Journal of Science and Technology, Vol. 42, No. 2 (2024), pp 65 - 78
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https://dx.doi.org/10.4314/just.v42i2.5

PROXIMATE COMPOSITION AND RELATIVE PREFERENCE MAPPING OF MILK CHOCOLATE EMULSIFIED WITH OKRA PECTIN

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ABSTRACT
In chocolate, the primary emulsifier used is soy lecithin. However, soy lecithin is a major allergen to some people and also considered expensive as it is imported. In this study, three different genotypes of okra pectin were extracted and used to replace lecithin in chocolate production as an emulsifier. The okra pectin samples were combined in different ratios and used in different chocolate formulations. The new formulations were evaluated by means proximate analysis and relative preference mapping (RPM). Results showed that there were no significant differences between the moisture content (1.85-2.25 %) and the ash content (2.54-2.82%) for all formulations (p > 0.05). However, there were slight differences among the formulations regarding the fat (30.34-30.99%) and sugar (22.12-31.61%) contents. The RPM results indicated that product F8, F9, F10, F13, F14 and F16 were considered to be similar to the control and liked as much as the control. All these products contain some ratio of Balabi pectin in their formulation except product F10. Product F8 which was the most liked product had fat and sugar contents lower than the control. The study showed that none of the products containing a single pectin variety was found in the area of interest suggesting that combining the pectin varieties gives a better result in the formulation of chocolate compared to using pectin from a single okra genotype.

Keywords: Chocolate formulation, Ingredient; Emulsifier, Sensory acceptability

INTRODUCTION

The demand for natural ingredients in food and non-food industries has increased in recent times. This has derived the need to investigate different sources of pectin and their properties for new technological functionality in emulsions (Cuevas-Bernardino *et al.*, 2016). Emulsifiers are surface- active agents that facilitates the formation of emulsions by the reduction of the interfacial tension between the two immiscible phases. Emulsifiers are required in many food products to stabilize the oil-water droplets dispersed in the continuous aqueous phase. Pectin is a heteropolysaccharide which possess some industrial importance (gelling agent, stabilizing agent, etc) and has diverse functionalities due to its structure. Homogalacturonan (HG) and rhamnogalacturonan I (RG I) are the two main blocks of pectin. Homogalacturonan (HG) is abundant and occupies about 65% polymeric segments. It is composed of long chains of linearly linked 1 →4 α-D-galacturonic acid (Nyarko *et al.*, 2021; Kpodo *et al.*, 2017; Mohnen, 2008). The homogalacturonan segment is referred to as the smooth region of pectin because of the absence of branching. Some of the carboxyl groups are methyl esterified at C-6 position. Pectin with degree of esterification above 50% is known as high methyl-esterified pectin and those below 50% are termed as low methyl-esterified pectin. Pectin can also have an acetyl esterification at O-2 and/or O-3 positions of the galacturonic acid. The rhamnogalacturonan I is also made up of repeating disaccharides galacturonic acid and rhamnose [α-(1→2)-D-galacturonic acid-α-(1→4)-L-rhamnose]*n*, where *n* can be greater than 100. Rhamnose unit on rhamnogalacturonan-I backbone contain polymeric side chains composed predominately of neutral sugars galactose or arabinose or both. This region is also known as the hairy region of the pectin. Other moieties may be observed depending on the botanical origin and the method used for the extraction for example the rhamnogalacturonan II, arabinan, arabinogalactan, xylogalacturonan or apiogalacturonan. They may also have proteins attached to the side chains of RG-I regions contributing further to the complexity of the structure (Sinnott, 2007).

The emulsifying capacity of sugar beets pectin (Chen *et al.*, 2016; Ma *et al.*, 2013; Schmidt *et al.*, 2015), hawthorn (Cuevas-Bernardino *et al.*, 2016), citrus (Leroux *et al.*, 2003; Schmidt *et al.* 2017), pumpkin (Cui & Chang 2014) and okra have been demonstrated (Kpodo *et al.*, 2018; Alba *et al.*,2013; Alba *et al.*, 2016). The emulsifying properties of okra and sugar beets pectins have been attributed generally to either covalently bounded proteins or presence of ferulic acids or high acetyl content (Schmidt *et al.*, 2017; Alba *et al.*, 2013). The side chain has also been shown to play a role on the emulsification capacity and the stability suggesting that pectin containing rhamnogalacturonan–I could have improved emulsifying properties as compared to pectins with linear backbone (Kpodo *et al.*, 2021; Cui *et al.*, 2017; Alba & Kontogiorgos, 2017).

It has been reported that pectin extracted from okra can be used as a diverse food ingredient (Afotey *et al.*, 2023; Donkor-Boateng *et al.* 2022; Williams *et al.* 2023; Agbenorhevi *et al.* 2020; Tobil *et al.*, 2020; Costantino and Romanchick-Cerpoviez, 2004; Woolfe *et al.*, 1977). Okra pectin has been found to be acidic, random coil polysaccharides composed of galacturonic acid, galactose and rhamnose. The repeating unit has been reported to be α-(1-2) - rhamnose and α (1-4)-galacturonic acid residues including disaccharides side chains (Zhu *et al.*, 2020) and they form a viscous solution that can exhibit pseudoplastic behavior (Kpodo *et al.* 2017; Kontogiorgos *et al.*, 2012; Georgiadis *et al.*, 2011). They also differ from pectin extracted from citrus, apples and sugar beets greatly in terms of the acetyl content and protein, which indicates their greater hydrophobic property and substantial surface activity at the oil-water interface suggesting that, okra pectin can be used as an effective emulsifying agent (Kravtchenko *et al.*,1992; Sengkhamparn *et al.*, 2009). Pectin isolated from six different okra genotypes has shown diversity in structure and composition and can be used to achieve adjustable functionality in food and pharmaceutical applications (Kpodo *et al.*, 2017, 2018, 2021).

Chocolate is one of the most popular confectioneries in the world that most people enjoy for its taste and health benefit. It is a product of cocoa masse, cocoa butter, sugar and other ingredients. Cocoa butter is the most expensive ingredient in chocolate production and accounts for one third of the cost of the final product (Kissiedu *et al.* 2020; Dimick, 1999). It is economically prudent for chocolate manufacturers to look more closely at replacing cocoa butter with emulsifiers to help reduce cost of production. Soy lecithin is the most common emulsifier used in chocolate production. Some people have concerns about this ingredient in food products because it is considered a major food allergen by the US Food and Drugs Administration (USFDA, 2009).

Lecithin and other alternative emulsifiers such as ammonium phosphate and polyglycerol polyricinoleate are considered to be expensive as they are imported (Kissiedu *et al.*, 2020). There is therefore the need to investigate the use of locally manufactured emulsifiers such as okra pectin in the production of chocolate. However, expectations of the consumer are important factors in influencing the strategy of the manufacturers of chocolate. The promotion of healthy lifestyle has informed consumers' choice of confectionery products. Based on this, manufacturers launch products that are produced with natural ingredients and healthy additives (Piwowar-Sulej *et al.*, 2019). Manufacturers of chocolate come across numerous challenges which have increased the interest of the companies in the implementation of different types of innovative products. It has become obvious that these companies may lose their current position on the markets without these product-based or process-based innovations (Piwowar-Sulej *et al.*, 2019). Some of the current innovations in chocolate production include the development of ruby chocolate with a berry flavored taste and ruby colour (Januszewska, 2018).

In a previous study, okra pectin was used as lecithin substitute in chocolate production and its effect on the yield, texture and consumer acceptability was evaluated using the traditional 9-point hedonic scale (Datsomor *et al.*, 2019). The 9-point hedonic scale method allows for direct measurement of consumer appeal but fails to identify adequately what drives the appeal and how consumers choose the most acceptable product. Furthermore, the sensory acceptability of milk chocolate containing okra pectin as emulsifier was optimized whereby okra pectin (from Asha genotype) was held constant at 0.145% while other ingredients were varied in each formulation (Kissiedu *et al.*, 2020). There are different okra genotypes with high pectin yield. For okra pectin to be used as an emulsifier in the chocolate industry, it must be produced on a large scale to ensure constant supply, this can only be possible by the combination of pectin from different high yielding okra genotypes. There is therefore the need to study different pectin combinations from different okra genotypes and their emulsifying ability in chocolate production. Also, there is the need for further research using other sensory tools to understand the impact of the okra pectin as an emulsifier on the sensory properties of the chocolate. Relative Preference Mapping (RPM) method provides an alternative which allows quick identification of innovative flavours within a product set when compared to a known reference product. This allows rapid selection of improved flavours which may be taken into further development (Blay, 2012).

The objective of the present study, therefore, was to determine the proximate composition and relative preference mapping of milk chocolate formulations emulsified with okra pectin from three genotypes combined in different ratios.

MATERIALS AND METHODS

Materials

Three okra genotypes namely, Asha, Balabi and Agbagoma were obtained from Ho in the Volta region of Ghana. All chemicals used were analytical–grade reagents. Distilled water was used throughout the extraction. The ingredient used for the chocolate, cocoa butter, cocoa liquor, sugar and milk powder were obtained from the Research and Development Department of Cocoa Processing Company Limited, Tema, Ghana. The okra pectin from three genotypes Asha, Balabi and Agbagoma used as emulsifier were extracted in the Department of Food Science and Technology, KNUST using protocol as previously reported (Kpodo *et al.*, 2017).

Chocolate production

Chocolate was produced by the method previously described by Datsomor *et al.* (2019) with some modifications. A 2500 g of milk chocolate was produced for each batch using the attrition ball mill (Wiener and co., Netherlands). The ingredients were weighed and milled in the attrition ball mill after which it was counched for 30 min. The mixture was drained, tempered at a temperature of 31˚C and molded. They were then refrigerated, demolded and packaged (Figure 1).

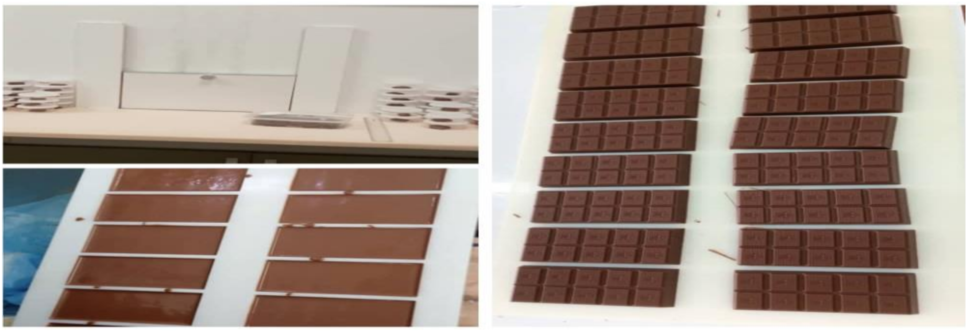

Figure 1: Molded and demolded okra pectin chocolate samples

Table 1. Okra pectin combinations for each chocolate formulation

Formulations	Lecithin (%)	Agbagoma(Ag) (%)	Asha(As) (%)	Balabi (Ba) (%)	Total (%)
F17	0.2	0	0	0	0.2
F1	0	0	0.2	0	0.2
F2	0	0.2	0	0	0.2
F3	0	0	0	0.2	0.2
F4	0	0.1	0.1	0	0.2
F5	0	0	0.1	0.1	0.2
F6	0	0.1	0	0.1	0.2
F7	0	0.05	0.05	0.1	0.2
F8	0	0.05	0.1	0.05	0.2
F9	0	0.1	0.05	0.05	0.2
F10	0	0.15	0.05	0	0.2
F11	0	0.15	0	0.05	0.2
F12	0	0.05	0.15	0	0.2
F13	0	0.05	0	0.15	0.2
F14	0	0	0.15	0.05	0.2
F15	0	0	0.05	0.15	0.2
F16	0	0.066	0.066	0.066	0.2

Okra pectin substitutions

The Minitab software (mixture design-simplex-centroid) was used to generate 17 product formulations. The lower and upper bound constraints are shown in Table 1.

Determination of proximate composition

Moisture content was determined using official methods AOAC (2005). A 3 g of the prepared chocolate for each formulation was measured into a petri dish with known mass. The products in the petri dishes were placed in a hot-air oven at a temperature of 105˚C for continuous 5 h. The samples were removed and cooled in a desiccator. The cooled samples were weighed and the moisture content was calculated by difference in masses and expressed as percentage.

The ash content was determined as described by AOAC (2005). A 2 g of each formulated product was weighed into a crucible of known mass and ignited in a furnace at 600˚C for 2 h. The crucibles were removed and cooled in a desiccator. Ash content was calculated from the difference in masses expressed as percentage.

Fat content was determined using the soxhlet method as described by Beckett (2000). The chocolate sample were weighed, cut into pieces and wrapped in a filter paper and placed in a soxhlet apparatus. Petroleum ether was used as solvent. The solvent was boiled with an electric mantle. The vapor from the boiling solvent evaporate, condenses and dissolves the fats in the chocolate as it passes over it. The fat containing liquid passes through the filter paper and collect in a flask with known mass. This was done for 8 h, the fat remaining in the flask after this period was weighed.

Determination of sugar content

Sugar concentration was determined using polarimetry as described by Elwakeel *et al.* (2019) with some modifications. A 40 g of each formulated chocolate was weighed into 200 ml beaker and dissolved in 100 ml of warm distilled water. It was allowed to cool. A 25 ml of lead acetate was added and topped to the 200 ml mark. The solution was filtered using a filter paper. A 1:1 dilution was performed using 20 ml of filtrate and 20 ml of distilled water. The resulting solution was placed in a cell and placed in a polarimeter. The polarized light passes through the sample solution and gives the polarized light rotation and concentration. The concentration obtained was multiplied by 100.

Relative preference mapping.

The relative preference mapping (RPM) was a test carried out at food fairs to depict a social setting. It uses a T-map scale (Figure 2) which has two axes; the x-axis depicts the difference axis and the y-axis shows the liking axis. The method used was as described by Adjei *et al.* (2020).

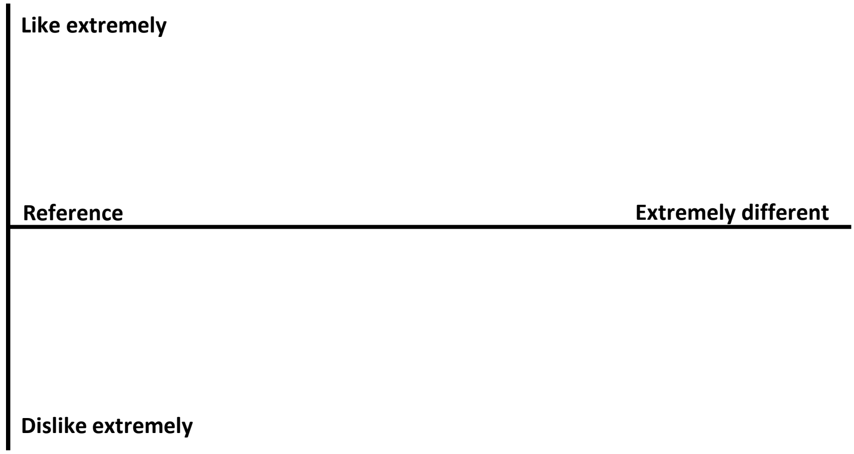

Figure 2: T-Map scale used for the relative preference mapping (RPM).

The T-map scale (Figure 2) was used for the evaluation of the chocolate samples. A total of 30 assessors were used for the test. The assessors were selected by an online interview and were regular chocolate consumers or had consumed chocolate about a month before the test. The assessors evaluated 16 products in the test with reference to a given control. The control was 50 g Kings Bite chocolate with lecithin as an emulsifier. The assessors were asked to evaluate simultaneously how different the products were to the control and how much they were liked. Each assessor was served with 20 g of the reference and 5 g of the sample. The assessors were allowed to retaste the reference as often as they want. Ethical approval for the sensory study was granted by the Ethics Committee for Basic and Applied Sciences (ECBAS) with protocol number 048/15-16.

Data analysis

Data from proximate compositions were analyzed using One-Way Analysis of Variance (One-Way ANOVA). The scores generated from the RPM were analyzed using Generalized Procrustes Analysis (GPA) as described by Blay (2012). The mark made by each assessor from the end of each of the axes were used to derive the scores. Two-way analysis of variance was used to analyze data generated from the liking and difference axis separately. Individual product maps created by consumers were condensed into the consensus product map using the Generalized Procrustes Analysis (GPA) method. The region of innovation was highlighted as the space between the liking and difference axis on the consensus map. All RPM data were analyzed using XLSTAT (Addinsoft 40, rue Damremont 75018, Paris, France).

RESULTS AND DISCUSSION

Proximate composition of the formulated okra pectin chocolate

The proximate compositions of all the seventeen formulations are shown in Table 2.

Table 2. Proximate composition of chocolate formulations

Formulations	Moisture (%)	Ash (%)	Fat (%)	Sugar (%)
F1	2.09 ± 0.08^{a}	2.82 ± 0.08^{a}	30.51 ± 0.06^{ab}	25.88 ± 0.01^{abc}
F2	1.87 ± 0.21^{a}	2.78 ± 0.08^{a}	30.69 ± 0.09^{bc}	27.35 ± 0.03^{abcd}
F3	2.03 ± 0.03^{a}	2.81 ± 0.08^{a}	30.77 ± 0.03^{bc}	22.12 ± 0.06^{a}
F4	2.01 ± 0.01^{a}	2.75 ± 0.08^{a}	30.75 ± 0.02^{bc}	28.25 ± 0.03^{bcd}
F5	2.11 ± 0.10^{a}	2.76 ± 0.08^{a}	30.73 ± 0.11^{bc}	28.87 ± 2.75^{bcd}
F6	1.85 ± 0.18^{a}	2.54 ± 0.12^{a}	30.54 ± 0.06^{ab}	26.50 ± 0.01^{abcd}
F7	1.95 ± 0.13^{a}	2.76 ± 0.12^{a}	30.99 ± 0.09^{c}	25.75 ± 0.01^{abc}
F8	2.15 ± 0.27^{a}	2.81 ± 0.18^{a}	30.34 ± 0.11^{a}	25.81 ± 0.01^{abc}
F9	2.25 ± 0.28^{a}	2.80 ± 0.05^{a}	30.82 ± 0.06^{bc}	23.74 ± 0.13^{ab}
F10	1.97 ± 0.11^{a}	2.69 ± 0.08^{a}	30.57 ± 0.11^{ab}	23.99 ± 0.01^{ab}
F11	2.08 ± 0.05^{a}	2.69 ± 0.10^{a}	30.77 ± 0.18^{bc}	26.38 ± 5.40^{abcd}
F12	2.17 ± 0.16^{a}	2.80 ± 0.08^{a}	30.62 ± 0.05^{ab}	31.61 ± 0.04^{d}
F13	2.08 ± 0.13^{a}	2.80 ± 0.12^{a}	30.67 ± 0.04^{abc}	24.83 ± 0.10^{abc}
F14	2.30 ± 0.28^{a}	2.77 ± 0.16^{a}	30.78 ± 0.06^{bc}	28.03 ± 0.11^{bcd}
F15	2.10 ± 0.24^{a}	2.71 ± 0.15^{a}	30.82 ± 0.02^{bc}	25.37 ± 0.24^{abc}
F16	2.09 ± 0.06^{a}	2.56 ± 0.17^{a}	30.63 ± 0.08^{ab}	27.88 ± 0.09^{bcd}
F17	2.18 ± 0.22^{a}	2.74 ± 0.11^{a}	30.54 ± 0.13^{bc}	$29.93^{cd} \pm 0.02^{cd}$

Values represent mean ±SD. $^{a\text{-}d}$Values with the same superscript letter in a column are not significantly different ($p > 0.05$).

The okra pectin chocolate had moisture content of 1.85% to 2.30%, ash content of 2.54% to 2.82, fat content of 30.34% to 30.99% and sugar content of 22.12% to 31.61 overall. There were no significant differences between the moisture content and the ash content recorded for all the formulations. However, the fat content and sugar content recorded some slight differences between the formulations (Table 2).

In chocolate, every 0.3% extra moisture left after conching, an extra 1% of fat must be added (Aeschlimann & Beckett, 2000) and because fat is the most expensive component in chocolate production, it is important to remove any “free water’’ as much as possible. Moisture at the surfaces of sugar particles increases friction and also aggregates particles of sugar in chocolate to form gritty lumps (Afoakwa *et al.*, 2008). Yield value and viscosity of chocolate increases at 3% to 4 % (Beckett, 2017). Ash content is the measure of inorganic minerals present in a food material. The ash content in this experiment ranged from 2.54 % to 2.82% with F1 recording the highest ash content and F6 recording the lowest. Samples F2, F3, F8, F9, F12 and F13 had ash content a little higher than the standard (2.80%). All these chocolate products contained a certain ratio of either Agbagoma or Balabi or both. The sugar content of the formulated chocolate was high in F12 (31.61%) and low in F3 (22.12%). The fat content recorded ranged from 30.34% for F8 to 30.99 % for F7. Chocolate is a confectionary with high fat and sugar content. There is evidence that cocoa-derived phytochemical constituents in chocolate may mitigate the health impact of added fat and sugar on health (Gu *et al.*, 2006). The addition of sugar to chocolate is to contribute to sweetness and because of its cheap cost compared to other ingredients like fats, it is reported that a change in sugar content by just 1 to 2% has large cost implications which explains why manufacturers may be reluctant to reformulate (Afoakwa *et al.* 2007; Beckett *et al.*, 2017). Most chocolate contain about 25 to 35% fat content. According to Beckett (2000) fat content of 24 to 26% would be a very low-fat content for chocolate and result in high viscosity, however chocolate of high fat content of 34 to 36% would results in a very thin product, hence, a high-quality chocolate is likely to contain a higher fat content. The content of fat in the chocolate has significant effect on its viscosity hence chocolate containing 28-32% fat has more pronounced viscosity changes than chocolate with fat content above 32% (Beckett, 2000). The rheological and textural behaviour of chocolate are affected by the specific composition, that is the fat content, milk, sugar and emulsifier. Fat in chocolate comes from the cocoa butter and it is made up of stearic acid, palmitic acid and oleic acid (Loisel *et al.*, 1998). Although stearic acid can have a neutral effect on cholesterol in chocolate, palmitic acid and oleic acid are associated with some conditions such as obesity and disturbance in hormonal functions as well as liver functions and thus the fat content of chocolate should be considered during consumption (Simoneau *et al.*, 2002; Afoakwa *et al.*, 2008).

Relative preference mapping (RPM)

Figure 3 is a biplot showing liking and difference of the formulated product. The area of importance is the bottom right quadrant where the products that were considered to be innovative as compared to the reference/control-F17 (chocolate made with lecithin) were products that were not different from the reference/control but liked more.

Although Relative Preference Mapping (RPM) is a tool used to identify innovative products (where innovation means different from the control but liked) (Adjei *et al.*, 2020), the present study used the RPM to ascertain which of the 16 samples were not different from the control but liked more. This was very important because okra pectin was meant to replace lecithin and still maintain the properties of the chocolate, hence the area of interest in this study was the bottom right quadrant that was generated from the product map.

From the biplot, samples that were clustered in the top left quadrant were seen to be statistically significantly different from the control but degree of liking was not very clear. They could be liked more or just like the control. These samples include F1 (100% As), F3 (100% Ba), F7 (25% As: 25% Ag: 50% Ba) and F15 (25% As: 75% Ba).

In the top right quadrant samples F2 (100% Ag), F4 (50% As: 50% Ag), F6 (50% Ag: 50% Ba) and F12 (75% As: 25% Ag) were statistically different from the control but liked.

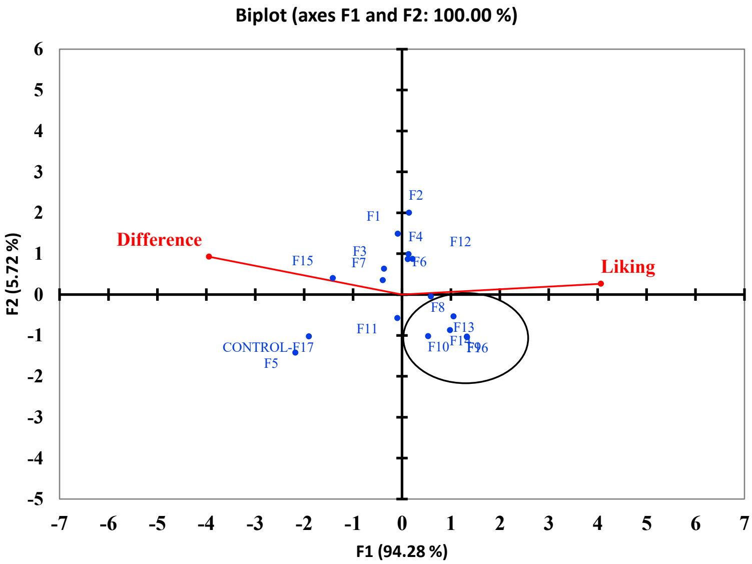

Figure 3: Biplot of product difference and liking.

Note: *Innovative products of interest: bottom right quadrant where the products were not different from the reference/control but liked more.*

Samples F8 (50% As:25% Ag:25% Ba), F9 (50% Ba:25% As: 25%Ba), F10 (25% As:75% Ag), F13 (25% Ag:75% Ba), F14 (25% Ba:75% As), and F16 (33.33% As:33.33% Ba:33.33% Ag) all in the bottom right quadrant were liked but not statistically different from the control. Finally, samples F5 (50% As: 50% Ba) and F11 (25% Ba: 75% Ag) were not different from the control and were also not liked. In a previous study, fourteen out of fifteen samples were rated above 5.0 for appearance, taste, mouthfeel, aftertaste and overall acceptability on milk chocolate prepared with mixtures containing 30 to 44% sugar, 20 to 34% cocoa butter,18 to 32% cocoa liquor, 18 to 32% milk and constant okra pectin percentage (Kissiedu *et al.* (2020). In the present study, samples of importance were F8 (50% As,25% Ag ,25% Ba), F9 (50% Ag,25% As,25% Ba), F10 (25% As, 75% Ag), F13 (25%Ag, 75% Ba), F14 (25%Ba, 75%As), and F16 (33.33% As,33.33% Ba, 33.33% Ag). Three out of these samples were a combination of all three okra pectin varieties but with different ratios. F7 (25% As: 25% Ag: 50% Ba) was the only product which had all the three okra combinations but was different and not liked much. It could be observed that Balabi in the other three ratio combinations were lower compared to its ratio in F7 (25% As: 25% Ag: 50% Ba).

The sweetness of products did not have much effect on liking. F12 (75% As: 25% Ag) which had sugar content greater than the control fell in the fourth quadrant which means that the product was different from the control but was not liked. Although F14 (25% Ba:75% As), and F16 (33.33% As,33.33% Ba, 33.33% Ag) recorded high sugar contents and were part of the products around interest suggesting that they were not different from the control and also liked, their scores were low compared to the other product in that same quadrant. The fat content also did not have much effect on the degree of liking of a particular product. All products with single pectin or formulations with 1:1 ratio were considered to be different from the control except F5 (50% As: 50% Ba) which fell in the same quadrant as the control suggesting that it was not different from the control. Product F11 (25% Ba: 75% Ag) also fell in this quadrant but could be seen to be closer to the border of the right bottom quadrant which is the area of interest. Taking product F5 (50% As: 50% Ba) into consideration, both Asha and Balabi are hairy pectin having a short or intermediate rhamnogalacturonan I branching whiles Agbagoma is a smooth pectin (Kpodo *et al.*, 2017) suggesting that, for a product to be similar to the control it must contain some amount of these pectin. Looking at the area of interest, only product F10 (25% As: 75% Ag) had lesser amount of the hairy pectin and F9 (50% Ag, 25% As,25% Ba) having same proportion of both the hairy and smooth pectin. All the other products had more of the hairy pectin. The molecular properties of the samples disclose branching and rhamnogalacturonan I content importance. Pectin with intermediate length of branching like Balabi contributes to emulsification favourably whiles short branched pectin (Asha) and long branched pectin (Agbagoma) do not assist emulsification (Alba *et al.*, 2016; Kpodo *et al.*, 2017, 2018; 2021).

Emulsifiers have been used to modify chocolate texture in commercial coating and also to influence the structural properties hence impacting perception of consumers on flavor and texture. It has been recognized by trained sensory panelist that evaluation of chocolate by consumers are done at different point during consumption (initial bite, chewing and rubbing of melted chocolate) (Tscheuschner and Markov, 1986). All these properties are essential in describing chocolate fully hence the role of an emulsifier cannot be disregarded. According to Tisoncik (2010), the emulsifier helps in the evenly distribution of particles throughout the emulsion and prevent agglomeration by coating the sugar particles to help facilitate flow in the continuous fat phase in the chocolate matrix. Having this in mind, it can suggest that products containing Balabi will have great texture and impact on choice of the panel. Apart from product F10 (25% As: 75% Ag), which had no Balabi in its combination, all the other product that fell in the area of interest had some ratio of Balabi in their formulation.

CONCLUSION

The proximate composition showed that the products had high fat content and sugar content which is normal for a milk chocolate. Products F8, F9, F10, F13, F14 and F16 were considered to be similar to the control and liked as much as the control. All these products were seen to contain some ratio of Balabi pectin in their formulation except product F10. Product F8 which was the most liked product had fat content slightly lower than the control and sugar content also lower than the control. Product F11 which fell in the same quadrant as the control but closer to the area of interest could also be considered for further optimization. It was found that combining the pectin varieties gives a better emulsification and consumer appeal than using each pectin variety alone. With products F8, F9, F10, F13, F14 and F16 rated by consumers to be similar to the control and liked as much as the control, it can be concluded that different okra pectin can be used in chocolate production and still produce the same functionality as lecithin substitute in chocolate. Also, the issue of allergy pertaining to the use of lecithin will be resolved when okra pectin is used.

DECLARATIONS OF CONFLICT OF INTEREST

The authors declare no conflict of interest.

ACKNOWLEDGEMENT

The authors are grateful for technical support with the chocolate production at the Cocoa Processing Company Limited, Tema, Ghana.

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