Adams et al., 2019).

2.5. Statistical analysis

The data obtained from sensory and chemical analysis were analyzed statistically by using SPSS version 20 (IBM SPSS Statistics, US). Data were subjected to completely randomized analysis of variance (ANOVA) at $p < 0.05$ followed by Tukey LSD post hoc tests. Results were analyzed at 5% significance level (95% confidence interval).

3. Results and discussion

3.1. Microbial load of okra pectin treated tigernut milk

The results obtained for the microbial load of the tigernut milk–okra pectin mixed system are shown in Table 1. The aerobic plate count for the samples ranged from 2×10^2 cfu/ml to 5×10^2 cfu/ml with 0% (control) having the least count ($2x10^2$ cfu/ml) and 0.4% having the highest count. Compared to the control, samples with pectin concentration recorded higher aerobic plate count but all the samples were within the permissible limits for aerobic plate count.

The results obtained in this study were lower than the aerobic count of tigernut beverage recorded by Badau et al. (2018) that ranged between 3.13×10^4 cfu/ml to 9.94×10^4 and that of tigernut beverages made from home recorded by Sebastia et al. (2012); 4.68×10^3 to 2.95×10^6 cfu/ml (3.67 to 6.47 log cfu/ml). The presence of *E. coli* was not detected in any of the samples as recommended by most regulatory bodies. Other studies conducted by Sebastia et al. (2012) and Badau et al. (2018) detected the presence of *E. coli* above the recommended official threshold. This could be attributed to unhygienic/improper handling during the processing of the tigernut beverages. Aerobic plate count and presence of coliforms (*E. coli*) is an indication of bacterial contamination and faecal contamination by humans and animals, respectively (Badau et al., 2018). Since the aerobic count and the *E. coli* count in this current study were within permissible regulatory limits, it implies that the samples were wholesome for consumption. *Bacillus cereus* count ranged from 4.0×10^1 to 7.0×10^1 (1.60–1.85 log cfu/ml) which is lower than the results recorded in the work of Sebastia et al. (2012); 1.79–2.47 log cfu/ml. The results in this study were within the acceptable limits for *B. cereus. Bacillus cereus*, a spore-forming bacterium, is ubiquitous in nature and withstands harsh environmental conditions; hence, it is difficult to be completely eliminated in the processing of foods (Andersson et al., 1995; Sebastia et al., 2012).

3.2. Viscosity

The viscosity of the samples ranged from 4.67 cP to 10.50 cP with the control (with 0% okra pectin) recording the least value (4.67 ± 0.00 cP) and 0.6% (okra pectin concentration) recording the highest value of 10.50 ± 0.15 cP (Figure 1). The viscosities of the control and the tigernut milk with the various pectin concentrations were significantly different ($p < 0.05$).

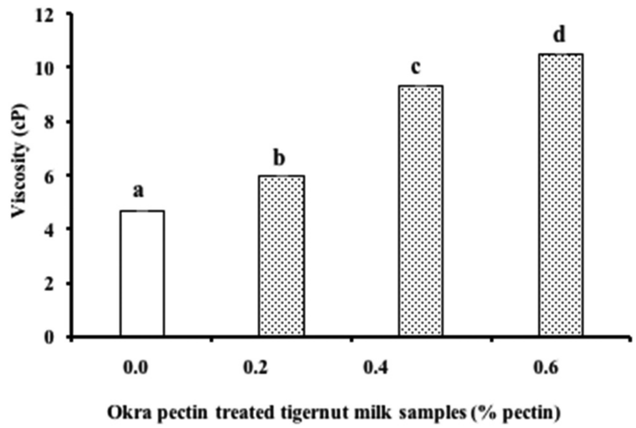
The results indicate that the viscosity of the tigernut milk increased with increasing concentration of the okra pectin. A similar trend was observed in the work of Abedi et al. (2014) and that of

Table 1. Microbial load of okra pectin treated tigernut milk

Sample code	Aerobic plate count (cfu/ml)	*E. coli* (cfu/ml)	*Bacillus cereus* (cfu/ml)
0.0% (control)	$2.0x10^2$	Absent	$4.0x10^1$
0.2%	$3.0x10^2$	Absent	$5.0x10^1$
0.4%	$5.0x10^2$	Absent	$7.0x10^1$
0.6%	$4.0x10^2$	Absent	$6.0x10^1$
Legislated levels	$< 1.0x10^3$	Absent	$< 1.0x10^2$

Figure 1. Viscosity of okra pectin treated tigernut milk.

[a-d]Bars with different alphabets are significantly different ($p < 0.05$).



Hashemi et al. (2014) where increasing pectin concentration increased the viscosity of raspberry juice-milk and fermented whey beverage, respectively. The observed trend in the current study could be attributed to the higher degree of galacturonic acids (63.4%) (Datsomor et al., 2019; Kpodo et al., 2017) on okra (*asha* genotype) pectin. A higher degree of galacturonic acid residues has been reported to resulting in greater repulsive forces between residues subsequently causing the expansion of polymers to occupy larger hydrodynamic volume with increased viscosity (Datsomor et al., 2019; Kontogiorgos et al., 2012).

3.3. Consumer acceptability of okra pectin treated tigernut milk

For the sensorial properties, statistically, there was no significant difference ($p > 0.05$) between the treated and untreated tigernut milk samples for all the parameters except for the appearance (Table 2). The mean score for appearance ranged between 5.80 and7.23 with the control recording the highest score and 0.4% recording the least score. Although the appearance for the control (0%) tigernut milk recorded the highest preference score for appearance, this preference score was not significantly higher than that recorded for tigernut milk samples containing 0.2% okra pectin.

The mean scores for perceived taste indicate panelists slightly disliked the taste of the samples including the control (0% pectin concentration). Generally, mean scores for overall acceptability indicate that the samples were neither liked nor disliked by the panelists.

3.4. Moisture, fat and colour (L, a, b) of okra pectin treated fried yam

The effects of concentration of pectin on the moisture content of fried yam were investigated and the results are presented in Table 3.

Moisture content ranged from 54.33% in the control (0% pectin treatment) fried yam sample to 56.71% in 0.4% okra pectin treated fried yam. The results showed that okra pectin

Table 2. Consumer acceptability test scores of okra pectin treated tigernut milk

Sample	Appearance	Taste	Consistency	Smell	Thickness	Aftertaste	Acceptability
0.0% (control)	7.23 ± 1.33^{a}	4.10 ± 1.86^{a}	5.43 ± 1.98^{a}	5.90 ± 1.97^{a}	6.13 ± 1.6^{a}	5.27 ± 1.98^{a}	5.60 ± 1.87^{a}
0.2%	7.10 ± 1.21^{ab}	4.20 ± 1.77^{a}	5.40 ± 1.65^{a}	5.37 ± 1.79^{a}	6.30 ± 1.32^{a}	5.23 ± 1.57^{a}	5.33 ± 1.71^{a}
0.4%	5.80 ± 1.95^{c}	4.43 ± 1.60^{a}	5.53 ± 1.74^{a}	5.03 ± 1.90^{a}	6.53 ± 1.22^{a}	4.23 ± 1.79^{a}	4.83 ± 1.72^{a}
0.6%	6.17 ± 1.66^{bc}	4.50 ± 1.89^{a}	5.53 ± 2.19^{a}	4.77 ± 1.89^{a}	6.57 ± 1.48^{a}	5.07 ± 1.93^{a}	5.07 ± 1.93^{a}

Values with different alphabets in the same column are significantly different ($p < 0.05$). Sensory 9-point Hedonic scale: 1—Dislike Extremely; 2—Dislike very much; 3—Dislike moderately; 4—Dislike slightly; 5—Neither like nor dislike; 6—Like slightly; 7—Like moderately; 8—Like very much; 9—like extremely.

Table 3. Moisture, fat and colour (L, a, b) of okra pectin treated fried yam

Sample	Moisture (%)	Fat (%)	L*	a*	b*
Control	54.33 ± 0.84^{a}	4.44 ± 0.23^{ab}	63.06 ± 0.01^{a}	−1.26 ± 0.00^{b}	16.67 ± 0.01^{a}
0.2%	55.92 ± 0.20^{ab}	5.50 ± 0.17 ^{c}	65.96 ± 0.21^{b}	−1.19 ± 0.01 ^{c}	16.90 ± 0.01^{b}
0.4%	56.71 ± 0.47^{b}	4.00 ± 0.55^{a}	70.47 ± 0.28 ^{c}	−1.13 ± 0.01 ^{c}	17.18 ± 0.02 ^{c}
0.6%	56.26 ± 0.11^{b}	4.76 ± 0.46^{b}	71.01 ± 0.14^{d}	−1.85 ± 0.00^{d}	17.20 ± 0.04^{b}

Values are Mean±SD for at least duplicate determinations. Values in the same column with different superscript letters are significantly different (p < 0.05).

significantly influenced the moisture content of the fried yam samples. Generally, there was a significant difference ($p > 0.05$) between the moisture values of the treated and untreated fried yam samples. The property of pectin's ability to bind water and prevent excessive moisture loss during frying influenced the variation in moisture content. The difference in the moisture content of okra pectin may be attributed to the disparity in water-holding properties (Maity et al., 2013). Hydrocolloids like pectin have been shown to be effective in retaining moisture content in deep-fat carrot slices (Akdeniz et al., 2006).

The oil uptake values of the fried yam samples are as shown in Table 3. The values ranged from 4.00% in the 0.4% okra pectin treated samples to 5.50% in the 0.2% okra pectin treated yam samples. There was a significant difference ($p < 0.05$) among the values recorded for the various treatments. Oil absorption in fried foods is a surface phenomenon. The mechanism of oil absorption during frying occurs at the cooling phase after the food has completely fried. As a consequence of decreased internal pressure during cooling, the oil adhered to the surface is sucked into the voids (Maity et al., 2013; Saguy & Dana, 2003). The thin viscous nature of 0.2% concentration leads to the ability of oil on the surface of the pretreated fried yam to easily fill the vacant voids.

An increase in oil uptake could also be as a result of pore spaces i2n yams influenced by capillary force (ability of pore spaces to draw up liquid). In a study reported by Saguy (1995), porosity positively correlated with the amount of oil intake. Also, small pore spaces have been reported to cause higher capillary pressure and then higher oil absorption (Moreira & Barrufet, 1998).

Colour is one of the most important quality factors of fried snacks or products (Abe-Inge et al., 2020; Adams et al., 2019; Tortoe et al., 2014). The make-up colour of fried yam slices is as a result of Maillard reaction which is dependent on the content of reducing sugars and amino acid as well as frying time and temperature. The established and acceptable colour of fried yam is golden yellow (Krokida et al., 2001). The colour of the fried yam chips was evaluated in terms of lightness (L*), yellowness (b*) and redness (a*) to assess the variation in the colour. As indicated in Table 4, there was a significant ($p < 0.05$) increase in lightness (L*) as the concentration of pectin increases with control fried yam samples recording the least L* value of 65.06%

Table 4. Consumer acceptability of okra pectin treated fried yam

Sample	Appearance	Taste	Crispness	Mouth feel	After taste	Aroma	Overall acceptability
Control	6.38 ± 1.85^{a}	6.20 ± 2.00^{a}	5.10 ± 1.92^{a}	6.58 ± 1.65^{a}	6.13 ± 1.83^{a}	6.28 ± 1.81^{a}	6.23 ± 1.55^{a}
0.2%	6.25 ± 1.86^{a}	5.98 ± 1.98^{a}	5.78 ± 2.14^{a}	6.08 ± 1.91^{a}	6.15 ± 1.93^{a}	6.85 ± 1.81^{a}	6.58 ± 1.66^{a}
0.4%	6.25 ± 1.78^{a}	6.43 ± 2.01^{a}	5.68 ± 1.81^{a}	5.73 ± 1.83^{a}	6.08 ± 2.12^{a}	6.4 ± 1.95^{a}	6.18 ± 1.78^{a}
0.6%	6.43 ± 1.96^{a}	6.38 ± 1.89^{a}	5.55 ± 2.04^{a}	6.25 ± 2.00^{a}	5.90 ± 1.86^{a}	6.5 ± 1.97^{a}	6.30 ± 1.59^{a}

Values in the same column with the same superscript letters are not significantly different (p > 0.05). Scale: 1—Dislike very much; 2—Dislike moderately; 3—Dislike slightly; 4—Neither like nor dislike; 5—Like slightly; 6—Like Moderately; 7—Like very much.

and 0.6% concentration recording the highest L-value of 71.01. The trend of lightness observed in this study concurs with the findings of Maity et al. (2015), who reported an increase in lightness among pectin treated fried jack fruits. The lightness of colour can be due to okra pectin interfering with the mechanism of browning. Pangloli et al. (2002) had previously established that lightness of fried potato chips readings above 60 are excellent, 56–60 are acceptable and 50–55 are slightly acceptable.

An increase in lightness was complemented by an increase in yellowness (b*). The control (0%) fried yam slices recorded a value of 16.67, while other treatments (0.2%, 0.4% and 0.6%) recorded 16.90, 17.18 and 17.20, respectively. Maity et al. (2015) also recorded an increase in yellowness of fried jack fruits as the concentration of pectin increases. The observation of an increase in yellowness of samples in this study is in disparity with a report by Garcia et al. (2002) that applying edible coating to fried food does not affect the final colour. The variation in the colour values could be attributed to the nature of product and modification of surface property of tissues.

As shown in Table 3, a* values which indicate redness of samples ranged from −1.85 in the 0.6% fried yam samples to −1.13 in 0.4% okra pectin treated fried yam. There was no clear trend in a* values, although fried yam samples with the highest concentration (0.6%) of okra pectin pretreatment recorded the least a* value (hence the highest level of redness). According to Sobukola et al. (2007), red colour is an undesirable quality characteristic of fried yam. Therefore, fried products with lower red colour will be more acceptable to consumers.

3.5. Consumer acceptability of okra pectin treated fried yam

Sensory quality of fried yam is an imperative feature in consumer choices of food products. As shown in Table 4, there was no significant difference ($p > 0.05$) among the fried yam samples for all assessed sensory parameters (appearance, taste, crispiness, mouthfeel, aftertaste, aroma and overall acceptability).

Despite the insignificant difference, 0.6% (6.43) okra pectin treated fried yam samples recorded the highest score for appearance (6.43). Also, 0.4% okra pectin treated fried yam samples recorded the highest score for taste (6.43), while control samples recorded the lowest value (6.20).

Fried yam samples with 0.2% okra pectin solution pretreatment recorded the highest score (5.78) for crispness. Crispness constitutes one of the most essential sensory attributes of fried yam. This evident in the overall acceptability scores where 0.2% okra pectin pretreated recorded the highest score of 6.58. Although 0.2% samples recorded the highest overall acceptability and aroma scores, statistically, these scores were insignificantly different ($p > 0.05$) compared to samples of other concentrations of pretreatment.

4. Conclusion

The study showed that the viscosity of tigernut milk samples increased with increasing okra pectin concentration. However, there was no significant difference between the control and tigernut milk with different okra pectin concentrations for all the sensory attributes except the appearance. The appearance for the control (0%) was most preferred followed by that of the tigernut milk containing 0.2% pectin though there was no significant difference between the two. The presence of okra pectin did not have a negative effect on the microbial quality of the tigernut milk.

The results suggest that okra pectin treatment generally influenced the moisture content, colour and fat content of fried yam. However, 0.2% okra pectin treated yam had the highest mean value for overall acceptability. The findings indicate that treatment with okra pectin had a good impact on fried yam which would ultimately contribute to food security and will create new food market opportunities.

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References

Abedi, F., Sani, A. M., & Karazhiyan, H. (2014). Effect of some hydrocolloids blend on viscosity and sensory properties of raspberry juice-milk. *Journal of Food Science and Technology*, *51*(9), 2246–2250. https://doi.org/10.1007/s13197-012-0705-0

Abe-Inge, V., Asaam, E. S., Agbenorhevi, J. K., Bawa, N. M., & Kpodo, F. M. (2020). Development and evaluation of African palmyra palm (*Borasus aethiopum)* fruit flour-wheat composite flour noodles. *Cogent Food & Agriculture*, *6*(1), 1749216. https://doi.org/10.1080/23311932.2020.1749216

Adams, Z. S., Wireko-Manu, F. D., Agbenorhevi, J., & Oduro, I. (2019). Improved Yam-Baobab-tamarind flour blends: Its potential use in extrusion cooking. *Scientific African*, *6*, e00126. https://doi.org/10.1016/j.sciaf.2019.e00126

Adejuyitan, J. A. (2011). Tigernut processing: Its food uses and health benefits. *American Journal of Food Technology*, *6*(3), 197–201. https://doi.org/10.3923/ajft.2011.197.201

Agbenorhevi, J. K., Kontogiorgos, V., Morris, G. A., Kpodo, F. M., Oduro, I. N., Bonsu, K. O., & Kaledzi, P. D. (2015, August 6–7). Okra extract – A versatile material for technological applications. In: *1st International Conference on Engineering, Science, Technology and Entrepreneurship (ESTE)*, 27.

Agbenorhevi, J. K., Kpodo, F. M., Banful, B. K. B., Oduro, I. N., Abe-Inge, V., Datsomor, D. N., Atongo, J., & Obeng, B. (2020). Survey and evaluation of okra pectin extracted at different maturity stages. *Cogent Food & Agriculture*, *6*(1), 1760476. https://doi.org/10.1080/23311932.2020.1760476

Akdeniz, N., Sahin, S., & Sumnu, G. (2006). Functionality of batters containing different gums for deep-fat frying of carrot slices. *Journal of Food Engineering*, *75*(4), 522–526. https://doi.org/10.1016/j.jfoodeng.2005.04.035

Andersson, A., Ronner, U., & Granum, P. E. (1995). What problems does the food industry have with the spore-forming pathogens *Bacillus cereus* and *Clostridium perfringens? International Journal of Food Microbiology*, *28*(2), 145–155. https://doi.org/10.1016/0168-1605(95)00053-4

AOAC. (2005). *Official methods of analysis of the Association of Analytical Chemists International*.

Asante, F. A. (2018). *Process development and evaluation of tiger nut based chocolate products* [Doctoral Thesis]. Kwame Nkrumah University of Science and Technology, 41. http://hdl.handle.net/123456789/11468

Badau, M. H., Bilyaminu, D., Ogori, A. F., Charles, B., & Ogori, J. (2018). Microbial quality evaluation of tiger nut beverage (Kunun Aya) processed sold in University of Maiduguri. *EC Nutrition*, *13*(3), 138–142.

Bahrami, M., Ahmadi, D., Alizadeh, M., & Hosseini, F. (2013). Physicochemical and sensorial properties of probiotic yoghurt as affected by the addition of different types of hydrocolloids. *Korean Journal for Food Science of Animal Resources*, *33*(3), 363–368. https://doi.org/10.5851/kosfa.2013.33.3.363

Chen, Y., & Moreira, R. G. (1997). Modelling of a batch deep-fat frying process for tortilla chips. *Food and Bioproducts Processing*, *75*(3), 181–190. https://doi.org/10.1205/096030897531531

Datsomor, D. N., Agbenorhevi, J. K., Kpodo, F. M., & Oduro, I. N. (2019). Okra pectin as lecithin substitute in chocolate. *Scientific African*, *3*, e00070. https://doi.org/10.1016/j.sciaf.2019.e00070

Gambo, A., & Da'u, A. (2014). Tiger nut (*Cyperus esculentus*): Composition, products, uses and health benefits – A review. *Bayero Journal of Pure and Applied Sciences*, *7*(1), 56–61. https://doi.org/10.4314/bajopas.v7i1.11

Garcia, M. A., Ferrero, C., Bertola, N. C., Martino, M. A., & Zaritzky, N. E. (2002). Edible coating from cellulose derivatives to reduce oil uptake in fried products. *Innovative Food Science and Emerging Technologies*, *3*(4), 391–397. https://doi.org/10.1016/S1466-8564(02)00050-4

Hashemi, F. S., Pezeshky, A., Gharedaghi, K., & Javani, R. (2014, October 22-23). Effect of hydrocolloids on sensory properties of the fermented whey beverage. *1st International Conference on Natural Food Hydrocolloids*.

ISO 4833:2003. (2003). Microbiology of food and animal feeding stuffs — Horizontal method for the enumeration of microorganisms — Colony-count technique at 30 °C.

ISO 7251:2005. (2005). Microbiology of food and animal feeding stuffs — Horizontal method for the detection and enumeration of presumptive Escherichia coli — Most probable number technique.

ISO 7932:2004. (2004). Microbiology of food and animal feeding stuffs-Horizontal method for the enumeration of presumptive *Bacillus cereus*-Colony-count technique at 30 °C.

Kontogiorgos, V., Margelou, I., Georgiadis, N., & Ritzoulis, C. (2012). Rheological characterization of okra pectins. *Food Hydrocolloids*, *29*(2), 356–362. https://doi.org/10.1016/j.foodhyd.2012.04.003

Kpodo, F., Agbenorhevi, J. K., Alba, K., Bingham, R., Oduro, I., Morris, G., & Kontogiorgos, V. (2017). Pectin isolation and characterization from six okra genotypes. *Food Hydrocolloids*, *72*, 323–330. https://doi.org/10.1016/j.foodhyd.2017.06.014

Kpodo, F., Agbenorhevi, J. K., Alba, K., Oduro, I., Morris, G., & Kontogiorgos, V. (2018). Structure-function relationships in pectin emulsification. *Food Biophysics,13*, *13*(1), 71–79. https://doi.org/10.1007/s11483-017-9513-4

Krokida, M. K., Oreopoulou, V., Maroulis, Z. B., & Marinos-Kouris, D. (2001). Effect of pre-drying on quality of French fries. *Journal of Food Engineering*, *49*(4),

347–354. https://doi.org/10.1016/S0260-8774(00)00233-8
Maity, T., Bawa, A. S., & Raju, P. S. (2015). Use of hydrocolloids to improve the quality of vacuum fried jackfruit chips. *International Food Research Journal*, *22*(4), 1571–1577.
Maity, T., Raju, P. S., & Bawa, A. S. (2013). Effect of hydrocolloid pre-treatment on instrumental and sensory texture attributes of frozen carrot *(Daucus carota)*. *International Journal of Food Properties*, *16*(2), 461–474. https://doi.org/10.1080/10942912.2011.553756
Mallikarjunan, P., Ngadi, M. O., & Chinnan, M. S. (2009). *Breaded fried foods* (Vol. 9). CRC Press.
Maxwell, E. G., Belshaw, N. J., Waldron, K. W., & Morris, V. J. (2012). Pectin–an emerging new bioactive food polysaccharide. *Trends in Food Science & Technology*, *24*(2), 64–73. https://doi.org/10.1016/j.tifs.2011.11.002
Moreira, R. G., & Barrufet, M. A. (1998). A new approach to describe oil absorption in fried foods: A simulation study. *Journal of Food Engineering*, *35*(1), 1–22. https://doi.org/10.1016/S0260-8774(98)00020-X
Nyarko-Mensah, P. (2018). *Sensory and physicochemical evaluation of "Burkina" made with composite (Cow and Tiger Nut) milk* [MPhil Thesis (Published)]. University of Ghana, p. 17. http://ugspace.ug.edu.gh/handle/123456789/27367
Pangloli, P., Melton, S. L., Collins, J. L., Penfield, M. P., & Saxton, A. M. (2002). Flavour and storage stability of potato chips fried in cottonseed and sunflower oils and palm olein/sunflower oil blends. *Journal of Food Science*, *67*(1), 97–103. https://doi.org/10.1111/j.1365-2621.2002.tb11366.x
Saguy, I. S. (1995). Oil uptake during deep-fat frying: Factors and mechanism. *Food Technology*, *49*(4), 142–145.
Saguy, S., & Dana, D. (2003). Integrated approach to deep fat frying: Engineering, nutrition, health and consumer aspects. *Journal of Food Engineering*, *56*(2–3), 143–152. https://doi.org/10.1016/S0260-8774(02)00243-1
Sebastia, N., El-Shenawy, M., Manes, J., & Soriano, J. M. (2012). Assessment of microbial quality of commercial and homemade tiger-nut beverages. *Letters in Applied Microbiology*, *54*(4), 299–305. https://doi.org/10.1111/j.1472-765X.2012.03212.x
Sobukola, O. P., Dairo, O. U., Sanni, L. O., Odunewu, V. A., & Fafiolu, O. B. (2007). Thin layer drying of some leafy vegetables under open sun. *Food Science and Technology International*, *13*(1), 35–40. https://doi.org/10.1177/1082013207075953
Suleiman, M. S., Olajide, J. E., Omale, J. A., Abbah, O. C., & Ejembi, D. O. (2018). Proximate composition, mineral and some vitamin contents of tigernut (*Cyperus esculentus*). *Clinical Investigation*, *8*(4), 161–165. https://doi.org/10.4172/Clinical-Investigation.1000143
Tobil, M., Deh, C. Y., Agbenorhevi, J. K., Sampson, G. O., & Kpodo, F. M. (2020). Effect of okra pectin on the sensory, physicochemical and microbial quality of Yoghurt. *Food and Nutrition Sciences*, *11*(6), 442–456. https://doi.org/10.4236/fns.2020.116032
Tortoe, C., Akonor, P. T., Nketia, S., Owusu, M., Glover-Amengor, M., Hagan, L., & Otoo, E. (2014). Evaluation of the sensory characteristics and consumer acceptability of deep-fried yam (*Dioscorea rotundata*) crisps in the Accra Metropolitan Area. *Journal of Food and Nutrition Sciences*, *2*(1), 19–23. https://doi.org/10.11648/j.jfns.20140201.13