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Chocolate Spread Emulsion: Effects of Varying Oil Types on Physico-chemical Properties, Sensory Qualities and Storage Stability

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ABSTRACT

Chocolate spread emulsion is an alternative product to the conventional dry-based chocolate spreads. The main objective of this study was to evaluate the use of three potential oils; palm olein, olive oil and corn oil, in the production of chocolate spread emulsions. The palm olein chocolate spread was the easiest to spread compared to the olive oil and corn oil chocolate spread emulsions. The melting point of the commercial spread was higher than the emulsion samples, but the sensory scores of the samples were comparable to the commercial spread. The proximate analyses of the samples with different oil types gave no significant difference in the values of moisture, ash, protein, fat, fibre and carbohydrate. Further study on the storage stability of all samples for 28 days at 28 and 10 °C revealed that the firmness of the spread emulsions generally decreased by week, while the water activity (a_w) values decreased during the storage at 28 °C and increased at 10 °C. There was no oil separation and microbial growth observed on the chocolate spread samples throughout the storage period at both temperatures.

Keywords: Palm olein, chocolate spread, emulsion, sensory and storage study.

INTRODUCTION

Chocolate spread is the sweet taste chocolate paste commonly consumed with bread, pancake, biscuit and other spreadable foods. It should not solidify at room temperature and is not recommended to be stored in the fridge. An ideal spread should have a creamy, light consistency without oil separation throughout its shelf-life of 6-12 months. Chocolate spreads usually contain cocoa powder, vegetable or palm oil, sugar, and additional flavour.

Alternatively, a chocolate spread can also be formulated as a water-in-oil emulsion that contains an aqueous phase dispersed in a continuous oil phase (Samsudin, 2004). The consistency of this chocolate spread emulsion can be adjusted by the balance of liquid oil and solid fats. Sufficient solid fat in the fat system will ensure product stability and good shelf-life. The product should have solid appearance but spreadable and not become oily or greasy from oil separation over time at room temperature. The product requires a fat system that contains low solids at room temperature but resists oil separation. A typical fat used as the continuous phase in chocolate spread is partially hydrogenated soybean oil with a melting range of 32 °C - 38 °C. The fat content varies from 40 % - 44 % for ordinary chocolate spreads to 28 % - 35 % for low-fat spreads (Samsudin, 2004). The type of oil used can add to the functionality of the chocolate spread, allowing it to be marketed as a functional food that improves health and well being while reducing the risk of diseases (Walzem, 2004).

In the present study, chocolate spread emulsions were formulated from three types of oil; RBD (refined, bleached and deodorised) palm olein, olive oil and corn oil, with different nutritional benefits and melting points. Although the use of these oils is quite common in different commercial chocolate spread products (without water), their incorporation in emulsion-based chocolate spreads is new and information on the emulsion properties is still limited. Palm olein is a semi-liquid oil derived from the mesocarp (reddish pulp) of the oil palm fruits. Before being refined, bleached and deodorised, palm olein is naturally red in colour owing to the presence of high beta-carotene content. Corn oil on the other hand is extracted from the germ of maize which contains high polyunsaturated fatty acid. Olive oil is an oil obtained from the fruit of the *Olea europaea* (olive tree), a traditional tree crop from the Mediterranean region, which fruits are wholly pressed to produce oil (Kumar, 2015). Olive oil contains polyphenols; natural compounds with multiple phenolic groups. The polyphenols in olive oil range from 50 to 1000 mg/kg (Gorzynik-Debicka et al., 2018). Olive oil is also a monounsaturated fat that brings health benefits to its consumers.

The main objective of this study is to investigate the effects of using palm olein, olive oil or corn oil on the rheology and sensory characteristics of chocolate spread emulsions formulated from chocolate bars. Furthermore, this work compared the nutritional attributes of the three different chocolate spread emulsions and assessed the effect of storage temperature and time on their stability in terms of spreadability and water activity.

MATERIALS AND METHODS

Materials

The chocolate bar used in this study was from the Malaysia Cocoa Board, Nilai, Malaysia. It was the compound chocolate formulated from palm oil as the milk substitute. Sodium stearoyl lactylate (SSL) as the emulsifier was bought Pulau Pinang while the filtered water was supplied from the bakery lab of the Faculty of Bioresources and Food Industry, Universiti Sultan Zainal Abidin, Besut, Malaysia. Corn oil, olive oil, and RBD palm olein were purchased at the Giant supermarket, Jerteh, Malaysia. The control palm-based chocolate spread sample was also purchased from the Giant supermarket, Jerteh, Malaysia.

Preparation of Chocolate Spread Emulsion

In general, the chocolate spread emulsions in this study were prepared according to Samsudin (2004) with some modifications (Fig. 1). The samples contained chocolate bar (60% w/w), oil (24% w/w), water (15% w/w), sodium stearoyl lactylate (SSL) (0.08% w/w) and potassium sorbate (1% w/w). The ingredients were categorised into two phases; aqueous phase and oil phase. For the aqueous phase, water and SSL were first mixed at 55 °C for 15 min and let to cool aside. For the oil phase, the chocolate bar was first melted by double boiling in a water bath maintained at 45 °C, before the liquid oil was added and further heated for another 45 min at 50 °C. Then both phases were blended together for 20 min to form the smooth spread emulsion. Finally, the finish product was filled into 100 mL glass containers (beaker was sterilized with hot water at 100 °C) for storage at 10 °C and room temperature (28 °C). The chocolate spread samples were taken out for analyses up to 1-month period.

Proximate analysis

The chemical compositions (moisture, crude protein, crude fat, ash, and crude fibre) of the chocolate spread emulsion were determined according to the Association of Official Analytical Chemists (AOAC, 1995). Oven drying method (AOAC method 977.11) was conducted to examine the moisture content, Kjeldahl's method (AOAC method 955.04) for crude protein determination, Soxhlet method (AOAC method 960.39) for crude fat determination, dry ashing method (AOAC method 923.03) for ash content, and gravimetric method (AOAC method 991.43) was used to determine the crude fibre. The carbohydrate content was then calculated as follows: Carbohydrate (g) = 100 g – (moisture + crude protein + crude fat + ash) g. The result was expressed as gram per hundred grams of dry matter (g/100 g of dry matter). Finally the energy value of the sample was calculated by adding all calories including carbohydrate, protein, and fat. The % of energy was calculated as follows:

$$\text{Energy (kcal)} = (4\ \text{kcal/g} \times \text{grams of protein}) + (9\ \text{kcal/g} \times \text{grams of fat}) + (4\ \text{kcal/g} \times \text{grams of carbohydrate}) \qquad \textbf{Eqn. 1}$$

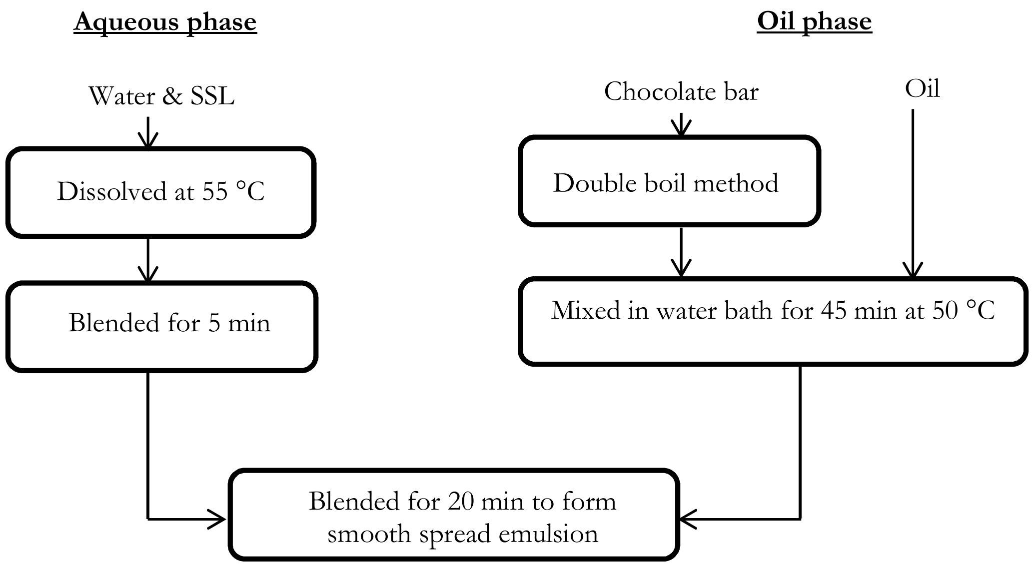

Fig. 1: Flowchart of the chocolate spread emulsion preparation.

Sensory Evaluation

The quantitative descriptive analysis (QDA) of the sample was assessed by the standard method (Yilmaz & Aydeniz, 2012) and followed the ISO standard (International Standard ISO 8586-2/2008,2008). The evaluation was conducted on 65 semi-trained panellists, who graded the chocolate spread samples in terms of following attributes: colour, spreadability, texture, melting quality and overall acceptability, using the 1 to 7 point hedonic scale (7 = like very much, 6 = like moderately, 5 = like slightly, 4 = neither like nor dislike, 3 = dislike slightly, 2 = dislike moderately, 1 = dislike very much). Water was provided to cleanse the palate before or in the middle of the sensory evaluation session.

Water Activity

The water activity (a_w) of sample was measured using AquaLab Series analyser in duplicates. Each sample was weighed into 1-2 g and spread onto a Retronic dispensable cup. The cup was placed in a closed analyser chamber and the reading was recorded in a table when the optimum value was reached.

Storage Study

10 g of each chocolate spread emulsion sample was filled into a polyethylene terephthalate plastic and sealed. The chocolate spread emulsion samples were stored both in a chiller (at 10 °C) and at room temperature (28 °C). The four-week storage study comprised two analyses; texture and water activity, which were conducted weekly. Each sample was duplicated for both analyses.

Statistical Analysis.

The results of chemical and instrumental analyses were statistically analysed using MS Excel XLSTAT 2013 (Microsoft Corporation, Redmond, Washington, USA). The data were expressed as means ± standard deviations.

RESULTS AND DISCUSSION

Texture of Chocolate Spread Emulsion

Fig. 2 shows the average firmness of the chocolate spread emulsions with different oils in comparison to a commercial sample. The spreadability of chocolate spread decreases as the firmness increases over the storage time (Mohd Razalli et al., 2016). The firmness of the palm olein, olive oil and corn oil chocolate spread emulsion were 596.62 g, 1165.22 g and 1025.14 g respectively, while the commercial palm-based chocolate spread was 823.73 g. Although palm olein is considered more saturated than olive and corn oils, the chocolate spread emulsion unexpectedly had the lowest value, indicating a better spreadability among other samples. Emulsification might have caused samples with olive and corn oils to become firmer and less spreadable.

The sample with palm olein however had the firmness close to that of the commercial product since the latter uses cocoa butter substitute derived from palm oil in its formulation. The slightly higher firmness value of the commercial product compared to that of palm olein sample was due to the incorporation of food stabiliser (Samsudin, 2004). The firmness values were significantly different ($p<0.05$) between the emulsion samples but there was no significant difference ($p\geq0.05$) between the firmness of the olive and corn oil chocolate spread emulsions.

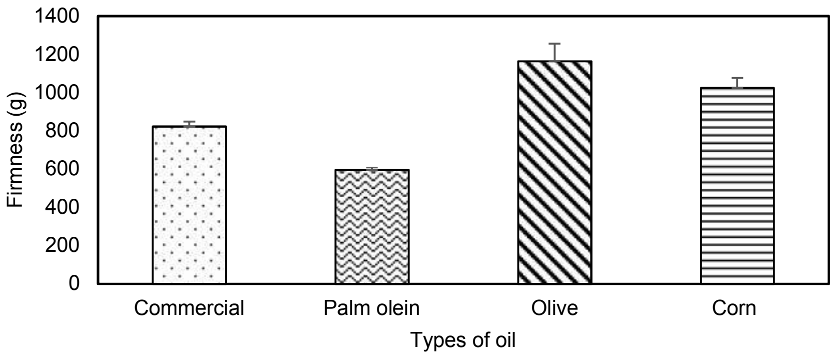

Fig. 2: Firmness of the chocolate spread emulsion

Melting Properties of Chocolate Spread Emulsion

The melting point of a sample is characterized by a number of broadening and overlapping peak due to the presence of triacylglycerol fractions by means of polymorphic transformations occurred during heating (Manzocco et al., 2014). The polymorphic behaviour of the spread samples were determined by the presence of fatty acid within the triglycerides (Gunstone, 2002). Table 1 shows the melting properties of the chocolate spread emulsions from three different oils in comparison to that of the palm-based commercial spread as control. The control sample had the highest melting point while the spreads with either olive, corn and palm olein had lower but not significantly different melting points of 33 to 35 °C. This result is consistent with the study by Samsudin (2004) who compared the melting temperatures of different chocolate spread emulsions with several commercial products. Although the control sample was palm-based, the chocolate spread emulsion with palm olein showed a lower melting point value due the emulsion system, which incorporate water that has a much lower melting point than that of palm olein (~16 °C). The melting points of the samples with olive and corn oils were understandably lower due to the low melting point of both oils (below 0 °C) as compared to palm olein.

Table 1: The melting point of chocolate spread emulsions with palm olein (PO), olive oil (OO) and corn oil (CO) as compared to that of commercial spread as control.

Type of chocolate spread emulsion	Melting point (°C)
PO	35.34 ± 0.22^{a}
OO	34.68 ± 1.15^{a}
CO	35.20 ± 0.08^{a}
Control	37.67 ± 0.65^{b}

$^{a-b}$ Means with the same superscript in the column are not significantly different to each other (p≥0.05)

Sensory Evaluation of Chocolate Spread Emulsion

The results of sensory properties (colour, spreadability, texture, melting quality and overall acceptability) of different chocolate spread emulsions and the control sample are shown in Table 2. Higher scores correspond to a higher preference of the property by the panels. The colour determines the first impression of panels towards each sample. In this study, since the spreads were all milk-chocolate based, their colour should appear milky and not too dark. As spreads, each sample must be easily spreadble on a slice of bread, and the texture should be smooth and silky. When put into mouth, the samples should immediately melt and not stuck on the palate surface.

Fig. 3 illustrates more clearly the preference of panelists between the chocolate spread emulsions with different oil types and the commercial spread as a control. The highest mean score for each property was recorded by the control sample. This was consistently followed by the samples with corn oil, palm olein, then olive oil, except for the colour property, which shows the sample with olive oil received higher mean score than that with palm olein.

Table 2: Mean scores of different chocolate spread qualities in sensory evaluation by 65 semi-trained panelists.

Types of oil	Palm Olein	Olive Oil	Corn Oil	Control
Colour	5.14 ± 1.32 [a]	5.26 ± 1.17 [a]	5.62 ± 1.09 [a]	6.63 ± 0.60 [a]
Spreadability	5.05 ± 1.21 [b]	4.83 ± 1.2 [b]	5.40 ± 1.13 [b]	6.29 ± 0.96 [b]
Texture	5.15 ± 1.11 [c]	4.83 ± 1.2 [c]	5.42 ± 1.11 [c]	6.42 ± 0.78 [c]
Melting quality	5.25 ± 1.12 [d]	5.06 ± 1.21 [d]	5.69 ± 0.89 [d]	6.00 ± 1.04 [d]
Overall acceptability	5.18 ± 1.14 [e]	4.86 ± 1.36 [e]	5.60 ± 0.92 [e]	6.43 ± 0.82 [e]

[a-e] Means with the same superscript in a row are not significantly different to each other ($p \geq 0.05$)

The sample with olive oil seemed to be the least preferred due to its harder texture, which affected its spreadability and melting quality as imposed by its low scores by the panels. In a study by Kumar (2014), the combination effect of butter fat and olive oil in the production of a chocolate spread was found to decrease the body and texture scores. On the other hand, the chocolate spread emulsion with corn oil was rated the highest in most properties after the control sample, thus depicting its high acceptability as a chocolate spread product to compete in the market.

However statistically, there were no significant differences ($p<0.05$) in scores for all properties of the chocolate spread emulsion samples and the control, as shown in Table 2.

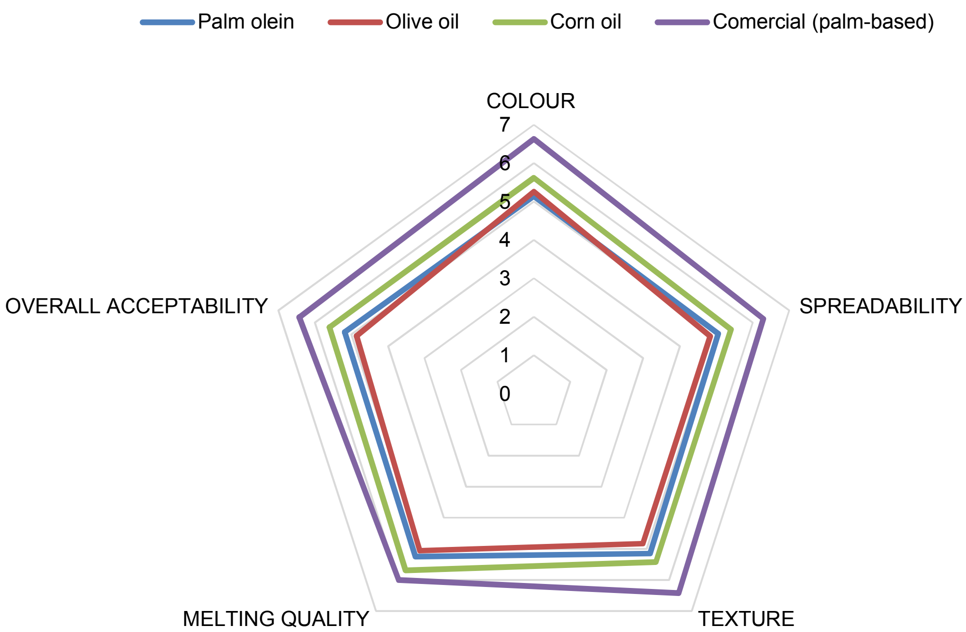

Fig. 3: The results of sensory evaluation of chocolate spread emulsions by 65 semi-trained panelists.

Proximate Analysis of Chocolate Spread Emulsion

The data pertaining to various proximate properties of different chocolate spread emulsions are depicted in Table 3. The data shows that in general, the nutritional content of all samples were similar and did not show significant differences. This can be explained by the same amount in percentage of ingredients added into the three formulations of chocolate spread emulsion. The only difference in the formulation was the type of oil used, which contributed to the small variations in fat, carbohydrate and thus the energy content between the three samples.

The protein traced in the chocolate spread was from the chocolate bar added as an ingredient. Kharat and Deshpande (2017) conducted a chemical analysis and reported that the crude protein in a chocolate bar was 6.81 %. The percentage was higher compared to the protein content of the chocolate spread emulsions in this study probably because the protein in the emulsion samples could have denatured due to the heating process involved (Joel et al., 2013; Kharat and Deshpande, 2017).

The fat content was higher in the chocolate sample with palm olein, although not significantly different from that with other oils. Nelson et al. (1996) stated that more oleic acid (43 % of fatty acid) is found in palm olein. The results also showed that the sample with olive oil generally had the lowest fat content. In fact, olive oil is a mixture of triacylglycerols, with some free fatty acids, mono- and diacylglycerols, and non-glyceridic constituents (0.5–1.5 %) (Gunstone, 2002). This also contributed to the lower energy value of the sample with olive oil in Table 3, compared to the samples with other oil types, since the energy calculated corresponds to the protein, fat and carbohydrate contents of the samples.

On the other hand, Table 3 depicts that the chocolate spread with olive oil had higher value of fiber (0.06±0.02), with no significant difference to that with other oil types. Fiber is known to help with digestion and excellent in reducing the risk of constipation (Amevor et al., 2018). A high value of fiber also aids in the spreadability of chocolate spreads, as reported by Amevor et al. (2018).

Table 3: Mean values of proximate analysis of chocolate spread emulsions with different oil types.

Type of oils	Palm Olein	Olive Oil	Corn Oil
Moisture (%)	0.17 ± 0.00 ^{a}	0.17 ± 0.00 ^{a}	0.17 ± 0.00 ^{a}
Ash (%)	0.02 ± 0.00 ^{b}	0.02 ± 0.01 ^{b}	0.02 ± 0.02 ^{b}
Protein (%)	1.43 ± 0.27 ^{c}	1.28 ± 0.03 ^{c}	1.32 ± 0.14 ^{c}
Fat (%)	0.22 ± 0.07 ^{d}	0.14 ± 0.04 ^{d}	0.20 ± 0.01 ^{d}
Fiber (%)	0.04 ± 0.01 ^{e}	0.06 ± 0.02 ^{e}	0.04 ± 0.01 ^{e}
Carbohydrate (%)	57.10 ± 7.41 ^{f}	65.42 ± 5.07 ^{f}	58.94 ± 0.64 ^{f}
Energy (kcal)	433.23 ± 32.56 ^{g}	395.61 ± 14.86 ^{g}	425.32 ± 6.37 ^{g}

$^{a\text{-}e}$ Means with the same superscript in a row are not significantly different to each other ($p \geq 0.05$)

Texture of Chocolate Spread Emulsions Upon Storage

The texture quality of each chocolate spread emulsion in this study was measured by its firmness throughout 28 days of storage. The firmness of chocolate spreads in Fig. 4 reflects their spreadability. The spreadability of a chocolate spread decreases as the firmness increases over storage time (Mohd Razalli et al., 2016). Fig. 4 shows that the storage time had significant effect on the firmness of chocolate spread emulsions. At room temperature of 28 °C, the firmness generally decreased by week, while at 10 °C, the firmness increased in the first week due to hardening, before plummetting and became stabilised in the final week.

Further statistical observation revealed that samples with olive oil had significant difference in firmness to those with palm olein and corn oil, while the firmness of palm oil-based samples showed no significant difference from the corn oil-based after 1 week of storage at 28 °C (Fig. 4a). On the other hand at 10 °C, the samples with olive oil and corn oil had no significant difference in firmness to that with palm olein, while the firmness of samples with olive oil had significant difference to that with corn oil (Fig. 4b).

Furthermore, the samples with olive oil showed higher firmness at both temperatures compared to those with palm olein and corn oil. According to Manzocco et al. (2014), using lipid with higher fluidness in production of chocolate spread may significantly decrease the physical stability, which results in oil separation during storage. The fact that olive oil is low in fluidness due to its low content of saturated fat and high in monounsaturated fat, had decreased the stability of emulsion systems by increasing the time of the crystalization in the chocolate bar added in the spread formulation. Cocoa butter in the chocolate bar can produce various forms of crystal and this phenomenon is called polymorphism (Limbardo et al., 2017). The more crystals formed, the lower the emulsion stabilty, thus the harder is the emulsion. Another study however stated that cocoa butter fat crystals contribute to emulsion stability (Norton and Fryer, 2012; Bari et al., 2017). Cocoa butter was also shown to have significant effects when combined with palm fat subtitute in chocolate bar in terms of rheological properties (El-kayoubi et al., 2011).

All formulations with different lipids did not show any oil separation within 28 days. The application of emulsifier added in the chocolate spreads helped to stabilise the system causing no oil separation. The flexibility of emulsifier molecules resulted in more stable interfacial film which led to a higher stability in emulsions.

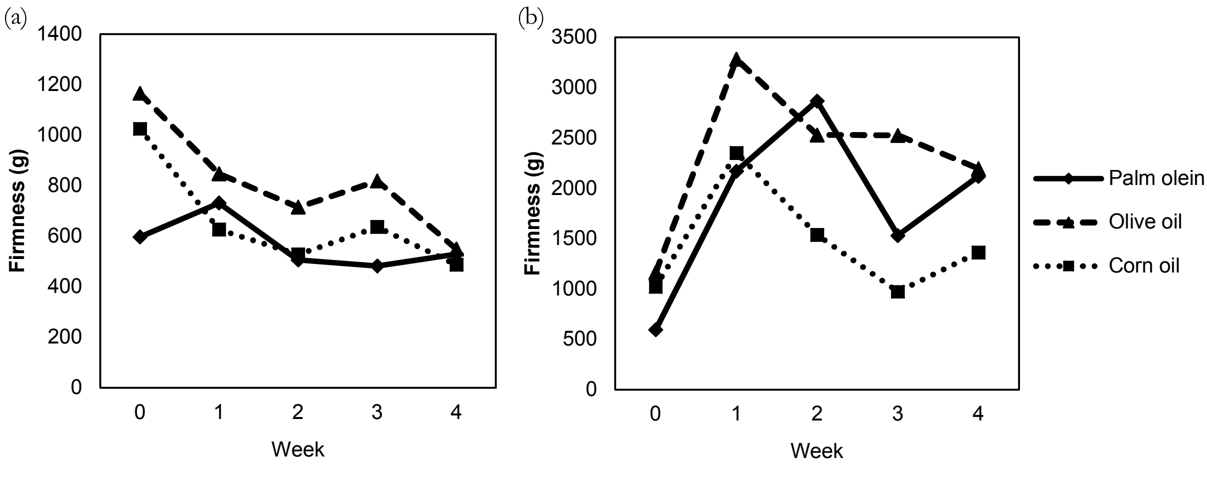

Fig. 4: Firmness of chocolate spread emulsions with different oil types stored for 28 days at (a) 28°C and (b) 10°C

Water Activity of Chocolate Spread Emulsions Upon Storage

Water acivity influences reactant mobility during storage and processing of food. This makes it a very useful parameter to understand the stability and quality of a food product (Bassal et al., 1993a; 1993b; Syamaladevi et al., 2016).

Fig. 5a shows the water activity of the chocolate spread emulsions decreasing gradually throughout the storage period at 28 °C. At 10 °C, statistically there was no significant differences in the water activity of the three samples during storage. The water activity values in this study were higher compared to that of commercial chocolate spreads reported by Samsudin (2004), which was in the range of 0.76 – 0.79. This was because the commercial chocolate spreads are based on full fat and no water is added in the formulation, while the experimetal samples consisted of water in the formulation as emulsification was involved. The incorporation of potassium sorbate at a permitted level by the Food Law 1985 (< 0.08%) in the chocolate spread emulsions helped to resist the bacterial growth for at least one month.

Moreover, during the storage period at 10 °C from week 2 until week 3, there was a temporal increase in water activity value of all samples as shown in Fig. 5b. According to Syamaladevi et al. (2016), dynamic changes in external factor (temperature and pressure) during processing or storage make the equilibrium between water in food and chemical potential of water vapour in the enviroment to be altered.

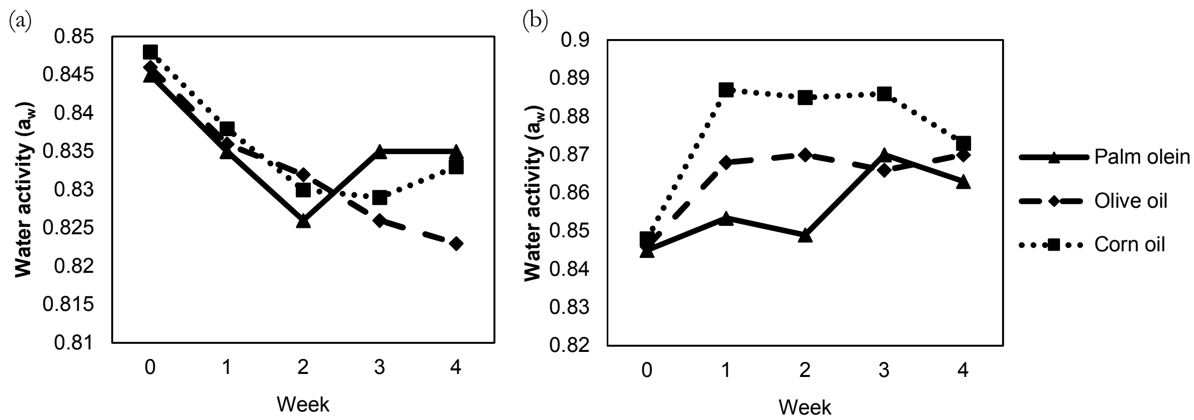

Fig. 5: Water activity of chocolate spread emulsions with different oil types stored for 28 days at (a) 28°C and (b) 10°C.

CONCLUSION

The chocolate spread emulsion produced with three different oil types (palm olein, olive oil and corn oil) had satisfactory results in physico-chemical, sensory evaluation and storage stability. In terms of rheological property, the palm olein chocolate spread was the lowest in firmness compared to the olive oil and corn oil chocolate spread emulsions. The lower the firmness, the higher the spreadability of the chocolate spread. Moreover, the melting points of all the chocolate spread emulsions were lower than that of the commercial palm-based chocolate spread, but not significantly different from each other. However the sensory evaluation showed that the qualities of the chocolate spread emulsion with different oil types matched the sensory scores of the control sample. Further evaluation on the nutritional contents of the spread emulsions revealed similar values of moisture, ash, protein, fat, fibre and carbohydrate, but the olive oil sample showed the lowest fat content and the highest fibre content for a healthier diet. In addition, upon storage at 28 and 10 °C, the firmness of all spread emulsions generally decreased by week, but the sample with olive oil was firmer at both temperatures due to its low content of saturated fat and high in monounsaturated fat. The emulsion products also decreased in water activity (a_w) during the storage at 28 °C, while increasing and became stabilised at a higher a_w values at 10 °C. There was no oil separation and microbial growth observed on the chocolate spread samples throughout the storage period at both temperatures. Further analysis of microbial activity may be useful to better ensure the food safety for consumers. Incorporating oil blends in the chocolate spread emulsion formulation may also yield interesting physico-chemical and sensory properties to be explored in future.

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