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FULL PAPER

Physicochemical, antioxidant and sensory properties of chocolate spread fortified with jackfruit (*Artocarpus heterophyllus*) flour

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Abstract

Chocolate spread is often considered as an unhealthy product with low antioxidant activity and phenolic content since it does not contain cocoa liquor. This research aimed to investigate the potential on the physicochemical composition and antioxidant activity of jackfruit *(Artocarpus heterophyllus)* flour and red palm olein in the chocolate spread formulations. The effect of the jack fruit and red palm olein incorporation on the quality attributes and high nutritional value of chocolate spread was also examined. Physicochemical properties of the fortified chocolate spread, as well as the evaluation of physical parameters in the chocolate spread, were investigated. Melting points were analyzed by DSC (Differential scanning calorimeter) method, colour lightness was analyzed by chromameter hunter method, profile bioactive compound was analyzed by gas chromatography-mass spectrometry (GC-MS), and whilst for viscosity by Brookfield Viscometer method. The analysis results obtained that the sample code F5 (10% jackfruit flour: 26% sugar) contains of 43.47% fat, 0,88% free fatty acids, polyphenol 127 mg/g, 160.16 mg/g carotenoids, 42.75 µg/mL antioxidant activity IC_{50}, and 6.19 degree of acidity per 100 g chocolate spreads and high panelists preference. However, the fortified chocolate spread had different characteristics from each other either in the chemical, physical or sensory properties. The best formulation code is F5 with 10% jackfruit flour, fortification significantly increased the antioxidant activity, carotenoid, polyphenols, viscosity, colour and melting points. Additionally, chocolate spread with 10% of jackfruit flour by-product presented the highest-ranking test rate of the three sensory attributes of aroma, taste and texture. Therefore, the use of jackfruit by-products in the development of chocolate spread is a viable alternative which can be explored for nutritional, technological and sensory purposes by the food industry.

1. Introduction

The production of fruits like nectars, pulps, sweets, jams, and minimally processed products has been growing and expansion of the processed food market. The current lifestyle is related to the high demand for these products, which requires convenient products and highly practical. Nevertheless, concomitant to the search for processed foods, the production of residues discarded by the industries increased, which might result in environmental damages and rise in costs for the industries (de Toledo *et al*., 2017). Jackfruit is the largest known edible fruit whose unutilized, accounts for 60% of the entire fruit parts include the fibre, peels, and the core. Content macronutrients and bioactive compounds are excellent sources that can be obtained at the edible pulp and seeds of ripe jackfruits (Adan *et al.*, 2020). Jackfruit rich in fibre, carotene, potassium, carbohydrate, lysine, phenylalanine and amino acid leucine was the highest compositions and most abundant amino acid found in jackfruit flour (Zuwariah *et al*., 2018; Ng *et al.*, 2019). There is however lack of reference and research available on the antioxidant activity and chemical composition of the peel, fibre and core of ripe jackfruits. Most studies on the jackfruit phytochemical, antioxidant properties and mineral analysis have focused on the edible regions (pulp and seeds) (Adan et al., 2020).

Palm oil is one of the seventeen major oils and fats that are produced and traded worldwide. The extracted

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crude palm oil is fluid at a tropical temperature and has a deep orange-red colour, contributed by a high carotene content. Accordingly, palm oil is a natural resource with high carotene (500-1500 ppm) and tocols (700-1000 ppm) (Mayamol *et al*., 2007; El-Hadad *et al*., 2011). The crude palm oil is refined physically or chemically to remove undesirable impurities and produce refined, bleached and deodorized palm oil (RBDPO), which can be fractionated into palm stearin and palm olein (Gee, 2007). As a result, the final product will provide a golden colour but will reduce the content of carotene and tocols *(Al-Saqer et al*., 2004). Carotene content of red palm olein (RPOL) has a high bioavailability compared to all plants with the same carotene content. RPOL is widely marketed in supermarkets and food stores, in the form of a pro-vitamin A carotenes which work very well for children who are whistly deficient in vitamin A (El-Hadad *et al*., 2011). Research on red palm oil in the form of low doses can avoid and protect children from the malnourished vitamin A deficiency and the risk of going blind. Other functions of carotene are as antioxidant activity, enhancing immune and anti-cancer activity (Sundram, 2005).

Research and analysis of the development of chocolate spread into food functional has been done by some researchers. Research Jeyarani *et al.* (2013) reported enriched chocolate spreads using soybean and coconut oils to increase the content of omega-3 fatty acids (linoleic and linolenic acid). Formulating chocolate spreads with the addition of red palm olein and butter-fat blends to enhance physicochemical characteristics of phytonutrient (Prasanth Kumar *et al.*, 2016). Study of the manufacture of low-fat chocolate spreads using palm oil, palm kernel fat and their blends (Manzocco *et al*., 2014). Research on the use of gelatin from the poultry industry in the fat replacement of chocolate spread to improve physicochemical properties and texture chocolate spread (Almeida and Lannes, 2017). On the other hand, Fayaz *et al.* (2017) reported beeswax fortification, propolis and partial substitutes of palm oil in functional chocolate spread (Fayaz *et al*., 2017). Process optimization in the manufacture of chocolate spread substitution whey protein concentrate, cocoa powder, olive oil and butterfat using response surface methodology (Kumar, 2015).

Research on jackfruit fortification and red palm olein (RPOL) in the manufacture of chocolate spread has never been reported. Jackfruit is suitable for chocolate raw material because it can be processed into the flour with high carbohydrate. Potential jackfruit is of dietary use and is an important source of carbohydrate, protein, fat, minerals, vitamins, and phytochemical contains useful compounds like the flavonoids, sterols and prenylflavones which may have been responsible for nutritional value *(Baliga et al*., 2011). While RPOL can be a source of tocopherols and tocotrienols and carotenes can be considered as important constituents in replacing the role of butterfat. Nowadays, functional foods are fast becoming a part of everyday life. This study may provide important information on the possibility of jackfruit and red palm olein chocolate spread as an appropriate way for micronutrients fortification and functional food. Therefore, this study was aimed to determine the effects of micronutrients fortification on the chocolate spread characteristics, physical properties, antioxidant activity and to select the best formulated chocolate spread.

2. Materials and methods

2.1 Materials

The making of jackfruit flour starts with stage separation of seed from the pulp (Figure 1). Seeds were washed using filtered tap water, sliced, and dried in a forced draft oven (Memmert, Germany) at 50°C for 12 hrs. The dried samples were milled into flour using a grinder (Toshiba, Japan) (Zuwariah *et al*., 2018). Red palm olein (RPOL) was kindly secured by organic red palm oil Salmira Nutri Palma Nabati Company, Indonesia. Fermented and non-fermented cocoa beans varieties Forastero (Figure 1) from Soppeng Regency, South Sulawesi, Indonesia. All samples were made of chocolate spread with lecithin from Sigma-Aldrich (St. Louis, Missouri, United States), cocoa butter from Mars Symbioscience Company (Makassar, South Sulawesi, Indonesia), skim milk by NZMP New Zealand, and sugar. All chemicals were of analytical grade, hexane (CAS: 110-54-3), Sodium carbonate (CAS: 497-19-8) and BHT (Butylated Hydroxytoluene*)* were supplied by Merck Millipore (Burlington, Massachusetts, United States), DPPH (D4313, CAS: 1898-66-4) was from Tokyo Chemical Industry (Tokyo, Japan), Folin Ciocalteaue (109001), while aluminium chloride (254134, CAS: 12125-02-9), sodium nitrate (CAS: 7631-99-4), Gallic acid (CAS: 149-91-7) and sodium hydroxide (CAS: 1310-73-2) were from Sigma-Aldrich (St. Louis, Missouri, United States).

Figure 1. Main ingredient making chocolate spread: a) fermented cocoa beans, and b) jackfruit

Tools water bath (Memmert WNB 7 Basic control) Hettich Zentrifugen EBA-20, rotary evaporator Buchi, Hitachi centrifuge brands, and Shimadzu GC-MS 2010 brand Gas Chromatography-Mass Spectrometry plus.

2.2 Chocolate spread production

Nibs cacao fermented (60%) and non-fermented (40%) roasted in (roasting machine KL Protech Type Number 043.13P033 capacity 15 kg) at 100-105°C for 1 hr, cooling up to reach the temperature 40-50°C. Then samples of cocoa beans were inserted in winnower (nibs separator machine KL Protech Type Number 049.13P043) to separate between nibs and shell (seeds and outer skin). Once separated from the seeds and outer skin, nibs and shells are weighted, nibs are then ground using a stone mill (KL Protech Type Number 066.13P063) to destroy nibs that initially shaped coarse solid granular into the cocoa paste (cocoa liquor). Furthermore, cocoa liquor and ingredient formulation on Table 1 was taken in a ball mill (ball mill mini KL Protech Type Number 041.,13P028) which is useful to smooth at 50°C, 50 rpm for 12 hrs.

Table 1. Chocolates spread formulation

Ingredient composition	Samples chocolate spreads (%)				
	F1 (control)	F2	F3	F4	F5
Cocoa liquor	19.5	19.5	19.5	19.5	19.5
Red palm olein	27	27	27	27	27
Sugar	36	36	36	31	26
Skim milk	16.41	11.41	6.41	16.41	16.41
Lechitin	1	1	1	1	1
Vanilla	0.02	0.02	0.02	0.02	0.02
Salt	0.07	0.07	0.07	0.07	0.07
Jackfruit flour	0	5	10	5	10

2.3 Physicochemical analysis of the chocolate spread

The chocolate spread was analyzed, in duplicate, for free fatty acids, lipids content, carotene content, viscosity (Brookfield viscometer), and analysis pH using approved methods 940.28-2012, 950.54-1950, 2005.07-2005, 967.16-1968 and 943.02-1943 of the Association of Official Analytical Chemists (AOAC, 2005).

2.4 DPPH radical scavenging activity

Analysis antioxidant activity (DPPH scavenging activity) was determined using by modifying the method Sulistyo and Haryanti (2020) the sample was subsequently incubated at room temperature 37°C for 30 mins, and the absorbance at 517 nm was then measured with a spectrophotometer, used synthetic antioxidant BHT (Butylated Hydroxytoluene*)* as a comparative sample.

2.5 Colour measurement using hunter method

Colour analysis of the samples was conducted using Minolta Chroma CR-400 (Minolta Co, Osaka, Japan) and Hunter method (as L, a, and b value) in duplicate with a. The parameter of the value L, a, b sample will be visible, where the value of luminosity (L), Hue angle (° h) and chromaticity (C) of the chocolate spread surface. The value (+) on a indicates the red colour and the value (-) on a show green colour, the value (+) in the b indicates the yellow colour and the value (-) on the b indicates the blue colour. It is then measured on the chart to know the colour specifications (de Toledo *et al.*, 2017).

2.6 Melting point analysis

Melting point determination using DSC/ differential scanning calorimetry, and total phenol content was determined using UV-VIS Shimadzu Japan (UV-1280 UV-Vis Spectrophotometer) with an absorbance of the mixture was measured at 760 nm.

2.7 Total phenol content

Total phenol content was expressed as milligram gallic acid equivalent per gram defatted chocolate spread (mg GAE/g DFLA) (Do *et al.*, 2014). Gas chromatography-mass spectrometry (GC-MS) was determined using Shimadzu GC-MS 2010 brand gas chromatography-mass spectrometry plus.

2.8 Sensory evaluation

The evaluation using a hedonic ranking test (Friedman test) with parameters texture, taste, and flavour. Panellist (n= 31) in the age range of 18–23 consisted of 30% males, and 70% of females chosen on the basis that they regularly consumed chocolate spreads. Sensory analyses conducted in the Department of Chemical Engineering Politeknik Negeri Ujung Pandang in panel booths which conform to the International Standards (ISO, 2007), under white light at room temperature. Assessors asked to evaluate the hedonic attributes using a 5-point ranking hedonic scale ranging (1 – like very much, 2 – like moderately, 3 – like slightly, 4 – dislike slightly, 5 – dislike very much).

3. Results and discussion

3.1 Physicochemical and antioxidant activity of chocolate spreads

The chemical composition of fortified chocolate spread is presented in Table 2. Analysis results showed that total fat content in fortified jackfruit chocolate spread was varying range 40-44%, while free fatty acid range 0.88-0.96%. Carotene concentrations in fortified jackfruit chocolate spread were much higher, highest rate 168.95 mg/g sample. In contrast to those parameters, jackfruit and red palm olein fortification affected the increased concentration of total fat, free fatty acid, and carotene content.

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Table 2. The colour characteristic of chocolate spread

Parameters	Sample				
	F1	F2	F3	F4	F5
*L	18.62	19.12	19.72	20.2	19.51
*a	2.42	2.58	2.91	2.84	3.31
*b	2.99	3.03	3.6	3.7	3.79
°Hue	3.84	3.98	4.63	4.66	5.02
Chromaticity	51.07	49.64	51.01	52.5	48.87
Colour	Red-purple	Red-purple	Red-purple	Red-purple	Red-purple

Lipids were the second class of macronutrients with great representativity, compounds which act as the main energy source to the organism. Sample F1 (control) and F2 (5% jackfruit flour: 36% sugar) presented the lowest lipid values. Lipids source in the manufacture of chocolate spreads derived from jackfruit flour, red palm olein and cocoa liquor. Jackfruit flour and red palm olein treatments have significant ($p<0.05$) effect on the lipids composition of chocolate spread. The effect of lipid type and content on spread physical stability and firmness was assessed by measuring mechanical properties and oil release. An increasing amount of lipids affects the texture of chocolate spread, independently of lipid nature, the increase in fat content was always associated with a decrease in chocolate spread firmness (Manzocco *et al.*, 2014).

Carotenoids, The use of red palm olein to enhance carotenoids in products and imparts a red colour to the oil. Figure 2 shows the carotenoid content of chocolate spread samples. The data shows that the sample F1 (control) has the lowest and F3 (10% jackfruit flour: 36% sugar) has the highest amounts of carotenoids content. The carotenoids content increased significantly ($p<0.05$) after addition jackfruit flour and red palm olein. Jackfruit flour and red palm olein contributed red colour to the blends. Best chocolate spread formulations by substituting butterfat with 20 to 100% red palm olein and reported that the product with 20% replacement was acceptable (El-Hadad *et al.*, 2011). Therefore, synthetic colouring agent can be replaced with the use of Jackfruit flour and red palm olein in various food preparations (Prasanth Kumar *et al.*, 2016). Carotenoids in chocolate spread products range from 122.07 – 168.95 mg/g samples. Samples with the addition of 10% jackfruit flour (sample F3 and F5) tend to be higher compared to samples with the addition of 5% jackfruit flour (sample F2 and F4) because in jackfruit there is vitamin A in the form of provitamin A that is α-carotene, β-carotene, and ϒ-carotene, so that with the addition of fruit powder jackfruit can increase the level of carotenoid in the product chocolate spread.

DPPH radical is a stable organic free radical with an absorption band at 517 nm. The results of antioxidant activity show that the sample F5 (10% jackfruit flour) has the highest DPPH radical scavenging activity and strongest antioxidant activity, by the value IC_{50} is 42.75 µg/mL, followed by sample F4 (5% jackfruit flour) 43.70 µg/mL, and sample F5 48.46 µg/mL. As comparison used BHT (Butylated Hydroxytoluene) which has IC_{50} 7.89 µg/mL, data in Figure 2. However, at concentrations ranging from 42.75 mg/mL to 49.96 mg/mL, its DPPH radical scavenging activity is significantly different from those of the BHT as comparison sample, studied by *Do et al.* (2014) a lower IC_{50} indicates a higher antioxidant activity of a compound. Figure 2 shows the IC_{50} values in the DPPH radical scavenging activity assay of the sample formulation in scope as the strongest antioxidant.

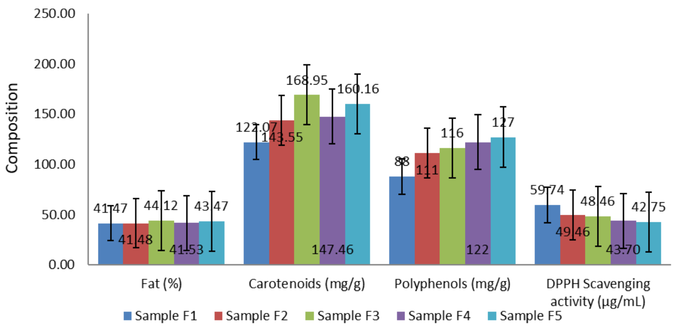

Figure 2. Chocolate spreads composition of fat, carotenoids and DPPH scavenging activity (values were presented as mean ± SD (n =10, 2 replicates)

Finally total polyphenols content. Polyphenols can be found in a wide variety of foodstuffs such as vegetables, tea, coffee, red wine fruit and fruits. According to research, there was found a high positive correlation between phenolic compounds and the number of cocoa solids (Cerit *et al.*, 2016). The total content of polyphenols of all samples is shown in Figure 2. Samples fortified with jackfruit and red palm olein had more polyphenols than the control sample (F1). Better results were obtained with jackfruit flour, even when the addition was in a lower amount than the control sample. Research on fruit fortification was shown that the addition of dried fruits (dried prunes, dried papaya, dried apricots, dried raisins and dried cranberries) especially prunes and cranberries increased the total phenolic content of dark and milk chocolates (Komes *et al.*, 2013). Studied about fortification sea buckthorn and mulberry of dark chocolate also shows the same thing, that the addition of fruit can increase polyphenols levels in the product (Godočiková *et al.*, 2017). Polyphenols increase antioxidant property and reduce human oxidative stress (Loffredo *et al.*, 2018). The concentration of all polyphenols can vary tremendously among different cocoa-containing foods. This concentration can also vary depending on the source of the processing conditions, how the chocolates were manufactured and the beans (Godočiková *et al*., 2017).

Free fatty acids, Figure 3 shows that sample F2 (5% jackfruit flour: 36% sugar) and F3 (10% jackfruit flour: 36% sugar) comprised the highest amount among all free fatty acids present in the chocolate spreads being around 0.98% and 0.96%, followed by samples F4, F1 and F5 which ranged from 0.93%% to 0.88%. Replacement of butter or cocoa butter by 27% red palm olein (RPOL) can decrease significantly the free fatty acids. The free fatty acids content decreased significantly (p>0.05) after addition jackfruit flour and substitute cocoa butter with red palm olein. *Trans* fatty acids in commercial chocolate products including chocolate spread range between 0.7%-11.1%. A major source of undesirable *trans*-fatty acids, since the chocolate spread is consumed by children in a reasonable quantity. The availability of especially fats from palm oil, which are virtually free of *trans* fatty acids, can be viewed as a healthy alternative.

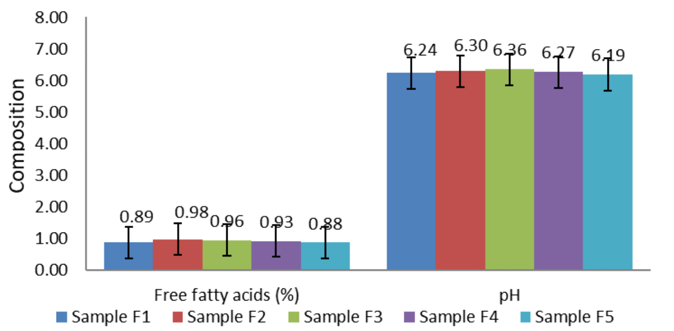

Figure 3. Chocolate spreads composition of free fatty acids and pH (values were presented as mean ± SD (n=10, 2 replicates)

Analysis of pH, pH of samples differed significantly and ranged from 6.19 to 6.36 (Figure 3). Sample F5 (10% jackfruit flour: 26% sugar) had the least pH (6.19) and sample F3 (10% jackfruit flour: 36% sugar) had the highest (6.36). The reference sample (F1) had a pH value of 6.24 which was not significantly different from sample F3 (10% jackfruit flour: 36% sugar) as shown in Figure 3. The addition of jackfruit flours, in general, significantly increased (p<0.05) the pH value of the samples. The results of this study are following those obtained research cashew nut–chocolate spread, with pH values, were higher than 4.90 in the fruit spread produced. Fruits are more acidic than nuts and seeds (such as cocoa and cashew nut) and will, therefore, be the reason for the relatively higher pH values obtained (Barcelon *et al*., 2015). Other research has shown that the pH values of the chocolate spread influence chemical reactions in fermentation cacao, such as Maillard reaction, generating alterations in colour, flavour and texture of the product, parameters related to the perception and sensory acceptance of the consumers (Andrés-Bello *et al*., 2013).

The viscosity of chocolate spread is a non-Newtonian liquid, and when the visible viscosity (cP) of chocolate formulated with red palm oil is measured, the following trends can be shown. Values of viscosity indicated the presence of a noticeable variation within samples, the apparent viscosity was 8983 cP for the control chocolate spread (F1) and 13932 cP for the sample (F3) in Figure 4. The noticeable variation is a function of the fat replacement effect (Afoakwa *et al*., 2007). Chocolate is a mixture of solids particles (sugar and cocoa solids) that are hydrophilic and cocoa fats that are finned hydrophobic. The magnitude of viscosity is influenced by several factors such as temperature, the tensile force between molecules, size, and several dissolved molecules. Viscosity difference in a chocolate spread can be caused by the difference in the content of pectin contained in the jackfruit flour. The content of pectin in the fruit during the heating process will undergo gelatination to cause increased viscosity, more addition of jackfruit powder can lead to increased viscosity of chocolate products (Vriesmann *et al*., 2011).

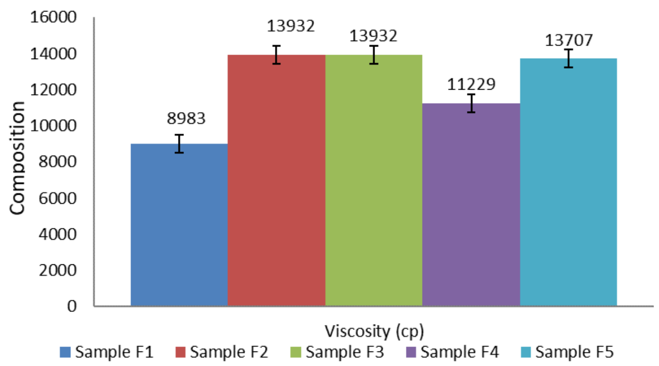

Figure 4. Chocolate spreads composition of viscosity (values were presented as mean±SD (n=10, 2 replicates)

3.2 Colour analysis of chocolate spread

The colour characteristic of fortified jackfruit flour chocolate spread is shown in Table 2.

The results show that there is not much difference in the colour lightness, redness and yellow colour components of spreads. The jackfruit flour and red palm olein spread showed a slightly higher brightness than the spreads. The low brightness value of the spreads indicates that the colour features of the spread as dark due to the ingredient used, cocoa liquor, which is dark in colour. The red and yellow colour components showed a slight increase with the increased content of jackfruit flour and red palm olein in spreads. The chocolate spread had a specific colour and melting point. They had red-purple and tended to have low brightness. Micronutrients fortification only gave a slight effect on their colour, where the affected colour parameter was only °Hue value. However, based on their °Hue values, the colour

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of fortified chocolate spread was categorized as the same colour, i.e. red-purple (RP). It means that micronutrients fortification did not give a significant effect on colour. The content of carotenoids was correlated well with the red colour components of the blends. The darkness of the chocolate spreads might be preventing the reflectance of the red and yellow colour in the spreads. Hence, all the spreads showed almost similar colour pattern (Prasanth Kumar *et al*., 2016).

3.3 Melting point determination of chocolate spread

Thermal behaviour or melting profile of fat and sugar components in samples produced from different substitution level for jackfruit flour were analyzed by using differential scanning calorimetry (DSC). Peak onset corresponds to the temperature at which a specific crystal form starts to melt; peak maximum, that at which melting rate is greatest; and end of melting, completion of liquefaction (Afoakwa *et al.*, 2008; Amir *et al*., 2013). Heat capacity Cp gradually and consistently increased to onset temperature (T_{onset}) then progressively increased more rapidly until peak temperature (T_{peak}), after which it decreased to the end temperature (T_{end}) indicating the chocolate was completely melted (Amir *et al.*, 2013). The melting profile of jackfruit flour, sugar and red palm olein blends at various temperature ranges are presented in supplementary Figure 5. The melting points of jackfruit flour and red palm olein were within 27.6 – 30.2°C. Varying jackfruit flour, sugar and substitution cocoa butter with red palm olein content, observed in the differences in peak widths and produce changes in crystallinity and melting properties (Afoakwa *et al.*, 2008). Increasing fat content caused a consistent decrease in T_{index} of products, because chocolate of lower fat content melts at a higher temperature, suggesting an inverse relationship of T_{index} with fat content. Higher fat contents than similar to lower fat chocolate require a longer time to melt products (Afoakwa *et al*., 2008).

3.4 GC-MS analysis of chocolate spread

The GC and MS running time for profile sample F5 (10% jackfruit flour: 26% sugar; 27% red palm olein) with the best characteristics in terms of physicochemical properties, antioxidant activity and sensory properties. A

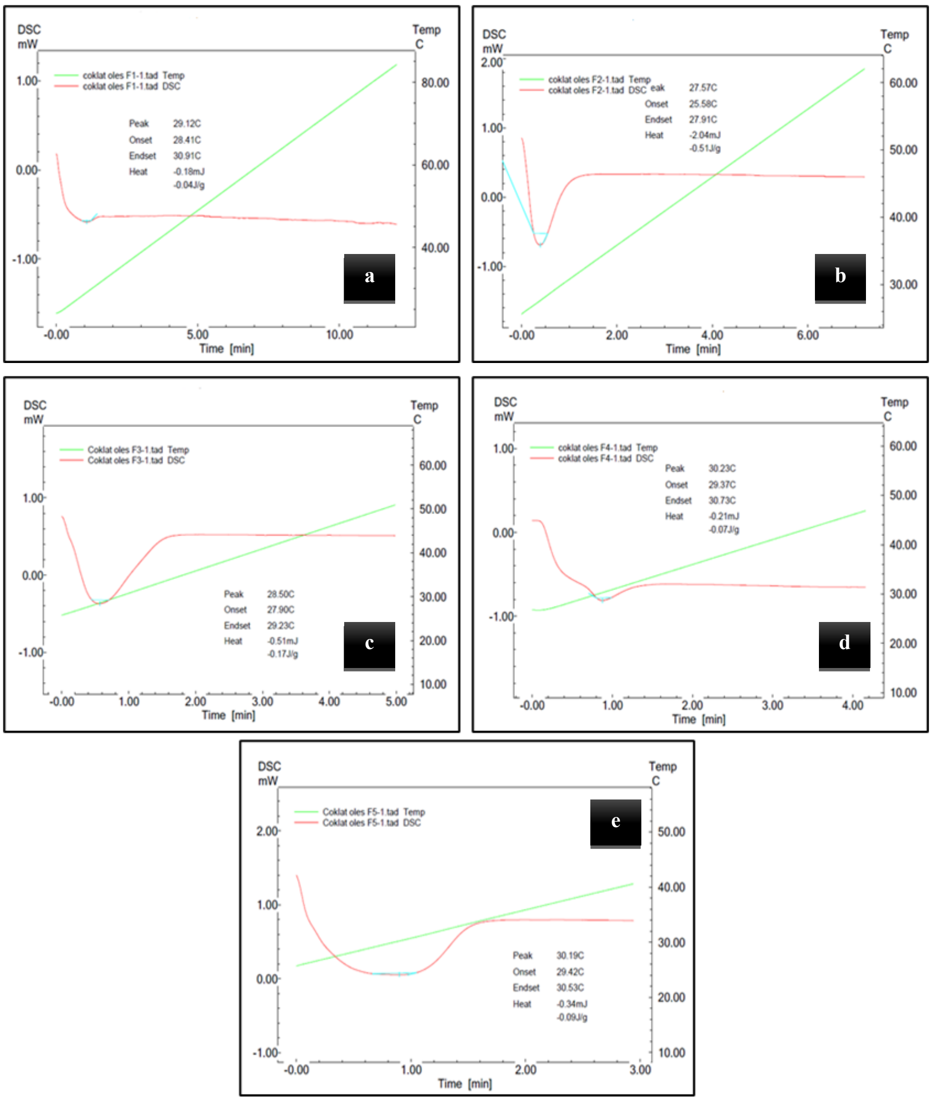

Figure 5. Characterization of melting properties in chocolate spread: a) sample F1 (control); b) sample F2; c) sample F3; d) sample F4; and e) sample F5

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typical chromatogram is shown in Figure 6.

GC-MS results (Figure 6) showing the presence of sixty peaks and components in the sample F5 chocolate spread. Major compounds quantified included: 2.3 butanediol (27.74%), 2-Furanmethanol (20.58%), 1,2-Propanediol (7.60%), 4-Cyclopentene-1,2,3-Triol, (1.Alpha.,2.Alpha.,3.Alpha.) (4.73%), Benzeneacetaldehyde (2.88%), Decanoic Acid (1.07%), and Cholest-4-EN-3-OL, (3.BETA.) (0.51%). Research Afoakwa *et al.* (2009) reported volatiles, such as butanediol, were also characterised by sweet, honey notes and caramel-like, likely derivatives of Strecker degradation and caramelization reactions developed during cocoa processing and transformed during chocolate flavour synthesis in conching. Heterocyclic compounds including furanmethanol (linalool oxide) were characterised by astringent vinegar notes and fruity -spicy. While the compound Cyclopentene (ketones), Cholest and Decanoic acid as an antioxidant (Singh *et al.*, 2020).

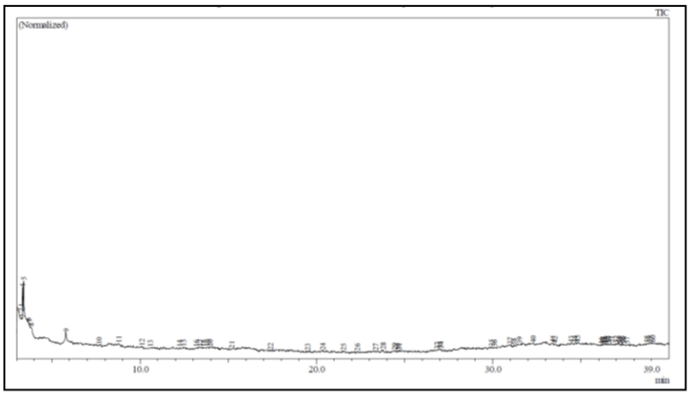

Figure 6. Gas chromatography-mass spectrometry profile chocolate spread in sample F5.

3.5 Sensory evaluation

The sensory evaluation of panellists for the jackfruit –chocolate spread samples are as shown in Table 3. Sample F4 (5% jackfruit flour: 31% sugar) had the highest preference for taste with a mean rank value of 2.29. The Sample F5 (10% jackfruit flour: 26% sugar) and F3 (10% jackfruit flour: 36% sugar), with a mean value of 2.61 was the second-highest. The reference sample, F1 (without addition jackfruit flour), with a mean value of 4.19 was the least ranking.

Table 3. Sensory evaluation of chocolate spread samples

Sample	Taste	Flavour	Texture
F1	4.19	4.37	4.24
F2	3.29	2.61	2.84
F3	2.61	2.68	2.61
F4	2.29	2.52	2.19
F5	2.61	2.82	3.11

Data are represented as mean rank in Friedman test. Means in the same column with the same superscript are significantly different at ($p < 0.05$).

Similarly, for flavour and texture, the reference sample: F1, had the least value of 4.37 for flavour and 4.24 for texture (Table 3). About flavour, sample F4 had the highest preference with a mean score of 2.52 and sample F2 (5% jackfruit flour: 36% sugar) followed as the second highest with a score of 2.61. The textural sensory attribute that describes the smoothness or generally how the sample feels in the palate of the panellist. The sample F4 had the highest preference with a mean score of 2.19, and sample F3 (10% jackfruit flour: 36% sugar) followed as the second highest with a score of 2.61. There were significant differences ($p<0.05$) amongst panellists' preference for these samples concerning the taste, flavour and texture. This could mean that panellist members could detect any differences in the samples chocolate spreads. From data obtained on the sensory evaluation of samples using the ranking hedonic scale used, chocolate spreads made from jackfruit flour and red palm olein will be accepted when introduced into the market.

4. Conclusion

The fortified chocolate spreads showed better emulsion stability and physicochemical characteristics. The formulated chocolate spreads contained relatively higher amounts of polyphenols, carotenoids, antioxidant, low free fatty acid, and better physical attributes (viscosity, colour, pH and melting point) than the control sample. Chocolate spread samples produced from fortified jackfruit and red palm olein composite were generally liked by a panellist. Jackfruit-red palm olein composite spread gave a better taste, flavour and aroma compared to the reference sample. The fortified jackfruit chocolate spreads could still be accepted by the panellists according to their physical and sensory characteristics. This product when adopted will provide an alternative use for replacing butter fat, but produce chocolate spread with good quality in terms of physicochemical, antioxidant acivity and sensory.

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