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Okra pectin as lecithin substitute in chocolate

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ABSTRACT

The effect of okra (*Abelmoschus* spp.) pectin as an emulsifier on the yield, textural properties, sensory and consumer acceptability of different chocolate formulations was investigated. Pectin was isolated from okra pods and incorporated into milk chocolate as lecithin substitute (emulsifier) at different levels (10–100%). Texture profile analysis and sensory evaluation (5-point hedonic scale) was performed on the different chocolate formulations. It was found that with increasing pectin content viscosity of the mixed system increased during milling and conching, which resulted in slower flow rate during draining from the ball mill and decreased yield. Substitution at 25:0 (%) (pectin: lecithin) yielded 84 bars of 9 g of chocolate per 1500 g of formulation after draining for 30 min compared to formulations containing lecithin. Chocolate samples 25:75 (%) (pectin:lecithin) had the highest overall acceptability (4.37 ± 0.30) which was not significantly different ($p > 0.05$) from sample 25:0 with overall acceptability of 4.23 ± 0.30. All the chocolate samples from the various formulations studied had similar sensory properties as well as textural parameters (hardness, cohesiveness, adhesiveness, springiness and chewiness). The present findings suggest that it is possible to use okra pectin as emulsifier to produce milk chocolate which is acceptable to consumers.

Introduction

Okra, *Abelmoschus esculentus* is a vegetable cultivated in the tropical, sub-tropical and warm temperate regions of the world for its fruits. The high mucilage content of the okra fruit is particularly desirable in the preparation of different soups and stews. Okra polysaccharides are predominantly pectins and consist of the sugars- galactose, rhamnose and galaturonic acid [1,2]. The polysaccharide content of okra extracts is responsible for its slimy texture and researchers have taken keen interest in this polysaccharide as it has several food, non- food, and medicinal/ pharmaceutical applications. Okra pectin can be used as emulsifiers, thickeners, stabilizers, binder, film former and clarifying agent in food and pharmaceutical products [1,3–6]. It is also used as a fat substitute in cookies, frozen desserts and chocolate bars [7]. Due to the unique water holding capacity and solubility of the polysaccharides, they can strengthen dough used for baking of cakes and cookies [8]. Okra pectin have shown good emulsion stability properties under acidic environments and hence have potential applications in

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Table 1
Molecular and emulsion characteristics of Asha okra pectin.

Properties	Asha okra pectin*
Protein %	5.5 ± 3.1
Total carbohydrate %	86.3 ± 2.0
D-GalA %	63.4 ± 1.1
Acetyl %	6.1 ± 0.1
DM %	17.2 ± 1.4
DA %	39.3 ± 4.3
(Ara + Gal)/Rha	1.9
RG-I	42.7
HG/RG-1	1.3
Mw (x 10^3 g/mol)	1202

* [2,4].

fruit drinks and acidified dairy products [1,3,4,7]. Okra mucilage has been used in traditional medicine as a dietary meal in the treatment of gastric irritations, dental diseases, ulcers and haemorrhoids [9].

Notwithstanding the potentials of okra, it is underutilized in Ghana and most African countries. This is partly due to limited knowledge on the impact of the polysaccharides when applied in specific locally manufactured food products. Local farmers also lack adequate knowledge on practices to produce varieties and maximize production for specific technological applications. There is therefore low economic value for okra in the country. Lecithin is used as the emulsifier during the production of chocolate in Ghana. The functional role of lecithin in chocolate manufacture is to act as a surface active ingredient that influences the viscosity and maintains desirable flow properties of the chocolate product [10]. However, lecithin is expensive since it is imported into the country and significantly adds to the cost of production. The need for other natural and relatively cheaper sources of emulsifiers have made it imperative to study the properties of non-protein emulsifiers such as sugar beet and okra pectin for food application. Traditionally, polysaccharides have not been considered as effective oil binders mainly due to their hydrophilicity and high molecular weight [11]. However, sugar beet and okra pectin have been noted to differ from other polysaccharides in terms of protein and acetyl content which impacts some hydrophobic characteristics when interacting with oil systems [12]. The isolation of pectins from okra for use in food products will add value to the vegetable and possibly increase its production. Increase in production would consequently result in job creation and also more income for local farmers and marketers of okra. Furthermore, the use of okra pectin to substitute some ingredients in food systems could also help to decrease the cost of these products due to the availability and low cost of okra.

In our previous studies, the stabilizing ability of okra pectin in acidic oil-in-water emulsions and the impact of different pectin molecular properties on emulsification were reported [3,4]. A hypothesis on pectin functionality in a chocolate system was formulated in the present study as a strategy to increase utilization of okra pectin as emulsifiers in food systems. Therefore, the aim of this work was to isolate okra pectin and investigate its emulsifying properties in chocolate as a substitute for lecithin. The effect of the okra pectin on the yield, texture and consumer acceptability of different chocolate formulations were also determined.

Material and methods

Materials and chemicals

Soft and mature okra pods of the Asha genotype were obtained from a local farmer in the Brong Ahafo region of Ghana. Buffer salts, ethanol (96% w/w), petroleum ether (bp 40–60 °C), all analytical grade were obtained from Sigma-Aldrich (Poole, UK). Deionized water was used throughout the extraction experiment. Cocoa liquor, sugar, emulsifier (lecithin), cocoa butter, skimmed milk and whey powder used as ingredients for chocolate manufacture was a kind donation from Cocoa Processing Company, Ghana. Okra pectins were extracted in our laboratories as described in the next section.

Extraction of okra pectin

Okra pectin was isolated using the hot phosphate buffer extraction method at pH 6.0 [2,13,14]. The deseeded pods were solar dried at 37–39 °C for 72 h to a moisture content below 10% and defatted using petroleum ether at 40–60 °C under reflux for 1 h at a ratio of 1 g:15 mL. Aqueous extraction was done with 0.1 M Phosphate Buffer, with pH 6 at 80 °C at a ratio of 1 g: 30 mL. The resulting mixture was then centrifuged at 2500 rpm for 15 min and the pectin precipitated from the supernatant with ethanol (96% v/v) and the precipitate oven dried at 60 °C for 6 h using the hot air oven (Binder Heating and Drying Oven, serial no: 15-18440, Tuttingen, Germany). The molecular characteristics (protein, total carbohydrate, galacturonic acid, acetyl, neutral sugars, RG-I fraction, intrinsic viscosity and average molecular weight) of the Asha okra pectin used are presented in Table 1. Asha okra pectin extracts have shown high acetyl and RG-I composition, and these unique molecular properties play a critical role in emulsification capacity and stability.

Table 2
Formulations for chocolate production with okra pectin substitution.

Formulation	Composite ratio Okra pectin: Lecithin	Proportion of emulsifier (%)	
		Okra pectin	Lecithin
F_1	10:0	0.058	0
F_2	10:90	0.058	0.522
F_3	25:0	0.145	0
F_4	25:75	0.145	0.435
F_5	50:0	0.290	0
F_6	50:50	0.290	0.290
F_7	75:0	0.435	0
F_8	75:25	0.435	0.145
F_9	100:0	0.580	0
F_{10}	0:100	0	0.580

Chocolate production

The compositional ratios of okra pectin-lecithin substitution used in the production of the chocolate products is shown in Table 2. The ingredients (cocoa liquor, sugar, emulsifier, cocoa butter, skimmed milk and whey powder) were weighed and milled using the attrition ball refiner (Wiener & co apparatebouw B.V, Amsterdam, The Netherlands) at an attritor speed of 4 for 1 h. The mixture was then drained, tempered (temperature 31 °C), moulded and refrigerated for 30 min before demoulding, allowing acclimatizing and then packaged.

Texture analysis

Texture profile analysis was conducted using the Brookfield CT3 Texture Analyzer and TexturePro CT software (Brookfield Engineering Laboratories, Middleboro, MA, USA). The parameters evaluated were hardness, cohesiveness, adhesiveness, springiness and chewiness. Test was conducted on samples of dimensions 3.2 × 2.4 × 1.2 (cm) with the stainless steel needle probe of 1.0 mm diameter and length 43 mm (TA9). Test speed was set at 0.50 mm/s, pretest speed of 2 mm/s and load of 100 g.

Sensory evaluation

Sensory evaluation was conducted using 30 untrained panellists recruited from the Department of Food Science and Technology, KNUST, in a consumer acceptability test. The criteria for recruitment were that they were chocolate consumers and willing to participate in the test. The chocolate samples included 10 different formulations with different compositional ratio of okra pectin and lecithin used as emulsifiers. Since over six samples were evaluated, a balanced incomplete block design (BIBD) was used to assign the samples to the panellists to prevent consumer fatigue [15]. The assessors evaluated the milk chocolates based on their texture, taste, appearance, mouthful and flavour using a 5 - point hedonic scale (1 – dislike very much, 3 – neither like nor dislike and 5 – like very much).

Statistical analyses

The data obtained were subjected to the analysis of variance (ANOVA), followed by Tukey's test to separate means at 5% probability level.

Results and discussion

Effect of okra pectin substitution on chocolate yield

The hot acid buffer isolated pectin from the okra genotype, Asha that was used in this study has molecular characteristics detailed in Table 1. The molecular characteristics of the Asha isolates which influenced the emulsification capacity of the pectin in the chocolate product include high total carbohydrate, galacturonic acid, degree of acetylation, rhamnogalacturonan-I (RG-I) and average molecular weight characteristics. Pectins implicated in emulsion studies are highly acetylated and branched and these unique molecular attributes influence emulsion stability by preventing aggregation of oil droplets through steric and mechanical stabilization effects [16]. The Asha pectin isolates were also low methoxyl pectins with comparatively low amount of proteins hence the emulsification capacity of the pectin in the chocolate system can largely be attributed to the molecular structure of the pectin in the isolate [4].

An increase in okra pectin concentration, increased the viscosity of the mixed system during milling using the ball attrition mill. This increase in viscosity resulted in slower flow rate during ball mill drainage leading to a reduction in product yield as pectin content increased. Galactouronic acid content of pectin isolates have been identified as possible active agents

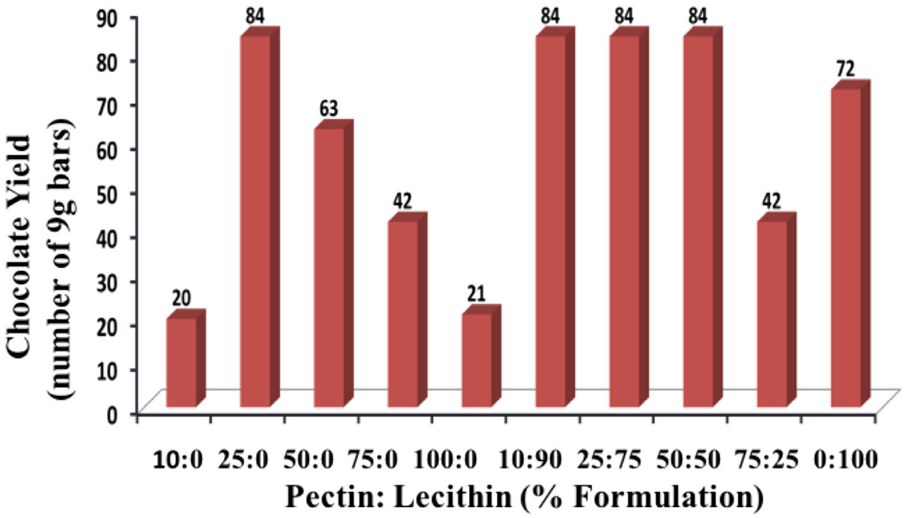

Fig. 1. Chocolate yield per 1500 g formulation after 30 min of draining.

Table 3
Mean sensory scores for different chocolate samples.

Formulation (%) (Pectin: Lecithin)	Appearance	Texture	Taste	Flavour	Mouthfeel	Overall acceptability
10:0	4.50 ± 0.55^a	4.00 ± 1.10^a	4.33 ± 1.21^a	4.17 ± 0.98^a	4.33 ± 1.21^a	4.27 ± 0.19^a
10:90	4.50 ± 0.8^a	4.50 ± 0.55^a	4.17 ± 0.75^a	4.5 ± 0.84^a	4.00 ± 1.10^a	4.33 ± 0.24^a
25:0	4.33 ± 1.20^a	4.00 ± 0.63^a	4.50 ± 0.55^a	4.5 ± 0.84^a	3.83 ± 0.75^a	4.23 ± 0.30^a
25:75	4.00 ± 0.60^a	4.33 ± 0.82^a	4.67 ± 0.52^b	4.17 ± 0.75^a	4.67 ± 0.82^a	4.37 ± 0.30^a
50:0	4.00 ± 1.26^a	3.83 ± 0.98^a	4.17 ± 0.41^a	3.67 ± 0.52^a	3.33 ± 0.82^a	3.80 ± 0.29^a
50:50	4.50 ± 0.80^a	4.17 ± 0.98^a	3.67 ± 1.37^a	3.50 ± 1.38^a	4.00 ± 1.26^a	3.97 ± 0.40^a
75:0	3.50 ± 1.05^a	3.83 ± 0.75^a	3.33 ± 1.37^a	3.33 ± 1.21^a	4.33 ± 0.82^a	3.67 ± 0.42^a
75:25	4.00 ± 0.89^a	3.67 ± 0.82^a	3.83 ± 0.75^a	3.83 ± 1.33^a	3.50 ± 1.05^a	3.77 ± 0.19^a
100:0	4.17 ± 0.75^a	3.83 ± 1.47^a	3.50 ± 1.64^a	3.33 ± 1.63^a	3.50 ± 1.64^a	3.67 ± 0.30^a
0:100	3.50 ± 1.22^a	3.33 ± 1.63^a	2.50 ± 1.22^a	3.00 ± 1.67^a	3.50 ± 1.22^a	3.17 ± 0.42^a

Values are mean scores of a 5-point hedonic scale: 1 – dislike very much, 2-dislike slightly, 3 – neither like nor dislike, 4- like slightly and 5 – like very much.
Values with different alphabets are significantly different ($p < 0.05$).

involved in mucilage binding of particles in a mixed system [17]. Hence the high galacturonic acid content of the Asha pectin in the chocolate mix increased coagulation and reduced the flow rate of the formulated product during drainage. Congruently, high amounts of galacturonic acid residues on a pectin chain results in greater repulsive forces between the residues, hence polymers tend to expand and occupy a larger hydrodynamic volume with increased viscosity [18,19]. Low molecular weight okra pectin isolates with reduced galacturonic acid content could decrease the viscosity of the mixed system and increase flow rate during drainage of the chocolate product using the ball attrition mill.

The yield of chocolate per 1500 g formulation after thirty (30) minutes of draining is shown in Fig. 1. Generally for samples containing okra pectin only (F_3, F_5, F_7 and F_9), the yield of chocolate decreased as pectin content increased from 25% to 100% (Fig. 1). Chocolate formulation with 25% okra pectin only (F_3) had a yield of 84 bars of 9 g chocolate whereas formulation with 100% okra pectin produced 21 bars of 9 g chocolate. The yield obtained when chocolate formulation was emulsified with 25% okra pectin only was comparable to yields (84 bars of 9 g chocolate) from samples containing a combination of okra pectin and lecithin (F_2-10:90, F_4-25:75 and F_6-50:50), and higher than the yield obtained for the formulation containing 100% lecithin (72 bars of 9 g chocolate). Polysaccharides are traditionally not known to be good emulsifiers when applied in oil systems because they are highly hydrophilic and have high molecular weight [11]. However pectin from okra and sugar beet have been noted to differ from other polysaccharide because they are highly acetylated and contain covalently bound proteins [3,20]. The acetyl groups and the protein moiety have been noted to be responsible for the emulsifying capacity of these pectins, hence the ability of okra pectin to exhibit hydrophobic characteristics when interacting with oil systems.

Effect of okra pectin substitution on sensory characteristics of chocolate products

The sensory characteristics of the different okra pectin substituted chocolate products were evaluated (Table 3). Mean consumer scores for appearance, texture, taste, flavour, mouth feel and overall acceptability for the okra substituted choco-

Table 4
Textural properties of different chocolate formulations.

Sample* (pectin: lecithin)	Hardness (g)	Adhesiveness (mj)	Cohesiveness	Springiness (mm)	Chewiness (mj)
10:0	97.97 ± 2.45	0.11 ± 0.01	0.28 ± 0.01	0.43 ± 0.06	0.12 ± 0.02
10:90	96.74 ± 4.13	0.07 ± 0.00	0.29 ± 0.01	0.21 ± 0.01	0.06 ± 0.01
25:0	98.47 ± 3.34	0.06 ± 0.01	0.22 ± 0.08	0.15 ± 0.05	0.03 ± 0.00
25:75	98.16 ± 2.49	0.10 ± 0.01	0.35 ± 0.03	0.64 ± 0.45	0.22 ± 0.17
50:0	97.71 ± 2.01	0.06 ± 0.02	0.56 ± 0.57	1.04 ± 1.45	0.98 ±1.38
50:50	98.26 ± 4.36	0.06 ± 0.03	0.66 ± 0.67	1.00 ± 1.20	1.05 ± 1.45
75:0	100.51 ± 1.57	0.12 ± 0.01	0.26 ± 0.04	0.40 ± 0.04	0.10 ± 0.03
75:25	97.39 ± 2.01	0.10 ±0.07	0.65 ± 0.52	1.41 ± 1.76	1.29 ± 1.77
100:0	99.23 ± 3.77	0.06 ± 0.00	0.30 ± 0.11	0.42 ± 0.27	0.14 ± 0.13
0:100	99.69 ± 0.38	0.13 ± 0.04	0.43 ± 0.11	2.16 ± 2.04	1.02 ± 1.09

* Formulation (%) (pectin: lecithin).

late products ranged from 3.50 to 4.50 for appearance; 3.83 to 4.50 for texture; 3.50 to 4.67 for taste; 3.33 to 4.50 for flavour; 3.50 to 4.67 for mouth feel and 3.67 to 4.37 for overall acceptability.

Formulations did not statistically vary ($p > 0.05$) with respect to appearance, texture, mouthfeel and flavour. Similar ratings had also been observed in the sensory evaluation of a chocolate frozen dairy dessert formulated with okra gum [7]. Statistical differences ($p < 0.05$) were however observed among the panelists with respect to the taste of the chocolate samples. This variation could be attributed to the different amount of whey powder added. Whey powder is often used as a cheaper substitute for milk. The overall acceptability values show that sample with 25% pectin and 75% lecithin was the most acceptable formulation (4.37 ± 0.30) which was however not significantly different from the sample containing 25% pectin only (4.23 ± 0.30).

Results from the sensory evaluation indicate that lecithin substitution with okra pectin as emulsifier did not affect the sensory characteristics of the chocolate products.

Effect of okra pectin substitution on texture characteristics of chocolate products

Analysis was conducted on the texture profile of the chocolate samples (Table 4). The attributes assessed (hardness, cohesiveness, adhesiveness, springiness and chewiness) for the 10 different chocolate formulations showed no significant differences ($p > 0.05$). This suggests that the addition of the okra pectin as lecithin substitute did not impact the texture properties of the chocolate and therefore can be used to replace lecithin effectively with respect to the texture of the product.

Conclusions

The present findings suggest that it is possible to use okra pectin as a substitute for lecithin in chocolate which is acceptable to consumers. Okra pectin added at 0.145% of the total weight of the ingredients produced chocolate with similar flow and yield to standard milk chocolate produced with 100% lecithin. Chocolate samples made with okra pectin did not have any significant differences with respect to most of the sensory properties (appearance, flavour, mouthfeel and texture) assessed. Texture properties (hardness, cohesiveness, adhesiveness, springiness and chewiness) of the different formulations did not differ significantly from each other and from the standard chocolate which served as the control.

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Conflict of interest

None.

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