International Food Research Journal 26(1): 237 - 245 (February 2019)

Journal homepage: *http://www.ifrj.upm.edu.my*

Effects of soy milk on physical, rheological, microbiological and sensory properties of cake

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Article history

Received: 16 January, 2018
Received in revised form: 28 June, 2018
Accepted: 11 July, 2018

Keywords

Cake development
Soy milk
Sensory properties
Batter
Rheological properties
Microbiology assay

Abstract

The aim of the present work was to produce a new soy milk-based cake. Soy milk was added at different percentages (0, 25, 50, 75, and 100%) during cake making to replace milk. Nutritional composition, batter characteristics, physical, and sensory properties, as well as the stability of cake during storage, were investigated. Sensory results indicated that cake with 50% soy milk had the most favourable acceptance scores with the highest score in the aroma, colour, and taste attributes. The addition of soy milk up to 50% produced a cake with higher protein content and lower carbohydrate content, along with lower density and higher specific volume compared to control. Cake with 50% soy milk addition had lower microbial counts as compared to control. Therefore, soy milk has the potential to act as a milk replacer in cake production.

Introduction

Bakery products are widely consumed around the world and becoming a major component of the international food market. Cakes are one of the most important products in the bakery industry. According to Wilderjans *et al*. (2013), the market for cake grows about 1.5% per year. Bakery products have always been used to deliver important food components in the human diet (Majzoobi *et al*., 2014).

Soybean (*Glycine max* (L.) Merr.) which contains high protein content is suitable to be added into bakery products (Shurtleff and Ayogi, 2013). Soybean is also known to have high nutritional values and is always associated with health benefits (Lite, 2006). One of the most important components in soybean is isoflavone which is within the range of 300 - 3,000 µg/g (Mariane, 2011). Hsu *et al*. (2010) reported that isoflavones exhibit physiological activities such as inhibiting cancer cell proliferation, reducing cardiovascular disease, preventing osteoporosis and alleviating hot flashes in menopausal women. Additionally, among legumes, soybean contains the highest protein content which is around 35 to 40%, and it is considered to be a source of complete protein as soybean contains all the essential amino acids (Jooyandeh, 2011). Soybean protein has high digestibility, about 92 to 100%, and can be easily absorbed by the body (Singh *et al*., 2008). Proteins provide many functional benefits. Functional properties can be defined as physical and chemical properties that influence the behaviour of proteins in food system during processing, storage, cooking and consumption (Jideani, 2011). In bakery products, those functional properties are important to determine the quality of the final products such as sensory, physicochemical and organoleptic properties (Rahmati and Tehrani, 2014). Soybean oil is low in saturated fat (≈15%) and rich in essential fatty acids. For unsaturated fats, the amount of poly and mono-unsaturated fatty acids are 15% and 61%, respectively (Jooyandeh, 2011). Soybean oil also contains α-linoleic acid (8%) which is an omega-3 fatty acid beneficial in lowering the risk of heart diseases (Perkin, 2015). Soybean contains a large amount of soluble carbohydrates (sucrose, raffinose, stachyose). Soybean has also been found to be a good source of several minerals that are needed for optimal health, including potassium, sodium, calcium, magnesium, sulphur, and phosphorus (Riaz, 2006).

Soy milk is a milky liquid that is made from the soybeans. It is typically produced by cleaning the soybeans to remove dirt, spoiled beans, and extraneous matter; soaking (hydrating) the beans to facilitate grinding and extraction of soluble solids; grinding the soaked soybeans to extract the solids; filtering to remove the insoluble portions of the

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Table 1 List of formulations for soymilk-based cakes.

Raw materials	Formulation of soymilk-based cake (g)				
	0%	25%	50%	75%	100%
Soymilk	0	60	120	120	240
Milk	240	180	120	60	0
Flour	220	220	220	220	220
Sugar	120	120	120	120	120
Margarine	60	60	60	60	60
Baking powder	8	8	8	8	8

beans; and boiling to destroy trypsin inhibitor and to improve flavour. Soy milk is one of the important traditional and low-cost beverages that have been consumed widely for centuries in Asian countries including China, Japan, Korea, Thailand, Malaysia and Singapore (Jiang *et al*., 2013). The absence of lactose in soy milk makes it a suitable choice of food for people with lactose intolerance (Ikya *et al*., 2013).

Nowadays, consumers have become better informed about food nutrition, with emerging in interest in healthy eating. The development of food formulations with low-fat and reduced-calorie is therefore more preferable to consumers (Singh *et al*., 2008). Furthermore, the market for functional foods is growing year by year around the world (Majzoobi *et al*., 2014). Hence, the present work attempted to develop a new functional cake using soy milk.

Materials and methods

Soy milk preparation

Soybeans were soaked in water at 28°C for 16 h to soften the hulls. After soaking, the hulls were removed. Next, the soybeans were blanched with water at 80°C for 2 min to minimise soybean odour generation during soy milk production (Yuan *et al*., 2008). After that, water at 60°C was added to soybeans at a ratio of 8:1 (water:soybean) and blended with a blender (Panasonic, MX-337, Japan) to obtain soybean slurry. The soybean slurry was filtered using cheese cloth to obtain the filtrate (soy milk). Soy milk was heated at 80°C for 15 min, followed by cooling to ambient temperature. The soymilk was then refrigerated until further analyses (Prabhakaran and Pepera, 2006).

Cake formulation

Cakes with five different formulations were produced following the method of Thompson (2015) with slight modification. Milk was substituted with soymilk at different levels of 0% (100% milk:0% soy milk), 25% (75% milk:25% soy milk), 50% (50% milk:50% soy milk), 75% (25% milk:75% soy milk) and 100% (0% milk:100% soy milk). The cake with 0% soy milk served as the control. Table 1 shows the list of formulations for control and soy milk-based cakes.

Cake preparation

To prepare cake samples, first, margarine and sugar were mixed using a mixer (Sinmag, sm-201, Taiwan) for 3 min. Then, based on the formulations (Table 1), different percentages of milk and soy milk were added into the batter. After that, all sifted dry ingredients (flour, corn starch, and baking powder) were added gradually into the batter and mixed for 3 min. Then, the cake batter was transferred into cake pan and baked in preheated oven (Sinmag sm-944f, Taiwan) at 200°C for 40 min (Thompson, 2015). After baking, the cakes were cooled down for 1 h at room temperature. Then, the cakes were stored in Low-Density Polyethylene (LDPE) bags at room temperature for further analysis.

Physical properties analysis

Batter specific gravity

Batter specific gravity was calculated by dividing the weight of cake batter to the weight of an equal volume of water (Majzoobi *et al*., 2014). The specific gravity was calculated using Equation 1 as follows:

$$\text{Specific gravity} = \frac{W_1\text{-}W_0}{W_2\text{-}W_0} \qquad \text{(Eq. 1)}$$

where W_0 was the weight of the empty container, W_1 was the weight of cake batter-filled container and W_2 was the weight of the water-filled container.

Batter yield

Batter yield is important in determining the amount of portion that could be produced from a single batter (Kim *et al*., 2012). Batter yield was calculated in weight basis by using Equation 2 as follows:

$$\text{Batter yield (\%)} = \frac{\text{(Weight of cake)}}{\text{(Weight of batter)}} \times 100\% \qquad \text{(Eq. 2)}$$

Baking loss

The baking loss, also known as moisture loss, is related to the structural formation and water diffusion during baking (Rahmati and Tehrani, 2015). The baking loss was calculated using Equation 3 as follows:

$$\text{Baking loss (\%)} = \frac{\text{(Weight of batter-Weight of cake)}}{\text{(Weight of cake)}} \times 100 \quad \text{(Eq. 3)}$$

Cake specific volume and density

The cake specific volume and density were determined using rapeseed displacement method according to AACC (2000). The specific volume of the cake was calculated by dividing the cake volume to cake weight. First, an empty container was filled up with rapeseed and the volume was measured using graduated cylinder (V_1). Then, cake was placed into the container and filled up with rapeseed. The volume of rapeseed that used to fill up the container with cake was measured using graduated cylinder (V_2). After that, the weight of cake was measured after removing from container using electronic balance (W). The specific volume and density of cake were calculated using Equations 4 and 5 as follows:

$$\text{Specific volume (cm}^3\text{ g}^{-1}) = \frac{(V_1 - V_2)}{W} \quad \text{(Eq. 4)}$$

$$\text{Density (g cm}^{-3}) = \frac{W}{(V_1 - V_2)} \quad \text{(Eq. 5)}$$

where W was the weight of the cake, V_1 was the volume of rapeseed that filled up the empty container and V_2 was the volume of rapeseed that filled up the container with cake.

Rheological properties analysis

Batter viscosity

Batter viscosity was determined using viscometer (Brookfield, UK). First, cake batter was transferred into a beaker and then levelled up to the brim. The spindle speed was set to 20 rpm, and spindle number seven was used. This experiment was carried out at room temperature (Ashwini *et al*., 2009).

Batter emulsion stability

Batter emulsion stability was determined using a centrifuge (Kubota, Japan). The cakes' batter was centrifuged at 5,000 rpm for 15 min (Rahmati and Tehrani, 2014), and the stability of the batter emulsions was calculated using Equation 6 as follows:

$$H\ (\%) = H_1 / H_0 \times 100\% \quad \text{(Eq. 6)}$$

where H was the emulsion stability percent, H_1 was the height of stable emulsion remained in the tube after centrifugation and H_0 was the initial height of batter transfer into the tube.

Cake texture

The cake texture was evaluated using a texture analyser (Stable Micro System, TA. XTPLUS, UK). Four texture characteristics namely hardness, cohesiveness, springiness, and chewiness, were analysed to measure the cake texture. To determine the texture of cake, the crust of cake was removed and cake crumb sample was cut into cubic shape (3 × 3 × 3 cm). A 25 mm diameter aluminium cylindrical probe was used to perform a double compression test. The cake crumb was compressed to 50% of its initial height at a test speed of 2 mm/s with a 30-second interval between first and second compression. The value of texture characteristics was calculated from texture profile analysis (TPA) curve (Barcenilla *et al*., 2016).

Proximate analysis

Proximate analysis was carried out to determine the proximate content of soymilk-based cakes including moisture, ash, crude protein, crude fat, crude fibre, and carbohydrate contents. In addition, the proximate content of soymilk and milk that used in cake preparation was also determined. All proximate analysis was conducted according to AOAC (2000).

Sensory evaluation

Sensory evaluation was conducted by 50 untrained panellists who were randomly selected from the Faculty of Food Science and Nutrition, Universiti Malaysia Sabah. Cake samples were cut into uniform cubes (2 × 2 × 2 cm). There were six attributes, namely aroma, colour, appearance, taste, texture, and overall acceptance, which were evaluated using a nine-point hedonic scale based on the intensity of the preference of panellists where, 1 indicated "extremely dislike", 5 indicated "neutrality", and 9 indicated "extremely like" (Chow and Wan, 2014).

Shelf life analysis

Soymilk-based cakes were each packed in low density polyethylene (LDPE) bag and stored at room temperature (25°C). The shelf life of the product was determined by microbiological assays. Microbiology assays were used to determine the changes of microbes' number during storage.

Sample preparation

To prepare sample for microbiological assay, 10 g sample with 90 mL peptone water were homogenised using a stomacher (Interscience, Malaysia).

Standard Plate Count

The pour plate method was applied to conduct the Standard Plate Count (SPC). The plate count agar (PCA) was used as the culture medium. The number of colonies on the plate were counted using a colony counter after incubation within the range of 30 to 300 (Brown, 2012). The SPC of the sample was calculated using Equation 7 as follows:

$$\text{SPC (CFU/g)} = (\text{No. of colony})/(\text{Dilution factor} \times \text{Sample volume}) \qquad (\text{Eq. 7})$$

Yeast and Mould Count

Pour plate method was applied to conduct total the Yeast and Mould Count (YMC). The potato dextrose agar (PDA) was used as culture the medium (Barcenilla *et al*., 2016). The number of colonies on the plate were counted using a colony counter after incubation within the range of 30 to 300 (Brown, 2012). The YMC of cake sample was also calculated using Equation 7.

Statistical analysis

All experiments were conducted in triplicate. The data from each experiment was analysed for significance differences among samples by one-way Analysis of Variance (ANOVA) using SPSS version 22.0 software. Tukey's Honestly Significant Difference (HSD) test was applied as post hoc test. For proximate analysis of milk and soymilk, independent t-test was applied to analyse the significant difference. For sensory evaluation, data collected from the hedonic test was analysed using Friedman test, and Wilcoxon Signed Ranks test was applied as post hoc test. The significant level was established at $p < 0.05$ with 95% confidence level.

Results and discussion

Proximate analysis of milk, soymilk and cake

Table 2 illustrates the proximate composition of milk, soymilk and cakes with different levels of soymilk addition. Excluding ash, the proximate composition of milk had a significant ($p < 0.05$) difference when compared to soymilk. Soymilk had higher nutritional profile than milk which could result in a higher nutritional composition in a cake added with soymilk.

Replacing milk with soymilk in the cakes had a significant ($p < 0.05$) effect on the nutritional composition. According to Rahmati and Tehrani (2015), soymilk could perform effectively in absorbing and holding water in order to retain the moisture of cake. They reported similar result in which the addition of soymilk in cake resulted in lower moisture loss and higher moisture content than cake without soymilk addition. In addition, the crude fat and protein contents significantly ($p < 0.05$) increased with the addition of soymilk. These results were obtained due to higher crude fat and crude protein contents in soymilk than milk (Table 2). Furthermore, there was no significant difference in crude fibre content (to 50% addition). The carbohydrate content of cake was found to be significantly ($p < 0.05$) decreasing with soymilk addition. On the basis of proximate analysis of cake, it could be concluded that the substitution of milk with soymilk in cakes modified the nutritional value leading to higher protein and lower carbohydrate contents.

Physical properties analysis

Batter yield and baking loss

Table 3 illustrates the results of baking loss and batter yield. Cake with soymilk addition showed significantly ($p < 0.05$) higher batter yield which indicated that batter with soymilk addition might

Table 2 Proximate composition of milk, soymilk, and cake with different levels of soymilk addition.

		Content (%)					
		Moisture	Crude Fat	Crude Protein	Ash	Crude Fibre	Carbohydrate
Milk		88.30 ± 0.042^{B}	0.13 ± 0.002^{B}	2.60 ± 0.008^{B}	0.23 ± 0.024^{A}	-	8.66 ± 0.009^{A}
Soymilk		93.78 ± 0.038^{A}	0.66 ± 0.013^{A}	3.70 ± 0.015^{A}	0.25 ± 0.043^{A}	0.09 ± 0.001	1.51 ± 0.004^{B}
Cake	Control	36.69 ± 0.007^{d}	6.34 ± 0.023^{d}	4.38 ± 0.022^{d}	1.03 ± 0.003^{b}	0.44 ± 0.002^{c}	51.12 ± 0.057^{a}
	25%	37.31 ± 0.266^{c}	$6.46 \pm 0.025^{c,d}$	4.47 ± 0.013^{c}	1.03 ± 0.002^{b}	$0.44 \pm 0.004^{b,c}$	50.28 ± 0.230^{b}
	50%	37.63 ± 0.001^{c}	$6.61 \pm 0.015^{b,c}$	4.61 ± 0.021^{b}	1.03 ± 0.004^{b}	$0.45 \pm 0.002^{b,c}$	49.67 ± 0.009^{c}
	75%	38.46 ± 0.151^{b}	$6.75 \pm 0.011^{a,b}$	4.66 ± 0.008^{b}	1.05 ± 0.003^{a}	$0.45 \pm 0.003^{a,b}$	48.63 ± 0.138^{d}
	100%	39.69 ± 0.045^{a}	6.91 ± 0.141^{a}	5.32 ± 0.039^{a}	1.05 ± 0.003^{a}	0.46 ± 0.001^{a}	46.57 ± 0.152^{e}

[1]mean ± standard deviation (SD) with different uppercase superscripts indicate significant differences between milk and soymilk.
[2]mean ± standard deviation (SD) with different lowercase superscripts indicate significant differences among cakes with different formulations.

Table 3 Effect of soymilk addition on physical properties, cake crumb texture, and sensory attributes of cakes.

Cake	Physical properties (%)				
	Batter yield	Baking loss	Batter specific gravity[2]	Cake specific volume (cm^3/g)	Cake density (g/cm^3)
Control	86.11 ± 0.348[b,c]	15.10 ± 0.129[a]	1.34 ± 0.003[a]	1.57 ± 0.057[d]	0.62 ± 0.006[a]
25%	86.66 ± 0.212[b,c]	14.48 ± 0.279[a,b]	1.21 ± 0.007[b]	1.64 ± 0.006[c,d]	0.60 ± 0.004[a]
50%	87.27 ± 0.329[a,b,c]	13.10 ± 0.093[b,c]	1.13 ± 0.001[c]	1.72 ± 0.018[b,c]	0.59 ± 0.009[a,b]
75%	87.35 ± 0.445[a,b]	13.41 ± 0.014[c,d]	1.08 ± 0.003[d]	1.77 ± 0.023[b]	0.53 ± 0.028[b]
100%	88.13 ± 0.056[a]	12.37 ± 0.488[d]	1.02 ± 0.015[e]	2.14 ± 0.005[a]	0.47 ± 0.001[c]

Cake	Texture Parameters			
	Hardness (g)	Cohesiveness[2]	Springiness[2]	Chewiness (g)
Control	384.86 ± 1.53[d]	0.60 ± 0.003[d]	1.00 ± 0.00[a]	231.57 ± 0.33[e]
25%	419.45 ± 0.60[c]	0.61 ± 0.003[c]	1.00 ± 0.00[a]	257.98 ± 0.96[d]
50%	422.85 ± 0.40[c]	0.64 ± 0.003[b]	1.00 ± 0.00[a]	269.43 ± 1.20[c]
75%	461.94 ± 2.32[b]	0.64 ± 0.004[b]	1.00 ± 0.00[a]	296.73 ± 0.19[b]
100%	567.27 ± 5.10[a]	0.69 ± 0.001[a]	1.00 ± 0.00[a]	389.47 ± 3.85[a]

Cake	Sensory attributes[3]				
	Aroma	Colour	Taste	Texture	Overall acceptability
Control	6.16 ± 1.44[a]	6.34 ± 1.14[a]	5.88 ± 1.31[a]	5.74 ± 1.51[a]	5.96 ± 1.37[a,b]
25%	5.86 ± 1.50[a]	6.18 ± 1.37[a]	5.90 ± 1.52[a]	6.06 ± 1.27[a]	6.04 ± 1.47[a,b]
50%	6.24 ± 1.42[a]	6.46 ± 1.11[a]	6.16 ± 1.36[a]	6.04 ± 1.38[a]	6.44 ± 1.11[a]
75%	5.70 ± 1.31[a]	6.16 ± 1.35[a]	5.72 ± 1.37[a]	6.04 ± 1.09[a]	6.08 ± 1.07[a,b]
100%	5.86 ± 1.31[a]	6.16 ± 1.32[a]	5.70 ± 1.64[a]	5.60 ± 1.60[a]	5.80 ± 1.40[b]

[1]mean ± SD with different superscript down the column are significantly different by Tuckey's HSD test at $p < 0.05$.
[2]Batter specific gravity, cohesiveness and springiness parameters are dimensionless.
[3]mean rank ± SD with different superscript down the column are significantly different by Wilcoxon Signed Ranks Test at $p < 0.05$.

produce higher cake portion in terms of weight as compared to control. Majzoobi *et al*. (2014) reported similar results in terms of soy protein isolate and soymilk. By referring to the Table 3, the cake baking loss decreased significantly ($p < 0.05$) with the addition of soymilk. Therefore, this result shows that soymilk had higher water-holding capacity that retained more water in the batter as compared to control, and resulted in fewer water vapours escaping from the surface. Rahmati and Tehrani (2015) stated the similar result in which cake with soymilk addition experienced lower baking loss.

Batter specific gravity, cake specific volume, and cake density

Data related to batter specific gravity, cake density, and specific volume are shown in Table 3. Batter specific gravity significantly ($p < 0.05$) decreased from 1.34 in control to 1.02 in cake with 100% soymilk addition. This indicates that more air could be retained in the batter during mixing by increasing the soymilk level. The expansion of cake products comes from the volume of air bubbles entrapped in the cake batter. The specific volume of the cake is dependent on the batter specific gravity (Gomez *et al*., 2007). Similar observations were made for the cake with soymilk. The cake specific volume significantly ($p < 0.05$) increased with soymilk addition. Zhou *et al*. (2011) reported that the final cake volume is possibly influenced by the capacity of batter in retaining air cells during mixing or baking instead of the quantities of air cells contained in the batter. Moreover, reports from Sahin (2007) indicated that final volume of cake was significantly affected by the protein content of cake, which is in agreement with the results of the present work. Additionally, Gomez *et al*. (2007) stated that the ability of the protein to retain air in batter was more important than the quantities of air present in the batter while determining the volume of cake. Therefore, higher amount of soymilk, as observed from baking loss determination, might help in absorption moisture and gave out better leavening effect which resulted in higher cake volume. Previous reports indicated that the substitution of eggs by soy protein isolate (SPI) led to a significant increase in the batter specific gravity and a decrease in the specific volume with respect to control (Lin *et al*., 2017). The limitations of SPI in terms of foam stability and gelling properties were responsible for the poor specific volume in eggless cakes (Xie

& Hettiarachchy, 1998). According to Table 3, cake density significantly ($p < 0.05$) decreased with soymilk addition.

Rheological properties analysis

Batter viscosity and batter emulsion stability

Figure 1 shows the batter viscosity and emulsion. Increasing the level of soymilk in cake led to a significant ($p < 0.05$) increase in the viscosity of batter (Figure 1). Control had the lowest viscosity whereas cake with 100% soymilk addition had the highest. The increase in batter viscosity could be related to the higher water binding capacity of soymilk as compared to milk. This is because higher water binding capacity might reduce free water in batter and led to a higher value in viscosity. In addition, Gomez *et al*. (2012) reported that the addition of the protein fraction led to an increase in batter viscosity. Moreover, Lin *et al*. (2017) found that the viscosity of the eggless cake batter containing SPI was significantly higher than control. Therefore, the increase in batter viscosity might also be due to higher protein content in soymilk as compared to in milk (Table 2).

Based on Figure 1, the batter emulsion stability significantly ($p < 0.05$) increased with milk addition. Control's batter yielded the lowest stability whereas cake with 100% soymilk addition showed the highest. This result indicates that soymilk might have higher emulsifying ability than milk. Chen *et al*. (2013) reported similar result in which the soybean protein showed better ability in reducing and stabilising interfacial tension in the cake batter. Rahmati and Tehrani, 2014 also reported similar findings, in which soymilk was more susceptible in stabilising oil-in-water emulsion.

Cake texture (crumb)

Table 3 shows the data of texture parameters obtained from cakes' crumb. The hardness of the cake significantly ($p < 0.05$) increased with soymilk addition. Control had the softest texture whereas cake with 100% soymilk addition had the hardest. This result is in line with several studies which also found

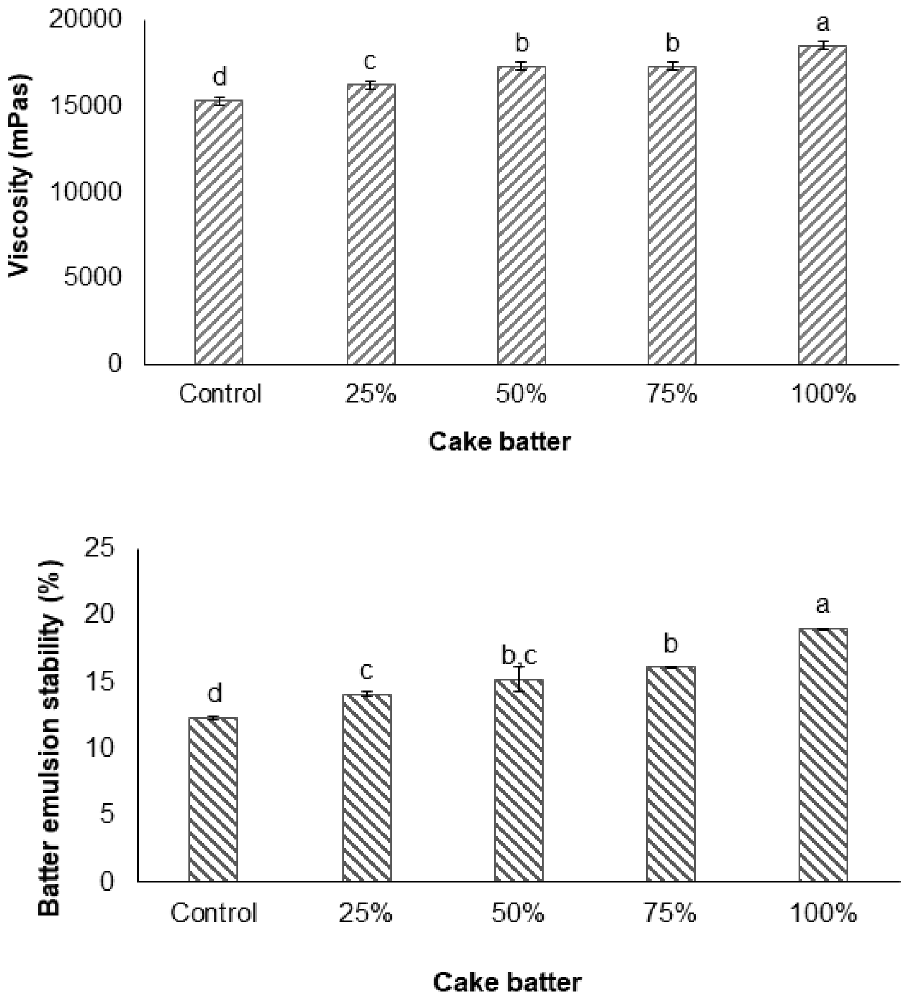

Figure 1 The effect of soymilk on cake batters' viscosity and emulsion stability.

that higher soybean protein led to higher hardness in bakery products (Nilufer-Erdil *et al*., 2012). Lin *et al*. (2017) reported that the replacement of eggs by SPI increased the hardness of the eggless cake. In terms of protein content, the increase in crumb hardness might be due to the strengthening of the crumb structure by the protein particles, and coagulation of protein during baking leads to the densest cake (Paraskevopoulou *et al*., 2015). Therefore, cake with soymilk addition had harder crumb as compared to control (Table 3). According to Table 3, the cohesiveness of cake significantly ($p < 0.05$) increased with soymilk addition in the cake. Control obtained the lowest cohesiveness value whereas cake with 100% soymilk addition obtained the highest. This indicates that the cake with soymilk addition was less susceptible to getting a fracture or crumble. It also expresses that soymilk protein formed a structure network with greater strength. Based on Table 3, there was no significant ($p > 0.05$) difference among cake samples in terms of springiness. Similar results also had been reported by Rahmati and Tehrani (2015) in which the addition of soymilk in cake showed no significant difference in springiness value. The constant value in springiness also indicated that the structures formed in the cake were strong enough to maintain the elasticity of the product. The addition of soymilk in cake also significantly ($p < 0.05$) increased the chewiness of cake. Similar results were also reported by Majzoobi *et al*. (2014) who stated that cake chewiness increased along with soymilk addition.

Sensory evaluation

Assessment of cake quality by sensory evaluation largely depends on personal and subjective judgement towards cakes. The result cannot be absolute but reflect the consumer preferences. Table 3 shows the mean scores of sensory attributes of the cake as perceived by the panellists. Except for overall acceptability, there was no significant ($p > 0.05$) difference between treatments among any of the sensory attributes. In general, for every sensory attribute, all cake samples received mean score of more than 5.60 which reflected the relatively high degree of likeness of panellists towards the cake samples, and that all formulations were acceptable. The cake with 50% soymilk addition received the highest score for aroma attribute whereas cake with 75% soymilk addition received the lowest. Additionally, cake with 50% soymilk addition received the highest mean score in taste attribute whereas cake with 100% soymilk addition received the lowest. The mean score was increased by addition of soymilk up to 50%, and decreased with further increase in soymilk content. This indicates that the addition of up to 50% soymilk might improve the taste of the cake, while further increase in soymilk reduced the score given to the taste and was less preferred by the panellists. Cakes with 50% and 75% soymilk addition also received a relatively high mean score in texture attribute whereas control sample received a relatively low mean score. On the basis of sensory evaluation, cake with 50% soymilk addition was more preferable by the panellists in which the cake received the highest values in all attributes in comparison with all other samples.

Shelf life analysis

Microbiological assays

To determine the microbiological quality of cake samples, two microbiological assays, namely SPC and YMC, were conducted. The duration of shelf life analysis was five days. Based on observation of microbial growth, moulds started to grow on day 2 of storage. Table 4 shows the microbial counts of cake samples with different soymilk levels during storage. By comparing between cake samples, except at day 3, increasing soymilk content significantly ($p < 0.05$) decreased total viable counts in the cake samples. However, the decrement was significant on the cake with 50% soymilk addition.

At day 0, cake with 100% soymilk addition had the lowest total viable counts whereas control had the highest. Throughout storage time, cake with 100% soymilk addition remained with the lowest total viable counts whereas control had the highest total viable count. It was likely due to higher carbohydrate content in control as compared to cake with 100% soymilk addition. Food products with high carbohydrate content could be more susceptible to microbial growth. This is because carbohydrate is the easiest nutrient source to support this growth. Nilufer-Erdil *et al*. (2012) reported similar results for using soymilk powder in producing bread. Therefore, the result in the present work indicated that bakery product with soymilk might have longer shelf life as compared to bakery products with milk.

The total viable count of cakes significantly ($p < 0.05$) increased from day to day (Table 4). Considering the storage temperature, room temperature might have influenced microbial growth in the cake. This is because room temperature is the optimum temperature that supports microbial growth in a more rapid manner (Niwawi *et al*., 2016). The YMC and SPC of cake samples showed a similar trend throughout storage. The only difference was the number of colonies formed on PDA, which was

Table 4 Total viable counts in cakes with different soymilk levels after five days storage at room temperature

Cake	Total Viable Counts (log CFU/g)					
	D0	D1	D2	D3	D4	D5
Control	4.64^{a,D}	5.80^{a,C}	6.85^{a,B}	7.19^{a,A}	TNTC	TNTC
25%	4.62^{a,b,D}	5.76^{a,C}	6.81^{b,B}	7.19^{a,A}	TNTC	TNTC
50%	4.55^{a,b,c,D}	5.54^{b,C}	6.81^{b,B}	7.17^{a,A}	7.61	TNTC
75%	4.51^{b,c,D}	5.72^{b,C}	6.82^{b,B}	7.17^{a,A}	7.58	TNTC
100%	4.50^{c,D}	5.50^{b,C}	6.82^{b,B}	7.08^{a,A}	7.55	TNTC
Cake	Yeast and Mould Counts (log CFU/g)					
	D0	D1	D2	D3	D4	D5
Control	4.78^{a,F}	5.76^{a,E}	6.70^{a,D}	6.99^{a,C}	7.25^{a,B}	7.55a^{,A}
25%	4.73^{a,F}	5.77^{a,E}	7.71^{a,D}	7.01^{a,C}	7.21^{b,B}	7.48^{b,A}
50%	4.71^{a,F}	5.73^{a,E}	6.67^{a,b,D}	6.98^{a,C}	7.18^{b,B}	7.49^{b,A}
75%	4.63^{a,F}	5.68^{a,E}	6.60^{b,c,D}	6.97^{a,C}	7.19^{b,B}	7.49^{b,A}
100%	4.65^{a,F}	5.69^{a,E}	6.50^{c,D}	6.96^{a,C}	7.19^{b,B}	7.49a^{,b,A}

[1]mean ± SD with different superscript are significantly different by Tuckey's HSD test at $p < 0.05$.
[2]Lowercase letters indicate significant differences among samples with different formulation at the same storage time.
[3]Uppercase letters indicate significant differences between five days storage for a cake sample.
[4]TNTC: Too Numerous To Count

much lower than the number of colonies formed on PCA agar. At Day 0, control had the highest YMC whereas cake with 75% soymilk addition had the lowest.

Conclusion

The present work revealed the potential use of soymilk as an alternative milk replacer in cakes without significantly influencing their organoleptic properties. It also revealed that soymilk was a good source of protein, besides milk, in increasing the overall nutritional composition of products. In the present work, it is generally accepted that the complete replacement of milk with soymilk could improve the nutritional composition, including moisture, protein, fat, fibre, and ash of the cakes. In addition, results showed that the addition of soymilk into the cake had positively affected the physical, rheological, and sensory properties of the cake. In terms of physical properties of cake, soymilk showed high performance in producing a cake with high volume. For rheological properties of cake, the addition of soymilk into batter resulted in desirable batter viscosity with high emulsion stability, which led to high volume in the final product. Soymilk addition also created satisfactory texture in cake crumb. In terms of sensory properties of cakes, soymilk addition showed no significant difference in terms of aroma, colour, taste and texture. Results also showed that 50% milk replacement with soymilk yielded the highest acceptability among the panellists. For shelf life analysis, although soymilk tended to slow down the food deterioration, results showed that cake samples had a short shelf life. In summary, the present work provided information in developing cake using soymilk. In addition, the present work also demonstrated the possibility of soymilk to act as inexpensive milk replacer which could reduce the production cost.

Acknowledgement

This research was supported by FRGS research grant (FRG0447-STG-1/2016) provided by Ministry of Higher Education, Malaysia. We thank Dr. M.R. Mozafari, from Australasian Nanoscience and Nanotechnology Initiative, for comments that greatly improved the manuscript.

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