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COMPARATIVE STUDY ON PHYSICAL PROPERTIES OF COOKIES AND DOUGH MADE WITH PALM-BASED SHORTENING AND LARD

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Abstract
A study was conducted to compare the effects of palm-based shortening and lard on physical properties of dough and cookies. The formulation for palm-based shortening was done by blending palm fractions and soybean oil namely; F91 (70:30) and F141 (65.2: 34.8). The hardness and compressibility of the dough were evaluated whereas the stiffest and the highest compressibility of dough was F91. Density of all dough was not significantly different (P>0.05). Dough made out from palm-based shortening and lard indicated solid-like structure. The values of thickness, width, spread ratio of all cookies were not significantly different (P>0.05). Cookies containing palm-based shortening were higher in lightness value (L*), stronger in redness (a*) and yellowness (b*) as compared with lard. The cookies made out from F141 shortening exhibited highest value in hardness. The results showed that palm-based shortening used in making of dough and cookies was comparable with use of lard.

Keywords--Palm-based shortening, lard, cookies, dough

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INTRODUCTION

A cookie is a baked or cooked convenient bakery food made out of ingredients such as flour, some types of oil or fat, sugar, salt and water. Other ingredients in a cookie include baking powder, emulsifier and skimmed milk to produce a gluten structure (Norhidayah, Noorlaila & Nur Fatin Izzati, 2014; Akinwande *et al*., 2008). Cookies shelf life is considered longer in comparison with other bakery products such as bread and cakes. This is mainly due to its lower moisture content. The quality of biscuit is influenced by the nature and quantity of the ingredients mixed in the dough (Mamat & Hill, 2018).

Fats is one of the major ingredients that acts as shortening functions in dough. Shortening could be sourced from animals or vegetables with 100% fats that tenderize bakery products by preventing the development of gluten strands cohesion (Metzroth, 2005). The presence of shortening isolates proteins and starch granules by fat encapsulation surrounding them, therefore shortens the network of protein and starch structures (Ghotra, Dyal & Narine, 2002).

In this context, palm oil and their fractions are preferred for use as natural sources of ingredients by food manufacturers. Palm oils exist as semi-solid at ambient temperature due to the balanced content of fatty acids where the level of saturated fatty acid and unsaturated fatty acid are equal in value (Fauzi, Rashid & Omar 2013; Neo, Tan & Ariffin, 2007). Hoffman (1989) mentioned that palm oil products are excellent hard stock for trans-free formulation for spread such as margarine, shortening, confectionary fats, and vanaspati without going through hydrogenation processes. Palm oil can be included as a major ingredient in shortening as it helps maintain consistency, texture, and structure of products (Aini & Miskandar, 2007). Besides vegetable oils, lard has been used as shortening for centuries due to liquid-to-solid content ratio that improves performance of bakery products (Metzroth, 2005; Hussain et al., 2018; Kamel, 1992). The different types of shortenings used in cookies give different results on the physical properties of final products. The present study was undertaken to compare the effects of palm-based shortening and lard on physical properties of dough and cookies.

MATERIALS AND METHODS

Materials

Lard used was extracted following procedures of Marikkar*et al.,* (2005). Palm oil and its fractions were obtained from Malaysian Palm Oil Board, Malaysia (MPOB). Soybean oil was purchased from a local supermarket. Materials for the preparation of dough and cookies such as wheat flour, sucrose, salt, and sodium bicarbonate were purchased from a local bakery mart.

Preparation of Shortening

Palm-based shortenings were prepared following procedures of Abdul Aziz*et al*., (2011) with some modifications. The shortenings were prepared with different compositions of palm fractions and soybean oil namely; F91 (70:30) and F141 (65.2: 34.8) with the addition of 1% of distilled monoglyceride (DMG) for each. Before mixing, the fats were melted at 70°C and stirred constantly with a magnetic stirrer at 10°C in 10 minutes. The prepared shortenings were kept at 5°C overnight and later stored at temperature room before being used.

Preparation of Cookie Dough

Cookie dough preparation was done according to a procedure described in the American Association of Cereal Chemists method AACC 10-50D with slight modifications (Sciarini*et al*., 2013). All ingredients were weighed and mixed as follows: shortening (64 g) was creamed with sugar (130 g), salt (2.1g) and sodium bicarbonate (2.5 g) for 3 min at low speed mixer. Subsequently, a 33g portion of sucrose solution (5.9% w/v) and 22.8 g of deionized water were added, and mixing was done for 2 min at high speed. Finally, 218.2g of wheat flour was added and mixed for 2 min at low speed; the bowl was scraped every 30 s. The dough was allowed to rest for 10 min before further analyses.

Dough Analyses

Dough Density

Dough density was calculated by weighing an individual portion of dough (a scoop of approximately 1 ml)**.** The volume of water displaced in a graduated cylinder was recorded as volume reading. Then, the measurement was calculated as g/cm^3 (Zhong, Allen & Martini, 2014)**.**

Texture Profile Analysis (TPA)

TPA was conducted according to Mamat and Hill (2014) with some modifications. The properties of dough were assessed using texture profile analysis with a texture analyzer (Stable Micro Systems, Surrey, UK, 25 kg load cell). A circular shape-cutter was used to prepare the cylinder dough disk of 35mm diameter and 5mm thick. A 75 mm diameter cylinder aluminum probe was used to compress the dough twice. The test speed was 1.0 mm/s, the compression distance was 2.5 mm, the post-test was 2.0 mm/s and the recovery period between the two strokes was 5 s. Values for hardness, compressibility, and adhesiveness were calculated from the recorded force values (Exponent version 6). As mentioned in the analyzed software, hardness is defined as the maximum peak force during the first compression cycle. Compressibility is defined as the ratio of the positive force area to that negative force area of the first compression. Meanwhile, adhesiveness is defined as the negative force area for the first compression where the total force necessary to pull the compression prober away from the sample. The measurements were tested three times and the results were recorded as mean values.

Rheological Properties

Rheological properties of dough were recorded using an AR2000 controlled-stress rheometer (TA Instruments, Brussels, Belgium) equipped with cross-hatched parallel-plate geometry according to method described by Sciarini*et al.* (2013) with slight modifications. After mixing, the dough was allowed to rest for 15 min. Then, a small piece was taken from the inner part of the dough, loaded between the parallel plates (diameter: 40 mm), and compressed to obtain a gap of 4 mm. The excess edges of the sample were carefully trimmed, some water drops were placed around the samples, and a solvent trap was placed to measure with constant ambient humidity. Before starting assays, samples were rested for 5 min to allow residual stress relaxation. The temperature of the dough was kept constant at 25°C. The test was done at 0.1-100 Hz, 0.05% strain (which was located within the LVR). Each sample was tested in triplicates.

Cookies Making and Evaluation

Cookie making was conducted according to Mamat and Hill (2014) with slight modifications. Dough pieces were cut out with a cutting ring of 5.7 cm diameter and baked for 8 min in an oven at 190 °C with air circulation. The cookies were left to cool for 30 min and placed in plastic containers for further analysis.

Thickness and Spread Ratio

Measurement of thickness and width were made using a verniercalliper (Raihana*et al.,* 2017). The spread factor of the cookies was calculated by dividing the diameter of the baked cookie (D) by the height of the cookie (H) (Yamsaengsung, Berghofer & Schoenlechner, 2012). Three measurements were taken for each sample.

Hardness

Cookie hardness was evaluated with a texture analyzer (TA. XT Plus, Stable Microsystems, Surrey, UK) equipped with a 5 kg load cell. Data were evaluated using Exponent Software (Version 6). The analysis was done according to Yamsaengsung*et al.* (2012) by using cylinder probe P/2 with the test speed was 0.2 mm/s and the distance was 3 mm. The maximum force and the distance to break off the sample were recorded and were referred to as the hardness of the biscuit. An average value of 10 replicates was recorded.

Color Analysis

Color of cookie surface was measured using a LabScan®XE Spectrophotometer (HunterLab). The measurements were referred to as L*a*b* color scale system. L* value represents lightness/darkness, a* value represent redness/greenness and b* value represents yellowness/blueness (Al-ansi*et al*., 2018). Three measurements were taken for each sample.

Statistical Analysis

All results from the analysis were indicated as the mean value ± standard deviation. Data were statistically analyzed by one-way analysis of variance (ANOVA) using Tukey's test of the MINITAB (Version 14) statistical package at 0.05 probability level.

RESULTS AND DISCUSSION

Dough Analysis

Table 1 shows texture profile and density of dough of F91, F141, and lard. In comparison, hardness of F91 was the highest compared to F141 and lard. Similarly, the higher force was needed to compress F91 dough as compared to the dough of F141 and lard. The adhesiveness of dough was also important in bakery processing. Among the samples, dough of F91 had the least adhesive as it was the stiffest dough. Meanwhile, lard dough described as the most adhesive since it was the softest dough with the lowest force.

Table 1. Texture profile analysis (TPA) and density of dough

	Hardness (N)	**Compressibility (N.mm)**	**Adhesiveness (N.mm)**	**Density (g/cm)**
F91	24.02±0.60^a	23.04±0.31^a	-2.20±0.07^b	1.41±0.25^a
F141	16.16±0.47^b	15.48±1.40^b	-1.21±0.56^{ab}	1.40±0.31^a
Lard	11.77±0.43^c	10.12±0.22^c	-0.80±0.43^a	1.43±0.29^a

Each value in the table represents mean of three replicates ± standard deviation. Means within each row with different superscripts are significantly different (P < 0.05).

According to Lahiji, Mohammadi & Moslemy (2015), the composition of shortening such as saturated- unsaturated ratio and physical measurements could be linked together. The ratio of saturated fatty acid to unsaturated fatty acid (SFA/USFA) in palm oil was higher as compared to lard (Yanty, Marikkar & Miskandar, 2012; Dubois *et al.,* 2007). Therefore, the effect of a higher SFA/USFA ratio could be related to the higher force needed to exert F91 and F14 dough as they contain palm-based blend in the shortening formulation. On the other hand, the density of the dough was not significantly different to each other.

It could probably due to the similar solid fat content of the palm-based blend shortening and lard during the mixing of the dough. Yanty*et al*. (2012) reported that the solid fat content of palm oil and lard similar at 25-40°C. According to Baltsavias, *et al.* (1997), the solid content of fat during mixing could influence the dough density whereas the dough with lower solid fat exhibited higher density due to less aeration in the dough.

Rheological Properties of Dough
In Table 2, the rheological properties of dough from different shortening are displayed. According to Omar *et al*. (2017), rheological properties of food are associated with other physical properties such as stability, shelf-life, sensory and texture. Moreover, it is crucial to establish the functionality of food ingredients in the product development of the food texture, structure, sensory and process condition (Danthine, 2011; Bourne, 1992).

Table 2. Rheological properties of dough

	G' (pa)	G''(pa)	Tan (delta)
F91	1925.5±5.50^{c}	1091.5±17.50^{b}	0.57± 0.01^{a}
F141	2226.5± 13.50^{b}	1249.5± 19.50^{a}	0.56±0.01^{ab}
Lard	2303.0± 9.00^{a}	1266.0± 3.00^{a}	0.55±0.00^{b}

Each value in the table represents mean of three replicates ± standard deviation. Means within each row bearing different superscripts are significantly (P < 0.05) different.

The rheological structure of dough is described by the viscoelastic system where the storage modulus (G') is over the loss (G"). Tan δ indicates the predominance of either elasticity or viscosity of the dough whereas the value should be less than 1 (Lahiji, Mohammadi & Moslemy, 2015). A big difference was found (p<0.05) between the storage modulus (G') of the dough prepared from palm-based shortening and lard (Table 2). The domination of storage modulus (G') over the loss (G') exhibited solid-like properties of the dough. This was supported by tan δ value which was less than 1 indicating solid-like structure of the dough. This finding was in agreement with the studies by Raihana *et al.* (2017) as well as Scriani*et al*. (2013) where tan δ of the dough were also reported representing elasticity property. According to Marangoni (2005), plastic fats contain fat crystal network. The nature of the fat crystal network affects the rheological of spread and the interaction between fat crystal aggregates of fat crystals in a network.

Cookies Analysis
Table 3 presents thickness, width, spread ratio and color analysis of cookies. Overall, there was no significance difference in size (thickness and width) and the spread ratio among the cookies. The findings of Parey*tet al*., (2009) suggested that the melting of fat took place in the midst of baking as well as the dissolving of sucrose thus enhanced the spread rate of cookie dough. Similarly, Maache-Rezzoug *et al*. (1998) explained the presence of fat in cookie dough would surround flour particles which separated them from each other that made it easily isolated. Thus, the more the fat content, the more friable the cookies after baking.

Colour was obtained as a consequence of complex interactions between food components (Damodaran, Parkin & Fennema, 2007). Table 3 presents data on colour analysis of the different cookies. Cookies of F91 and F141 (L* value; 29.6 and 26.97 respectively) contain palm-based shortening were found lighter than cookies made out with lard (L*; 19.07). The lower the L*, the darker the cookies surface colour due to Maillard reaction during baking (Pereira,Correia & Guiné, 2013; Martins, Jongen, & van Boekel , 2001). The content of reducing sugar and amino acids or protein is a significant contributory factor to the Maillard reactions (Morales & Jimenez-Perez, 2001).

All cookies indicated positive values of a* and b*. The positive value of a* represents the predominance of red over the green color. Meanwhile, the value of b* was also positive that refers to the dominance of the yellow color over the blue. The cookies of F91 and F141 possess the higher value of a* and b* as compared to the cookies made out from lard. As the former cookies contain palm-based shortening, the presence of minor constituents such as beta carotene could contribute to the strong redness and yellowness of them (Izyan, 2019). It was reported that palm oil and its fraction have a high content of carotenoid such as beta caratone that may have played a vital role in bringing about to the difference of color between the cookies prepared from lard (Sue & Pantzaris , 2009).

Table 3. Thickness, width, spread ratio and color analysis of cookies

	Thickness(mm)	Width (mm)	Spread ratio	Color		
				L*	a*	b*
F91	6.3±0.11^{a}	0.6±0.16^{a}	10.7±1.79^{a}	29.60±0.10^{a}	7.90±0.10^{b}	31.17±0.15^{a}
F141	6.6±0.03^{a}	0.7±0.10^{a}	9.5±0.45^{a}	26.97±0.23^{b}	9.30±0.36^{a}	31.80±0.17^{a}
Lard	6.2±0.08^{a}	0.7±0.17^{a}	9.6± 1.03^{a}	19.07±0.85^{c}	6.40±0.10^{c}	26.47±0.50^{b}

Each value in the table represents the mean of three replicates ± standard deviation. Means within each row bearing different superscripts are significantly different (P < 0.05).

Hardness of Cookies
Figure 1 shows hardness of cookies produced by palm-based shortenings and lard. The hardest cookies were displayed by F141 followed by cookies containing lard and F91 shortening. It could be probably due to the higher content of oil in F141 shortening formulation. This was in agreement with the findings of Jacob and Leelavathi (2001) who reported that cookies containing oil were the hardest. They suggested that stiffness of dough was not solely giving effect to hardness of cookies. According to Kamel (1994), the incorporation of air into liquid oil cannot be retained in the system thus exerted higher force to determine the hardness. The liquid oil dispersed in the dough with the form of globules that reduced the effectiveness in their shortening and the aeration (Hartnett & Thalheimer, 1979). Meanwhile, Scriani*et al.* (2013) and Raihana *et al.* (2017) mentioned that solid fat content of shortening could also influence hardness of cookies. The lower solid fat content of shortening, decreased time taken for melting fat. Consequently, it

promoted gluten reaction thus increased hardness of cookies. Scriani*et al*. (2013) discussed that the rheology of dough could not control hardness of cookies. The subject is mostly resulted by the process of baking.

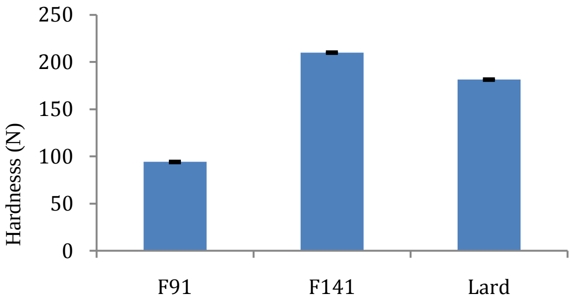

Figure 1. Hardness of cookies containing shortening of F91, F141 and lard

CONCLUSION

The present study discovered that rheological properties of dough containing palm-based shortening and lard indicated a solid-like structure. The value of thickness, width, spread ratio of cookies containing palm-based shortening was insignificantly different (P>0.05) to the cookies containing lard. The hardness of cookies was influenced by the liquid oil of the shortening. The higher liquid oil content contributed to harder cookies. The effect of palm-based shortening was comparable to lard in dough and cookie's physical properties.

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