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Effect of pink guava oil-palm stearin blends and lard on dough properties and cookies quality

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Abstract

A study was carried out to compare the cookie dough properties and cookie quality made out of pink guava oil-palm stearin blends and lard (LD). Since LD is prohibited under religious restrictions, plant shortenings were prepared by mixing pink guava seed oil with palm stearin (PGO/PS) in different ratios: PGO-1, 40:60; PGO-2, 45:55; PGO-3, 50:50; PGO-4; 55:45 as replacement. The effect of these formulated plant-based shortenings and LD shortening were compared on dough rheological properties and cookie quality. Rheology and hardness of the cookie dough were evaluated using Texture Analyser (TA). Cookie hardness was evaluated with TA while cookie surface colors were measured using the CIE $L^*a^*b^*$ colorimetric system. Among the samples, cookies made out of PGO-2 with the ratio 45:55 (PGO:PS) performed the best substitute for LD to be used as shortening in cookies. PGO-2 also displayed the closest similarity to LD in cookies for hardness, size and thickness, cracking size as well as colour. As PGO-2 was a shortening formulated with plant-based ingredients, it could comply with the halal and toyyiban requirements.

Introduction

Fats and oils play an important role in cookies production to give desirable characteristics such as tenderness, flavor, etc. They also assist in lubricating as well as producing a sensation of moistness in the mouth. The textural attributes, sensory perception and mouth-feel are largely affected by the crystallization of fats. The structure disruption might also happen due to interference with non-fat networks. During the mixing of the dough, there is a competition between the aqueous phase and the fat layer for the floured surface. Interaction of water or sugar with flour protein would develop gluten by forming a cohesive and extensible network. The existence of fat will coat the flour, which interrupts the network and affects the properties after baking (Manley, 2000). This can be solved by adding the shortening to the cookies (Sciarini *et al*., 2013). Shortening is the main ingredient in bakery production, which delivers functional properties to the end product such as bread, pies and cookies (Rios *et al*., 2014). Decreasing the amount of fat added to cookie is a good way to obtain a healthier and lower-calorie product, but this might affect the appearance and taste of the product. Hence, modification of fatty acid and TAG composition of shortening might help to produce healthier cookies while maintaining the texture and taste. Nowadays, consumers look for a halal and toyyiban aspect of foods since the permissibility of food sources and good quality with rich minerals and vitamins as required to be consumed. Since LD is a prohibited item according to Islamic law (Nasyrah *et al*., 2012), blend of pink guava seed oil- palm stearin can be a halal alternative fat from plant-based sources. The utilization of pink guava seed for oil production will not only help to reduce waste accumulation in the guava industry, but it also contribute to an additional income for the manufacturers (Prasad and Azeemoddin, 1994). Palm stearin is selected to be blended with pink guava seed oil due to it's low-cost which is very economical for shortening formulation (Abdul Azis *et al*., 2011). In addition to this, the blend may improve the plasticity of shortenings in the end product (Nor Aini and Maimon, 1996). Investigation on pink guava seeds oil-palm stearin shortening as a fat ingredient in cookie formulations has not been carried out previously. Hence, the objective of this study was to investigate the properties of dough and cookies made of pink guava seed oil-palm stearin

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shortening and to compare them with those of LD.

Materials and Methods

Materials

A sample of LD was obtained from a supermarket in Malaysia. Pink guava seed oil (PGO) was extracted from dried seeds of pink guava collected from Sime Darby Plantation, Sitiawan, Perak. A sample of palm stearin (PS) was purchased from Sime Darby Plantation, Teluk Panglima Garang, Selangor. All chemicals used in this research were of either analytical or HPLC grade. For dough and cookies preparation, wheat flour, sucrose, salt and sodium bicarbonate were purchased from a local bakery mart.

Shortening production

A total of four blends were prepared: (PGO-1) 40:60; (PGO-2) 45:55; (PGO-3) 50:50; (PGO-4) 55:45 (w/w), and identified by the mass ratio of pink guava seed oil to palm stearin. Shortenings of these blends were prepared according to a standard method described by Abdul Aziz *et al.* (2011) with some modification. PS was completely melted at 50-55°C before being blended with PGO by using a magnetic stirrer. The blends were continuously stirred at 20°C to obtain homogeneity and then subjected to rapid freezing at -20°C for 1h. The blends were removed from frozen storage, left static at room temperature before being used in cookies preparation (Abdul Azis *et al*., 2011; Sciarini *et al*., 2013).

Cookie dough preparation

Cookie dough formulation was carried out according to a procedure described in American Association of Cereal Chemists method AACC 10-50D with slight modifications (Sciarini *et al*., 2013). Prior to dough making, shortenings were kept in a thermostatic cabinet overnight (25°C ± 1.0°C), and the whole dough-making procedure carried out at 25°C. Briefly, shortening (64 g) was creamed with sugar (130 g), salt (2.1 g) and sodium bicarbonate (2.5 g) for 3 min at low speed in a mixer (the bowl was scraped every minute). Then, a 33 g portion of sucrose solution (5.9% w/v) and 22.8 g of deionized water were added, and mixing continued for 2 min at high speed. Finally, 218.2 g of wheat flour were added and mixed for 2 min at low speed; the bowl was scraped every 30 sec. The dough was allowed to rest for 10 min before further analyses.

Dough rheology

This was performed on an AR2000 controlled-stress rheometer (TA Instruments, Brussels, Belgium) equipped with cross-hatched parallel-plate geometry according to the method described by Sciarini *et al.* (2013). 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 3 mm. The excess edges of the sample were carefully trimmed, some water drops were placed around the sample, and a solvent trap was placed to measure with a constant ambient humidity. Before starting assays, samples were rested for 5 min to allow residual stresses relaxation. The temperature of the dough was kept constant at 20°C. The test was performed at 0.1-100 Hz, 0.05% strain (which was located within the LVR). Three independent dough batches were analyzed.

Dough hardness

The dough was rolled and cut (45 mm diameter, 20mm thick). Three discs were evaluated with a texture analyzer (TA-XT Plus, Stable Microsystem, Surrey, UK) equipped with a 5 kg load cell and a cylindrical probe (75 mm diameter). The dough samples were compressed until 50% deformation at the test speed of 1 mm/sec. The maximum force was recorded and evaluated as dough hardness. Three independent dough batches were analyzed (Sciarini *et al*., 2013).

Thermal profiling by differential scanning calorimetry (DSC)

This was performed according to the method described by Sciarini *et al.* (2013) using a Mettler Toledo differential scanning calorimeter (DSC 823 Model) equipped with a thermal analysis data station (STARe software, Version 9.0x, Schwerzenbach, Switzerland). Nitrogen (99.99% purity) was used as the purge gas at a rate of ~20 mL/min. Dough (8-10mg) was weighed in DSC aluminum pans, hermetically sealed and immediately ran in the calorimeter. Samples were equilibrated at 20°C for 5 min and then heated to 120°C at the rate of 10°C/min.

Cookie making and evaluation

Cookie preparation was carried out according to AACC method (AACC, 2000) with some modifications. The dough was allowed to rest for 10 min before sheeting and cutting (62 mm diameter, 5.5 mm thick). The cookie dough was then baked at 205°C for 13 min. Cookies were stored at room temperature (25°C) in a sealed plastic bag for further measurements.

Table 1. Rheological properties (G', G" and tan) and hardness (N) of dough

Sample	Frequency sweep (1 Hz) G' (kPa)	G" (kPa)	tan (δ)	Hardness (N)
PGO-1	52.51±8.41^{b}	26.77±4.77^{b}	0.51±0.03^{b}	9.89±0.85^{a}
PGO-2	41.30±2.01^{b}	22.47±1.41^{b}	0.54±0.02^{ab}	7.56±1.2^{abc}
PGO-3	37.44±4.24^{b}	20.49±1.47^{b}	0.55±0.06^{ab}	6.35±1.51^{bc}
PGO-4	29.86±4.10^{b}	17.87±2.27^{b}	0.60±0.01^{a}	5.65±0.18^{c}
Lard	99.36±19.49^{a}	54.85±6.88^{a}	0.53±0.03^{ab}	8.46±0.71^{ab}

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

Cookie thickness, colour and hardness

The width (W) and thickness (T) of cookies were measured with a Vernier caliper 1 h after baking. Cookie surface color and hardness were measured 24 h after baking. The surface color was determined by the Commission Internationale de l'Eclairage (CIE) $L^*a^*b^*$ colorimetric system (Konica Minolta Chroma Meter). Cookie hardness was evaluated with a texture analyzer (TA.XT Plus, Stable Microsystems, Surrey, UK) equipped with a 30 kg load cell, using a three-point break (HDP/BS) probe. Compression was applied until breaking at a speed of 1 mm/s. The maximum force required to break the cookie was considered as a hardness parameter (Sciarini *et al.*, 2013).

Statistical analysis

All results from analyses were expressed as mean ± standard deviation. Data were statistically analyzed by one-way analysis of variance (ANOVA) using Tukey's test of the MINITAB (version 16) statistical package at 0.05 probability level.

Results and discussion

Dough properties

Dough hardness of dough samples prepared with blends PGO-1, PGO-2, PGO-3, PGO-4 and LD were compared as shown in Table 1. Fat is the main ingredient that affects the hardness of dough where it is responsible for binding other ingredients (Manley, 2000). According to Table 1, the highest hardness value of 9.89N was displayed by dough incorporated with PGO-1 while the lowest hardness value of 5.65N was displayed by dough incorporated with PGO-4. The high value of hardness requires more strength to compress the dough to the required extend (Jacob and Leelavathi, 2007). On the other hand, least force was needed to compress for a sample of dough made out of PGO-4 which indicated as the softest dough. The differences of these hardness values might be due to the difference in the ratio of palm stearin and liquid oil of pink guava in the shortening. As the proportion of PS used in PGO-1, was higher (60%) than that used in PGO-4 (45%), it has resulted in slightly stiffer dough. According to Jacob and Leelavathi (2007), dough made with high percentage of unsaturated oil is generally more cohesive, viscous as well as softer. In another report, O'Bien *et al.* (2003) also stated that the amount of solid fat influences the properties of dough. According to Mamat *et al.* (2012), the dough should be not too firm or too soft in order to produce satisfactory cookie product. Among all the samples, the hardness values shown by dough samples made out of PGO-2 (7.56N) were comparably similar to that made with LD (8.46N) which produced the appropriate dough for satisfactory cookies.

Rheology

The relationship of G', G" and tan δ of dough for different blends of shortening were presented in Table 1. Rheology in food processing can help to predict acceptability and dough handling which presents information with regard to deformation and matter flow (Zaidel *et al.*, 2010). Rheological properties are usually related to the quality characteristics of end-product such as texture and loaf volume of bread (Sudha *et al.*, 2007) as well as sensory attributes (Lazaridou *et al.*, 2007). The characteristic for the structure of dough which is typical viscoelastic system was observed by the domination of storage modulus (G') over the loss (G"). Tan δ is a viscoelastic parameter that indicated the elasticity and viscosity of the dough, which should be less than 1 (Ljubica *et al.*, 2014). According to Table 1, there were big differences ($p < 0.05$) in the values of G' and G" of dough made out of LD and doughs made out of PGO-1, PGO-2, PGO-3 and PGO-4. The data presented also showed that G' was higher than G" for each sample with the tan δ values was less than 1. This was similar to the observation made in the previous study reported by Sciarini *et al.* (2013) where tan δ values with less than 1 indicating a solid elastic behavior of the doughs. In fact, this was in agreement with the findings reported by other research workers namely, Ahmed *et al.* (2012) and Lahiji *et al.* (2013).

Table 2. Hardness, size (thickness and width) and colour of cookies made out of PGO-1, PGO-2, PGO-3, PGO-4 and lard

Sample	Hardness (N)	Thickness (mm)	Width (mm)	Colour		
				*L**	*a**	*b**
PGO-1	16.77±0.38[a]	13.64±0.09[a]	65.68±0.24[a]	71.61±1.11[b]	2.52±0.02[a]	23.47±0.05[a]
PGO-2	13.43±1.46[b]	13.68±0.39[a]	66.37±0.60[a]	73.02±1.72[ab]	0.58±0.06[c]	20.58±0.66[b]
PGO-3	10.09±1.65[c]	13.72±0.44[a]	66.75±0.96[a]	75.08±0.08[a]	0.48±0.05[d]	19.98±0.76[b]
PGO-4	8.69±1.17[c]	14.53±0.39[a]	67.66±0.44[a]	75.21±0.28[a]	0.2±0.02[e]	16.98±0.4[c]
Lard	14.48±2.07[ab]	13.94±0.37[a]	66.54±1.25[a]	72.97±0.8[ab]	1.83±0.02[b]	21.22±0.43[b]

Each value in the table represents the mean of three replicates ± standard deviation. Means within each column bearing different superscripts are significantly ($p < 0.05$) different. L^*, lightness, a^*, red and green and b^*, yellow and blue.

According to Mirsaeedghazi *et al.* (2008), addition of solid fat has plasticizing effect on G' and G" inelastic region. This can be clearly seen from Table 1, where dough made out of PGO-1 with higher content of palm stearin displayed the highest values of G' and G" when compared to other dough samples. These results were comparable to the findings reported by Ahmed *et al.* (2012), who studied the elasticity derived from the fat crystal during small oscillation tests. During shortening preparation, the formation of larger crystals was enhanced by the molecular mobility due to the decreasing solid fat content (Himawan *et al.*, 2006). Among all samples, dough made out of PGO-2 displayed elasticity behavior, which was closely similar to the elasticity behavior displayed by dough made with LD due to the closer tan δ values which were 0.54 for PGO-2 and 0.53 for LD.

The thermal profiles of cookie dough samples made out of different PGO-PS blends and LD are compared as shown in Figure 1. The thermograms of various dough samples made out of different PGO-PS blends presented similar profile pattern by having a single thermal transition in between 55.76 and 57.23°C. Although thermograms of cookie dough made out of LD also displayed a similar profile, the position of the peak temperature of the thermal transition was found at 41.28°C. In parallel to the findings reported by Sciarini *et al.* (2013), these peaks of thermal transitions indicated the melting of fat from shortening in the dough. As showed in Figure 1, the DSC thermal transitions of dough made out of PGO-PS blends do not tally exactly with those of LD due to slight differences in their fatty acid and TAG compositions.

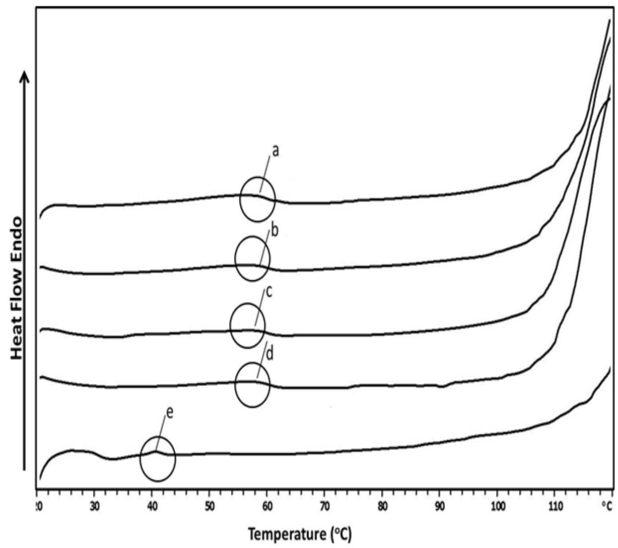

Figure 1. Melting profile of dough made with PGO-1 (a), PGO-2 (b), PGO-3 (c), PGO-4 (d) and lard (e)

Evaluation of Cookie Characteristics

Hardness of cookies.

The data presented in Table 2 compares hardness, thickness, width and colour of cookie samples made out of PGO-1, PGO-2, PGO-3, PGO-4 and LD. In baked goods, the hardness plays an important role as it may contribute to the freshness of products (Karaoğlu and Kotancilar, 2009). According to Table 2, the cookies made out of PGO-1 displayed the highest value of force (16.77N), followed by those made out of LD (14.48N), PGO-2 (13.43N), PGO-3 (10.09N) and PGO-4 (8.69N). This tends to mean that cookie made out of PGO-1 was the hardest while those made out of PGO-4 was the softest. This was due to a higher proportion of solid fat (palm stearin) in PGO-1 when compared to PGO-4. Previously, Zohng (2013) stated that higher solid content in oil portion resulted in hardening cookies texture. A similar result was also reported by O'Brien *et al.* (2003) who found that higher breaking strength needed to break cookies made with high solid fats. Besides this, the high values of force can also be affected by other factors which include loss of water holding capacity and solubilization of proteins and coagulation. It also could be due to the large amounts of air that cannot be retained in the system. Hence, it would cause the cookies texture to become harder (Kamel, 1994; Jacob and Leelavathi, 2007). On the other hand, cookies made out of PGO-2 and LD showed closer values to each other while the results were significantly different ($p < 0.05$) from those cookies made out of PGO-3 and PGO-4. According Manley (2000), fat and aqueous phase components compete with each other for the surface of flour particles. When the fat coats the flour before it is hydrated, the gluten would be interrupted and made the cookies softer. Thus, the cookies made out of PGO-3 and PGO-4 were not as effective in competing with the water (Mamat and Hill, 2012). Among the sample blends used in this study, the hardness of cookies made out of PGO-2 was the closest to those made with LD.

Size and thickness

Size and thickness of the cookies are shown in Table 2. Cookies made out of PGO-1 showed the lowest value of thickness (13.64 mm) and width (65.68 mm) followed by cookies made out of PGO-2 with the thickness value of 13.68mm and width value of 66.37mm. On the other hand, cookies made out of PGO-4 showed the highest value of thickness (14.53 mm) and width (67.66 mm). Pareyt and Delcour (2008) reported that spread rate, set time of the dough as well as types of shortening controlled the final diameter of cookies. According to Maache Rezzoug *et al*. (1998), the added fat types also would contribute to the width and thickness of the cookies. During baking, the dough would spread due to the melting of fat until the structure was finally set owing to an increase in the dough viscosity (Doescher and Hoseney, 1985). This is also in agreement with the findings reported by other researchers namely, Jacob and Leelavathi (2007) and Ahmadi and Marangoni (2009) where cookies made of highly unsaturated oil produced higher spread value than others. In a separate study, Zohng (2013) has reported the effect of lipid source in shortening on the size of cookies where a higher portion of liquid oil gave larger spread when compared to those made with high solid fat. Data from Table 2 showed that there was no significant difference for the values of thickness and width for all types of samples.

Colour of the cookies

The colour values of cookies baked with the formulated shortenings and lard are compared as shown in Table 2. Measuring colour is one of the important practices during baking as brown pigments appear due to Maillard browning and caramelization reactions. Beside this, other factors such as temperature, air velocity, moisture and heat transfer were also reported to have an influence on the colour development in the end product (Moss and Otten, 1989; Shibukawa *et al*., 1989; Goldstein and Seetharaman, 2011). L^* value generally indicates the darkness and brightness (lightness) of the cookies (Pereira *et al*., 2013). According to the data presented in Table 2, the value displayed by PGO-1 was significantly ($p<0.05$) different from those of PGO-3 and PGO-4. Cookies made out of PGO-1 and PGO-2 shortenings showed the lowest L^* value of 71.61 followed by LD with 72.97 and PGO-2 with 73.02. The lower value for L^* would represent the deep darkness of the surface of the cookie which could be attributed to more intense caramelization reactions during baking (Martins *et al*., 2001; Sciarini *et al*., 2013). Besides this, the darkening of the surface might also be due to direct contact of the cookies during baking process with hot air, which had a higher temperature in the oven tray. Positive a^* value indicated red colour predominance over the green (Pereira *et al*., 2013). The high value of a^* could be attributed to caramelization of sugar and darkening of cookies during baking. As shown in Table 2, the results obtained were not significantly ($p>0.05$) different for each type of cookies. Cookies made out of PGO-1 produced higher redness (2.52) when compared to those made out of PGO-4 (0.20). It was also found that redness of the cookies increased with the increasing of fat content in the shortening. Positive b^* value designates the strong predominance of yellow colour, in disfavor of the blue (Pereira *et al*., 2013). As it can be observed from the Table 2, all the values of b^* were positive which showed the yellowness of the cookies. The most yellowness was observed among cookies made out of PGO-1 (23.47) followed by LD (21.22) and PGO-2 (20.58). It was also observed that high content of fat in the shortening gave more yellowness to the cookies. On the other hand, cookies made out of high content of liquid oil (PGO-4) produced less yellowness with the lowest value (16.98). The values were not significantly ($p<0.05$) different for PGO-2, PGO-3 and LD. From Table 2, cookies made out PGO-1 and PGO-2 showed closely similar values to cookies made out of LD.

Surface appearance of the cookies

The appearance and quality of the cookies is also influenced by cracking pattern of the surface. The surface cracking pattern of cookies made out of PGO-1, PGO-2, PGO-3, PGO-4 and LD are shown in Figure 2. Previously, Doescher and Hoseney (1985) commented that there were many factors, which would affect the surface cracking on cookies. Besides the type of lipid used other factors such as moisture, types of flour, type of sugar and time interval before adding sugar have some influence. Cookies made out of PGO-1 and PGO-2 (high solid content) showed smaller cracking while PGO-4 (high liquid oil content) showed larger cracking on the top. This was similar to the findings previously reported by Jacob and Leelavathi (2007) who stated that cookies made out of the high content of liquid oil produced larger cracking compared to cookies made out of solid fat. Large size islands on the top of the cookies might be due to the high percentage of oil while a high percentage of fat produced smaller size islands. According to another study reported by Pareyt *et al.* (2009), high content of solid fat in formulation produced less cracking on the top of cookies. However, Pareyt *et al.* (2009) highlighted that different levels of sucrose could also be another reason to the uneven surface and cracking pattern on cookies. According to the Figure 2, cookies made out of PGO-1 and PGO-2 showed the surface cracking appearance that was closely similar to cookies made out of LD.

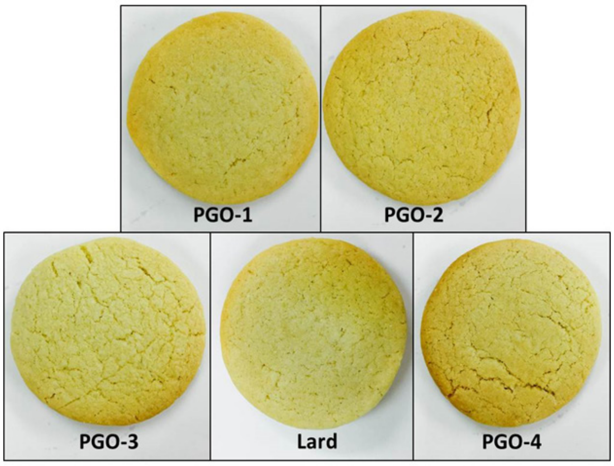

Figure 2. Surface cracking pattern on cookies made out of PGO-1, PGO-2, PGO-3, PGO-4 and lard

Conclusion

Shortening made out of Pink guava seed oil-Palm stearin (PGO-PS) was able to perform well to give a good quality cookie. Generally, the acceptability of cookies was highly influenced by hardness, fracturability and appearance. Among the samples, PGO-2 displayed the closest of lard in cookies for hardness, size and thickness, cracking size as well as colour. Cookies made out of PGO-2 with the ratio 45:55 (PGO:PS) performed the best substitute for lard to be used as shortening in cookies. As the shortenings used were formulated using plant based ingredients, they are compatible with the halal and toyyiban requirements. However, several applications can be done to establish the use of PGO-PS shortening either in food or non-food products in future.

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