Available online freely at www.isisn.org

Bioscience Research

Print ISSN: 1811-9506 Online ISSN: 2218-3973

Journal by Innovative Scientific Information & Services Network

RESEARCH ARTICLE BIOSCIENCE RESEARCH, 2019 16(SI): 143-156. **OPEN ACCESS**

Physico-chemical and sensory attributes of sponge cakes formulated with partial replacement of soybean flour and isomalt for wheat flour and sucrose

Lee-Hoon Ho* and Nur Eliya Farahin Mohd Halim

Department of Food Industry, Faculty of Bio resources and Food Industry, Universiti Sultan Zainal Abidin, Besut Campus, 22000 Besut, Terengganu, **Malaysia.**

***Correspondence:** holeehoon@yahoo.com, holeehoon@unisza.edu.my **Revised: 0**6 Oct. 2019, **Accepted: 08 Oct. 2**019 e-**Published:** 11 Nov. 2019 **Reviewed by:** Dr. Wan Anwar Fahmi Wan Mohamad, Wan Mohd Fadli Wan Mokhtar

The aim of this study was to evaluate the physico-chemical properties and sensory attributes of sponge cakes made by partial replacement of soybean flour and isomalt for wheat flour and sucrose, respectively. Wheat flour and sucrose were replaced by 10% soybean flour and 50% isomalt, respectively to produce SBC1; replacement of 20% soybean flour for wheat flour and 50% isomalt for sucrose to prepare SBC2; SBC3 was produced by substitution of 10% soybean flour and 100% isomalt for wheat flour and sucrose, respectively; sponge cake made of 100% wheat flour and sucrose was served as control. All produced sponge cakes were analysed for proximate composition, physical properties, and sensory attributes. Proximate composition results in SBC2 showed significant ($p<0.05$) higher in ash, crude protein, and crude fiber but lower in carbohydrate and calorie content than the other sponge cakes. SBC1 and SBC2 demonstrated a higher yield, weight, volume, and specific volume with a positive value of volume, symmetry, and uniformity index. Textural properties results showed significant ($p<0.05$) higher in hardness, cohesiveness, gumminess, and chewiness in SBC3 cake than the other sponge cakes. Incorporation of soybean flour in sponge cake at higher level (20%) showed a significantly affects the lightness value. Sensory evaluation showed no significant ($p>0.05$) difference in overall acceptability between SBC1 and SBC2 with control. These obtained results suggested that soybean flour and sucrose can be replaced for wheat flour and isomalt at substitution level up to 20% and 50%, respectively to produce a good-tasting and nutritional sponge cake.

Keywords: soybean flour, isomalt, physico-chemical properties, sensory attributes, sponge cake

INTRODUCTION

Baked products are enjoyed by consumers all over the world. Cakes are one of the most popular food products due to its particular organoleptic characteristics (Matsakidou et al., 2010). Sponge cake has light, aerated, and porous structures, which are obtained from leavening by beaten egg proteins with sugar (*i.e.*, sucrose) and folding with wheat flour, hence rising during baking (Tharise et al., 2014). Good quality cakes can be characterized as having various attributes, such as high volume, uniform crumb structure, soft texture, delicate flavour, and a long shelf life with tolerance to staling (Gelinas et al., 1999). Sucrose is one of the main ingredients in sponge cake production which provides significantly energy content. Every 100 g of sponge cake produces approximately 1,920 kJ or 460 kcal of energy. A large amount of sucrose intake can cause insulin resistance in body

(Salvador, 2013; Alsuhaibani and Al-Kuraieef, 2018). In addition, bakery products made from wheat flour is nutritionally poor whereby it lacks of dietary fiber, minerals, and other nutrients (Ho et al., 2017). Consuming this product continuously for a long time causes obesity and other health related problems (Lin et al., 2003; Sutwal et al. 2019). Therefore, there is an urge to develop sponge cakes with reduced sucrose and wheat flour used to control the uprising of diet-related health problems in Malaysia. Available option for reducing energy and sugar intakes is by appropriately partial replacing the sucrose and wheat flour with a low-calorie sweetener and non-wheat flour, respectively.

Sugar alcohols, often called as polyols are a low digestible carbohydrates, characterized with lower blood glucose response and can be metabolized without insulin. Thus, it does not provide calories nor influence the blood glucose (Livesey, 2003; Shankar at al., 2013). These compounds have a lower nutritional value than sugars, due to slower and incomplete absorption from the intestine, which results in indirect metabolism via fermentative degradation by the intestinal flora. Sugar alcohols' sweetness is usually lower than the monosaccharide, and therefore, they are used volume-for-volume like sugar and are called bulk sweeteners (Ghosh and Sudha, 2012). The sweetening effect of sugar alcohols, is about 40 to 100% of sucrose (Livesey, 2003).

The permitted sugar alcohol includes hydrogenated disaccharides such as isomalt, is a mixture of two isomeric disaccharide alcohols; gluco-mannitol (α-D-gluco-pyranosyl-1-6-mannitol) and gluco-sorbitol (α-d-gluco-pyranosyl-1-6-sorbitol) (Małgorzata, 2015). Its sweetness depends on concentration, temperature, as well the form of product in which it is used; on average, it has 45–65% of the sweetness of sucrose (Sentko and Willibald-Ettle, 2012). It only provide 2.0 kcal/g of caloric value, and has a very low glycaemic index of 9 (Livesey, 2003). Isomalt is a useful ingredient in the formulation of "light" or sugar-free baked goods. Only minimal modifications in formulations and processing methods are required for baked goods made with isomalt. The final baked products made with isomalt have a sugar-like taste and a long shelf life (Sentko and Bernard, 2012).

Soybean is a type of legumes which is an excellent source of protein (43.2%). It is rich in amino acids such as lysine, lecithin, and isoflavones (Sana et al., 2012). In addition, soybean flour also rich in Vitamin A, B, C, and D with sufficient amount of minerals such as calcium, iron, and phosphorus. Shahraki et al., (2013) reported that soybean flour is an economical and available food source can be applied in the cake baking industry. Ahmad et al., (2014) reported that soybean could be an enhancer of product quality and as an essential source of functional food. However, according to Cavalcante and Silva (2015), sponge cake with the partial or totally substitution of sucrose have their quality impaired such as appearance, volume, and texture. Therefore, the aim of this study is to determine the physico-chemical properties and sensory attributes of sponge cake formulated by partial substitution of soybean flour for wheat flour and partially replacement of isomalt for sucrose.

MATERIALS AND METHODS

Materials and chemicals

Soybean flour and isomalt were purchased from the Lifestyle Venture Company, Shah Alam, Selangor. The other ingredients such as all-purpose flour, sucrose, ovallette, eggs, milk, margarine, salt, baking powder, and vanilla essence were procured from Giant Supermarket at Jertih, Terengganu. All chemicals used in this study such as petroleum ether (40-60 °C boiling point) was purchased from R & M Marketing (Essex, UK). Sulphuric acid (H_2SO_4) and sodium hydroxide (NaOH) were purchased from Merck (Darmstadt, Germany). Ethanol was purchased from Qrec Asia (Selangor, Malaysia). Bromocresol green and methyl red dyes were purchased from Sigma-Aldrich (Missouri, USA) whereas Kjeltabs was purchased from Foss (Hilleroed, Denmark). All of the chemicals used are of analytical reagent (AR) grade.

Preparation of sponge cakes

Sponge cakes were prepared according to the all-in-one method. Four types of sponge cakes were prepared in this study; sponge cake made of 100% wheat flour and 100% sucrose referred as control; sponge cake incorporated with soybean flour at 10% level and sucrose replaced by isomalt at 50% level indicates as SBC1; sponge cake incorporated with soybean flour at 20% level and sucrose replaced by isomalt at 50% level indicates as SBC2; and sponge cake incorporated with soybean flour at 10% level and sucrose replaced by isomalt at 100% level indicates as SBC3 (Table 1).

Table 1; Formulation of sponge cakes.

Ingredient (g)	Control	SBC1	SBC2	SBC3
All-purpose flour	100	90	80	90
Soybean flour	-	10	20	10
Sucrose	80	40	40	-
Isomalt*	-	80	80	160
Egg white	120	120	120	120
Milk (mL)	50	50	50	50
Ovallete	30	30	30	30
Margarine	30	30	30	30
Baking powder	2	2	2	2
Salt	2	2	2	2
Vanilla essence	2	2	2	2

SBC1, all-purpose flour and sugar replaced by 10% soybean flour and 50% isomalt, respectively; SBC2, all-purpose flour and sugar replaced by 20% soybean flour and 50% isomalt, respectively; SBC3, all-purpose flour and sugar replaced by 10% soybean flour and 100% isomalt, respectively.
'-', Indicates without ingredient.
'*' , The weight of the isomalt used was calculated based on its' relative sweetness (0.5) to sucrose.

The dry ingredients (*i.e.*, all-purpose flour, with/without soybean flour, ovallette, sucrose or with/without isomalt, salt, and baking powder) and liquid ingredients (*i.e.*, egg white) were added into a mixing bowl and mixed until fluffy using a hand mixer (Philips HR1456/70, Toa Payoh, Singapore) for about 5 min. Then, milk, margarine (pre-melted), and vanilla essence were added into the batter and continue mixed for another 2 min until uniformly smooth batter obtained. The batter then was poured into a loaf pans (9 x 5 inch), weighed (approximately 800g), and baked in an oven at 180 °C for 45 min. The cakes were allowed to cool at room temperature for approximately 30 min prior analyses.

Proximate analyses

Proximate analyses for sponge cakes were conducted according to AOAC (2005). Moisture, ash, crude protein, crude fat, and crude fiber contents were determined according to the method of oven drying (AOAC Official Method 977.11), dry ashing (AOAC Official Method 923.03), Kjedahl (AOAC Official Method 955.04), Soxhlet (AOAC Official Method 991.43), and crude fiber (AOAC Official Method 991.43), respectively.

Total carbohydrates and energy estimation

The total carbohydrates content of the sponge cakes was estimated by difference [Total carbohydrate (% wet basis) = 100% – % (moisture + ash + crude protein + crude fat)] (BeMiller and Low, 1998). The energy of the sponge cakes was calculated by multiplied by the factor values; 1 g of crude protein or carbohydrate provides 4 kcal of energy and 1 g of crude fat provides 9 kcal of energy) [Energy (kcal/100g) = (crude protein x 4) + (total carbohydrate x 4) + (crude fat x 9)] (Nielsen, 1998).

Weight, yield, volume, specific volume, and density measurement

The sponge cake was weighed (g) after removing from the loaf pans using pre-calibrated 3-decimal point analytical balance. The yield (%) was calculated by dividing the weight of cake (after baked) over weight of batter (before baking) [% yield = (weight (g) of cake/ weight (g) of batter) x 100%]. The volume (cm^3) and specific volume (cm^3/g) were analyzed using a benchtop laser-based scanner (VolScan Profiler, Stable Micro Systems Ltd, Surrey, UK). A non-contact measurement system was selected for the volume and specific volume measurement using 3-dimensional assessment of soft and freshly baked sponge cakes. The support pin was inserted at the perimeter centre of the largest diameter of sponge cake. Then, it was placed on the product support platform and transferred onto turntable. The support pin from the top arm of VolScan Profiler was inserted into the crumb of sponge cake for supporting purpose. The sponge cake was then automatically weighed and an eye-safe laser device was used to scan vertically to measure the contours of the sponge cake whilst it rotates. The data was generated using VolScan Profiler Software (Stable Micro Systems Ltd, Surrey, UK). The density (g/ cm^3) of the sponge cake was calculated by dividing the weight (g) of sponge cake over the volume (cm^3) of sponge cake.

Physical indices measurement

Physical indices such as volume index, symmetry index, and uniformity index were determined according to the cross-section of sponge cake measuring template as proposed by AACC (1999) (AACC method 10-91). The values of volume index, symmetry index, and uniformity index of the sponge cake were obtained by calculation (see Figure 1). Volume index = B + C + D; symmetry index = 2C – B – D; uniformity index = B – D.

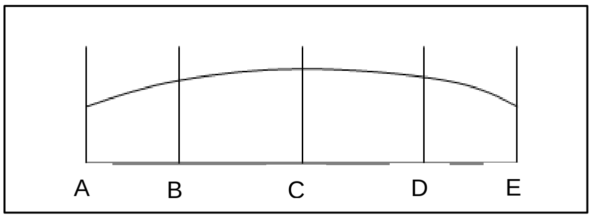

Figure 1; The cross-section of sponge cake

Texture profile analysis

Texture profile analysis for sponge cakes was performed using a TA-XT plus model Texture Analyzer (Stable Micro System co. Ltd., surrey, England). The texture analyzer was calibrated with 5 kg weight load cell and equipped with probe P/36R cylindrical probe (36 mm diameter). Then, the crumb of sponge cake was cut into 2.5 cm x 2.5 cm x 2.5 cm size from the middle of the sponge cake using clean knife. The cut crumb was placed centrally beneath the probe to meet with a consistent flat surface at entire analysis. The crumb was analysed under the force of compression at 25% of the product original height with duration of 30 s of examination. The tested parameters such as hardness, springiness, cohesiveness, gumminess, and chewiness of crumb were determined using Texture Expert Version 1.05 Software (Stable Micro System Ltd, Surrey, UK) (AACC, 2000).

Measurement of colour

The crust and crumb colours of the sponge cake were evaluated using Chromameter (Kanica Minolta, Chroma Meter CR-400, Tokyo, Japan) according to the L^* a^* and b^* scale. L^* indicates lightness, whereby, L^*=100 indices white and L^*=0 indices black. Chroma a^*, negative chromaticity (-60) denotes greenish, while positive chromaticity (+60) denotes red. Chroma b^*, negative chromaticity (-60) indices blue and positive chromaticity (+60) indices yellow. The chromameter was calibrated prior analysis using Konica Minolta white calibration plate. For crust colour evaluation, the result was taken from the top of the sponge cake, three points; top left edge, top middle, and top right edge were analyzed and the average values was calculated. For crumb colour, the sponge cake was sliced, then the colour of the internal (*i.e.*, crumb) of sponge cake was analyzed.

Sensory evaluation

The sensory attributes of all prepared sponge cakes were evaluated by 40 semi-trained panellists comprising of students and staffs of the Faculty Bioresources and Food Industry, Universiti Sultan Zainal Abidin, Terengganu, Malaysia. The sensory was evaluated using 7-point hedonic scale to determine sensory acceptability of the prepared sponge cakes by panellists, whereby score 1 = ‘dislike very much’ to score 7 = ‘like very much’ (Watts et al. 1989). The sponge cakes were cut into cubes of 2 cm x 2 cm x 2 cm using clean knife. Each sample was coded with different 3-digit numerical codes and then placed onto the paper plate. Each sample was presented to the panellists in the randomized order so that each sample appears in a particular position an equal number of times. Each panellist was received a plate of labelled sponge cakes, a cup of drinking water (300 mL), and a sensory form. The panellists were asked to rate the tested sponge cake on the scale for each attribute such as crust colour, crumb colour, aroma, sweetness, hardness, gumminess, and overall acceptability.

Statistical analysis

The data were analysed using Statistical Package for the Social Science (SPSS) for windows, version 20.0. Results recorded in this study are represented as mean values of three replicates ± standard deviation. One-way Analysis of Variance (ANOVA) was applied to determine the mean values among the samples. Duncan-multiple range test was used to compare the significance differences among the samples at $p<0.05$.

RESULTS AND DISCUSSION

Proximate compositions of sponge cakes

Results of proximate compositions of sponge cakes are presented in Table 2. SBC2 cake was found to have significantly ($p<0.05$) higher moisture content (32.63%) compared to other sponge cakes (30.95, 31.25, and 29.97% for Control, SBC1, and SBC3). This was attributed to the water absorption capacity nature of soybean fibre that consists of hydrophilic chain which tend to bind more water as a result improved in moisture retention (Riaz, 1999). The results obtained in the present study is in agreement with those reported by Moiraghi et al., (2012). The authors reported that fibre materials tend to absorb high moisture (Moiraghi et al., 2012). Lim and Wan Rosli (2013) also reported high fibre content can retain moisture by preventing evaporation process during baking. According to Rodge et al., (2012), moisture content greatly influences the shelf life of the food products. Lower moisture content in food products is preferred due to it extends the shelf life of the products during storage (Rakcejeva et al., 2011).

A significantly ($p<0.05$) higher ash content (2.92%) was observed in SBC2 than control (2.27%). Ash content is associated to the high mineral contents in food products (Lim and Rabeta, 2013). Therefore, higher ash content might due to the presence of higher proportion of minerals in soybean flour. This result is in line with a study done by Serrem et al. (2011) who reported that soybean flour contains a good amount of minerals such as calcium, magnesium, iron, and phosphorus. The same as other studies, with an increase of soybean flour level in bread making, the ash content increased in bread (Abioye et al., 2011; Awasthi et al., 2012). There was a significantly ($p<0.05$) higher crude protein content in sponge cakes containing soybean flour and isomalt (9.21-10.69%) than control (6.43%). This may due to the fact that soybean flour consists higher amount of protein (49.2%) compared to wheat flour (10.33%). The higher content of protein are in pair with the study by Hou and Chang (2004) and Ayo et al. (2014), whereby they reported that almost 90% of soybean protein stored in the globulins of the beans which contribute to the higher protein level when added to process food. Crude fat content in sponge cakes containing soybean flour and isomalt (7.87-8.04%) exhibited insignificant difference with control (8.18%). This indicates that soybean flour had similar crude fat value with wheat flour. According to Amin et al. (2016), the fat content influence the mouth feel and retains the flavour of the baked products. Therefore, the substitution of soybean flour for wheat flour did not influence the mouth feel of the prepared sponge cakes.

The crude fiber content of sponge cakes incorporated with soybean flour and isomalt ranged from 1.92% to 3.13% showed higher than the control (0.90%). The significant increase in crude fibre content was attributed to the replacement of soybean flour for wheat flour in the product as it is rich in crude fibre. This was supported by the result obtained from SBC2, whereby an increase of soybean flour substitution level from 10% to 20% results a significantly ($p<0.05$) higher crude fibre content (3.13%) than the SBC1 (1.92%) and SBC3 (2.08%) which contain 10% of soybean flour. The results obtained in this study is in line with study by Islam et al., (2007), who reported that crude fibre represents dietary fibre part includes mostly lignin, cellulose, and hemicelluloses constituents found in soybean. Riaz (1999) also reported that soybean hull contains approximately 65% dietary fibre which offer source of fibre for diverse food application. Results obtained in this study is in accordance with the study carried out by Ayo et al., (2014). They reported that crude fibre content of biscuits increased with increasing malted soybean flour fortifications.

Table 2; Proximate composition of sponge cakes.

Composition (%)	Control	SBC1	SBC2	SBC3
Moisture	30.95 ± 0.94^{b}	31.25 ± 0.33^{ab}	32.63 ± 1.08^{a}	29.97 ± 0.81^{b}
Ash	2.27 ± 0.3^{b}	2.57 ± 0.26^{ab}	2.92 ± 0.27^{a}	2.60 ± 0.33^{ab}
Crude protein	6.43 ± 0.06^{c}	9.99 ± 0.36^{a}	10.69 ± 0.45^{a}	$9.21\pm0.59^{\mathbf{b}}$
Crude fat	8.18 ± 0.14^{a}	7.87 ± 0.23^{a}	7.88 ± 0.13^{a}	8.04 ± 0.19^{a}
Crude fiber	0.90 ± 0.38^{c}	1.92 ± 0.12^{bc}	3.13 ± 0.39^{a}	2.08 ± 0.49^{b}
Total* carbohydrate	52.17 ± 1.19^{a}	48.31 ± 0.78^{b}	45.88 ± 1.37^{c}	50.18 ± 0.33^{b}
Calories* (Kcal/100g dry matter)	308.02 ± 3.86^{a}	304.07 ± 1.48^{a}	297.22 ± 3.13^{b}	309.95 ± 4.36^{a}

Values with different superscripts within the same row are statistically significant from each other ($p<0.05$)
Presented data are mean value of two replication ± standard deviation; * Values obtained by calculation.
SBC1, all-purpose flour and sugar replaced by 10% soybean flour and 50% isomalt, respectively; SBC2, all-purpose flour and sugar replaced by 20% soybean flour and 50% isomalt, respectively; SBC3, all-purpose flour and sugar replaced by 10% soybean flour and 100% isomalt, respectively.

In addition, the isomalt substituted for sucrose acts like fibre that increases the crude fibre of the sponge cakes. According to Wohlfarth (2006), isomalt may prove upsetting to the stomach because the body treats it as a dietary fibre instead of as a simple carbohydrate. Therefore, like most fibres, it increases bowel movement, passing through the bowel in virtually undigested form.

Regarding the carbohydrate value, the results for the sponge cakes containing soybean flour and isomalt were significantly ($p<0.05$) lower than the control (52.17%). Among the prepared sponge cakes, SBC2 showed the lowest value (45.88%) (Table 2). This was attributed to the lower carbohydrate content in soybean flour (21g/100g dry matter) compared to the wheat flour (76g/100g dry matter) (Farzana and Mohajan, 2015). The result obtained in this study is in line with findings by Farzana and Mohajan (2015), who reported that the incorporation of soybean flour into wheat flour for production of biscuits results in decreasing of carbohydrate content. The calories content in the SBC2 was observed to be significantly ($p>0.05$) lower (297.22kcal/100g) than control (308.02kcal/100g), SBC1 (304.07kcal/100g), and SBC3 (309.95kcal/100g). In conclusion, gradual substitution of soybean flour and isomalt for wheat flour and sucrose, respectively, increased the ash, crude protein, and crude fibre contents but decreased the carbohydrate value of the sponge cakes. Therefore, the nutritional value of the sponge cakes can be improved by partial substitution of soybean flour and isomalt for wheat flour and sucrose, respectively.

Weight, yield, volume, specific volume, and density of sponge cakes

Effects of different levels of soybean flour and isomalt on the physical properties (*i.e.*, weight, yield, volume, specific volume, and density) of sponge cakes are presented in Table 3. SBC1 showed significantly ($p<0.05$) higher (386.67 g) weight than the control (377.00 g) but insignificant difference with other cake samples containing soybean flour (SBC2 and SBC3). Result showed that there was a significant ($p<0.05$) highest yield in SBC2 (sponge cake containing 20% soybean flour and 50% isomalt). This might be attributed to the high water absorption of soybean flour in batter during mixing. Riaz (1999) reported that soybean flour can hold and bind large amount of water thus improve moisture retention and retain the moisture in cake, therefore can give a higher yield of end products.

As shown in Table 3, volume of all the sponge cakes containing soybean flour and isomalt (SBC1, SBC2, and SBC3; 1098.33 cm^3, 1086.67 cm^3, and 1019.00 cm^3, respectively) were higher than the control (1070.33 cm^3). However, the volume was decreased with an increase level of soybean flour and isomalt in sponge cake making. According to Li et al., (2007), there are several chemical changes in the batter during mixing and baking; the gradual replacement by isomalt for sucrose causes a dilution of the batter’s viscosity, leading to weaken the ability to hold the air bubbles in the batter during mixing (Cavalcante and Silva, 2015). Thus, lower entrapment of air bubbles in the batter could inferior to the volume of the final products. During baking, the batter undergoes starch gelatinization, protein coagulation, and later transform into a porous semi-solid structure. Sugar (*i.e.*, isomalt) delays the gelatinization of starch during baking by limiting the availability of water to starch granule to swell and formation of sugar bridges between starch chains and formation of an anti-plasticizing effect. Hence, this allows the air bubbles to expand by water vapour and carbon dioxide before the batter set (Siti Faridah and Noor Aziah, 2012). Therefore, totally replacement of sucrose by isomalt resulted in early starch gelatinization during baking and restricted the volume of sponge cakes. Moreover, a decrease in volume of SBC3 might be due to the lower water holding capacity of isomalt as the sucrose was totally replaced by isomalt (Struck et al. 2014), whereby when the surface of sponge cakes in contact with air, it causes the moisture of cake to evaporate easily to surrounding. Thus, this leads to a lower volume and weight loss.

The specific volume of the baked products indicates the quantity of air that can stand in the final products. Table 3 showed that specific volume was not affected by soybean flour and isomalt. However, as the isomalt replacement level increased, the specific volume decreased significantly.This was associated with a lower amount of air retained in the sponge cake containing high level of isomalt, which presented a

Table 3. Weight, yield, volume, specific volume, and density of sponge cakes.

Parameter	Control	SBC1	SBC2	SBC3
Weight (g)	377.00±3.00[b]	386.67±2.08[a]	380.67±4.16[ab]	382.67±3.79[ab]
Yield (%)	48.33±5.03[b]	54.00±7.00[b]	68.67±5.51[a]	48.33±2.08[b]
Volume (cm^3)	1070.33±7.02[b]	1098.33±6.51[a]	1086.67±4.51[ab]	1019.00±20.22[c]
Specific Volume (cm^3/g)	2.84±0.04[a]	2.84±0.03[a]	2.85±0.04[a]	2.66±0.05[b]
Density (g/cm^3)	0.35±0.01[b]	0.35±0.01[b]	0.35±0.01[b]	0.37±0.01[a]

Values with different superscripts within the same row are statistically significant from each other ($p<0.05$)
Presented data are mean value of three replication ± standard deviation.
SBC1, all-purpose flour and sugar replaced by 10% soybean flour and 50% isomalt, respectively; SBC2, all-purpose flour and sugar replaced by 20% soybean flour and 50% isomalt, respectively; SBC3, all-purpose flour and sugar replaced by 10% soybean flour and 100% isomalt, respectively.

weak water absorption capacity. As the isomalt has a weak capacity of holding or retain moisture, the air bubbles tend to escape from the batter during mixing. Similarly, Cavalcante and Silva (2015) also found a decrease in specific volume of sponge cakes with completely replace the sucrose as compared to the reference cake containing sucrose. In conclusion, the substitution of soybean flour at level 10-20% for wheat flour and up to 50% replacement of isomalt for sucrose could increase the weight, yield, volume and specific volume of sponge cakes.

In the present work, the SBC3 exhibited significantly ($p<0.05$) higher in density ($0.37 g/cm^3$) than the other sponge cakes ($0.35 g/cm^3$ for control, SBC1, and SBC3). This indicates that sponge cake made of 10% soybean flour and 100% of isomalt (SBC3) was compact than the other sponge cakes. This was attributed to the poor aeration process that caused by increasing levels of isomalt for sponge cake preparation. According to Rodríguez-García et al., (2014), the low solubility property of sugar replacer (*i.e.* isomalt) causes a lower amount of air incorporation during mixing stage. A decrease of air incorporation leads to a lesser air cells produced in the crumb. The results obtained in the present work is paired with a study performed by Rodríguez-García et al., (2014), who reported that air disentranced with a combination loss of carbon dioxide and bubble gas during mixing, results an increased density.

Physical indices of sponge cakes

The results of physical indices such as volume index, symmetry index, and uniformity index are shown in Table 4. Volume index is the primary quality measurement for cake products. It can be referred as the sum of cake height center with the height of the point from the outer edge. Sponge cakes made of 10% soybean flour and 50% isomalt (SBC1) showed the significantly ($p<0.05$) highest volume index (18.00 cm^3). This was attributed to the hydrophobic properties of proteins from the soybean flour which influence the development of sponge cakes. In addition, starch of the soybean flour is more accountable for attaining the final structure, gelatinizing, and increasing the consistency of the batter during baking (Ortolan, 2017). Moreover, according to Ortolan (2017), the proteins of the soybean flour are responsible for the gluten network development which provides the structure of bakery products as it has viscoelastic characteristics. However, an increase in the substitution level (from 10% to 20%) of soybean flour for all-purpose flour results in a significantly ($p<0.05$) decreased in volume index of sponge cake (SBC2) but insignificantly ($p>0.05$) difference in volume index as compared with control. This can be explained by the fact that the poor batter stability occurred during baking. The present obtained results is supported by the findings from Gómez et al. (2008), too high concentration of protein content in the formulation could results in a lower volume index, whereby the structure of the cakes tend to collapse during final baking or cooling.

A positive symmetry index value indicates the desirable characteristics as they represent the cake’s peak, whereas a negative value of symmetric index indicates a collapsed cake (Siti Faridah and Noor Aziah, 2012). Replacement of soybean flour for wheat flour at 10 and 20% levels and substitution of isomalt for sucrose at up to 50% had a significantly ($p<0.05$) positive effect on the symmetry index in SBC1 (0.10 cm) and SBC2 (0.10 cm) sponge cakes (Table 4). On the other hand, the similar pattern was observed on the negative effect of sponge cake containing 10% soybean flour and 100% isomalt (SBC3) and control. These results indicate a collapsed surface of control and SBC3 as completely replacement of sucrose with isomalt.

Table 4. Physical indices of sponge cakes.

Parameter	Control	SBC1	SBC2	SBC3
Volume Index (cm3)	17.63±0.15[b]	18.00±0.00[a]	17.67±0.29[b]	16.63±0.12[c]
Symmetric Index (cm)	-0.43±0.06[b]	0.10±0.17[a]	0.10±0.10[a]	-0.33±0.15[b]
Uniformity Index (cm)	0.03±0.06[a]	0.03±0.06[a]	0.17±0.06[a]	0.20±0.17[a]

Values with different superscripts within the same row are statistically significant from each other (p<0.05)
Presented data are mean value of three replication ± standard deviation.
SBC1, all-purpose flour and sugar replaced by 10% soybean flour and 50% isomalt, respectively; SBC2, all-purpose flour and sugar replaced by 20% soybean flour and 50% isomalt, respectively; SBC3, all-purpose flour and sugar replaced by 10% soybean flour and 100% isomalt, respectively.

According to Struck et al., (2014), sugar (*i.e.*, sucrose) delayed gelatinization of starch which allowed air bubbles to expand during baking, thus cake are fully aerated and increase in volume. However, isomalt cause to an early gelatinization of the starch of all-purpose flour and therefore restricted the expansion of the volume of sponge cake (Siti Faridah and Noor Aziah, 2012). Moreover, isomalt have no affinity to moisture holding. Moisture can be removed easily from the external and internal of the sponge cake to the surrounding during cooling (Struck et al., 2014). Therefore, this phenomena results in a collapsed structure of sponge cake. It can be concluded that a desired structure (positive symmetry index) of the sponge cakes can be obtained by replacement of soybean flour up to 20% level and isomalt for sucrose up to 50% level.

According to Siti Faridah and Noor Aziah (2012), a good quality cake should have uniformity index of closed zero. Table 4 shows no significant difference between sponge cakes containing soybean flour and isomalt (SBC1, SBC2, and SBC3; 0.03, 0.17, and 0.20 cm, respectively) with the control (0.03 cm) in uniformity index. All of the values demonstrated a positive effect which indicates that one side of the cake was similar with the other one.

Texture profile of sponge cakes

Effects of different levels of soybean flour and isomalt in sponge cakes on textural properties are presented in Table 5. Hardness is defined as the maximum force needed to compress a food at a specific height and length. Based on the results, the sponge cakes of SBC1, SBC2, and SBC3 revealed a significantly (p<0.05) higher hardness values (85.38N, 93.64N, and 142.39N, respectively) than the control (63.49N). This indicates the sponge cakes containing soybean flour and isomalt were more firmed than the control. Among the sponge cakes containing soybean flour and isomalt, SBC3 showed highest value of hardness. This was attributed to the dehydration occurred as the sucrose was completely replaced by isomalt. According to Struck et al., (2014), a low hygroscopicity characteristic of isomalt can cause the moisture transferred from internal crumb to external crust and then to surrounding as soon as after baking process. Therefore, completely replacement of sucrose with isomalt results in a dry sponge cake texture thus increased the hardness of sponge cake.

Springiness is referred to the ability of a food to recover or back to its origin shape during time elapsed between end of first compression and the start of second compression (Chaiya and Pungsawatmanit, 2011). Sponge cakes containing soybean flour and isomalt showed a significantly (p<0.05) lower springiness value than the control. Among the prepared sponge cakes, SBC3 demonstrated the significantly (p<0.05) lowest (0.64) in springiness value. This was attributed to a decrease of gas bubbles in the crumb cells as soybean flour replaced for wheat flour and completely replacement of isomalt for sucrose. The result of springiness was associated with the result of density (Table 3), whereby, the highest density value was observed in SBC3. This was supported by a study reported by Rodríguez-García et al., (2014), the springiness of a baked product (*i.e.*, cake) has an inverse relationship with the density value.

Cohesiveness is defined as the work area during the second compression divided over work area at first compression (Chaiya and Pungsawatmanit, 2011). On the other hand, it can be referred as the resistance of food to traction under mechanical action. SBC2 sponge cake showed a significantly (p<0.05) highest in cohesiveness value (0.64%).

Table 5; Textural properties of sponge cakes.

Parameter	Control	SBC1	SBC2	SBC3
Hardness (N)	63.49±2.27[c]	85.38±2.93[b]	93.64±14.19[b]	142.39±7.64[a]
Springiness (%)	0.92±0.03[a]	0.80±0.02[b]	0.78±0.02[b]	0.64±0.03[c]
Cohesiveness (%)	0.39±0.04[c]	0.54±0.04[b]	0.64±0.03[a]	0.51±0.02[b]
Gumminess (N)	36.45±0.87[c]	46.65±4.60[b]	50.63±7.32[ab]	57.88±1.57[a]
Chewiness (N)	27.03±2.73[c]	33.94±3.39[b]	39.80±2.64[ab]	41.80±5.77[a]

Values with different superscripts within the same row are statistically significant from each other (p<0.05)
Presented data are mean value of three replication ± standard deviation.
SBC1, all-purpose flour and sugar replaced by 10% soybean flour and 50% isomalt, respectively; SBC2, all-purpose flour and sugar replaced by 20% soybean flour and 50% isomalt, respectively; SBC3, all-purpose flour and sugar replaced by 10% soybean flour and 100% isomalt, respectively.

The results indicated that the SBC2 had higher ability to resist to the force between the teeth before the crumb structure breaks. Sponge cakes containing soybean flour and isomalt had higher cohesiveness value than the control and this was obvious when the all-purpose flour was replaced by soybean flour at 20% level. This can be explained by the fact that the presence of high starch content in soybean flour than in all-purpose flour. Starch influence the viscosity of batter as well as cohesion of the crumb. Starch gelatinization occurred during baking and this gelling property might strengthen the crumb structure that contributes to the cohesiveness of crumb.

Gumminess indicates the energy required to disintegrate the food to a state of readiness for taking into a throat whereas chewiness indicates the energy required to crunch the food (Majzoobi et al., 2013). The obtained gumminess and chewiness values exhibited a similar trend, whereby sponge cakes containing soybean flour and isomalt (SBC1, SBC2, and SBC3) showed a significantly (p<0.05) higher values of gumminess and chewiness than the control. This was attributed to the soybean flour which has higher starch content was used to replace the all-purpose flour. According to Ho et al., (2017), starch plays a vital role in influencing the gumminess of the baked products. The result obtained in the present study is in accordance with a study done by Natal et al., (2013). Natal et al., (2013) reported that the addition of whole soybean flour to potato bread increased the gumminess and chewiness of the bread crumb.

Colour of sponge cakes

Table 6 shows the colour parameters of crust and crumb of sponge cakes incorporated with soybean flour (at levels of 10 and 20%) and isomalt (at level of 50 and 100%). *L** value indicates lightness value. The results indicated that the SBC2 was statistically different from the sponge cakes of control, SBC1, and SBC3 for crust colours. Whereby, SBC2 had a significantly (p<0.05) darker (lower *L** value: 41.25) crust than the other sponge cakes. The crust of the SBC2 changed from white to brown (lower *L** value). According to Ho et al., (2017), the colour of the crust depends on the physicochemical characteristics of amino acid and sugars contained in batter as well as the operating conditions applied during baking. The darkest crust colour of the SBC2 was due to the Maillard reactions occurred during baking as highest percentage (20%) of soybean flour substituted for all-purpose flour. Whereby, the protein (*i.e.*, amino acid such as lysine) in the soybean flour reacted with reducing sugar (*i.e.*, sucrose) and caused the browning crust colour of the sponge cakes via Maillard reaction during baking (Ndife et al., 2011; Zhao et al., 2014). In addition, according to Ho et al., (2017), amylose and amylopectin of the starches have shown to influence the colour of the baked products such as biscuits and sponge cakes, whereby, gelatinization of starch during baking contributes to the formation of crust colour. The starches begin to gelatinize and undergoing caramelization by converting the starches into dextrin at temperatures above 180 ºC.

A positive *a** value indicates redness whereas, a negative *a** value indicates greenness colour. The a* value of all the prepared sponge cakes (control, SBC1, SBC2, and SBC3) were positive (13.24, 16.15, 15.78, and 13.08, respectively), indicates that the presence of red hues on the crust of sponge cakes. The SBC1 and SBC2 showed a significantly (p<0.05) higher value in redness (*a**) than control and SBC3. However, no significant differences were recorded for the *a** value in the control and SBC3 analyzed. The results obtained from the present study are similar to those from Nilufer et al., (2008), who reported that the crust colour of a baked product (*i.e.*, bread) containing soybean flour showed higher in *a** value than the control as the wheat flour was partially substituted with soybean flour. Regarding the results of the crust colour, the *b** value of sponge cakes containing soybean flour and isomalt showed a significant (p<0.05) higher value than the control. The *b** value increased with increasing of soybean flour replacement, *i.e.*, the soybean flour increased the tendency to yellow in crust compared with the other sponge cakes. According Nilufer et al. (2008), the greater yellow colour was resulted from Maillard reactions occurring when protein contents increase. Based on previous several studies as reported by Hou et al., (2000), Wang et al., (2003), and Liu (2004), sugars such as sucrose (5.5%), raffinose (0.9%), and stachyose (3.5%) as well as free amino acids are found in soybean. This might have contributed to the browning. Table 6 presents the significantly lower crumb lightness (*L**) value in SBC2 with other prepared sponge cakes. This indicates that SBC2 had darker crumb colour than the other sponge cakes. This was attributed to the highest percentage of soybean flour contained in the formulation. According to Sana et al., (2012) and Ho et al., (2017), the crumb colour is not affected by the temperature, but it is often corresponded by the raw materials or ingredients used in the formulation. This is because the temperature does not reach the crumb as high as the crust. Therefore, the temperature below 180 ºC is not sufficient enough to cause Maillard or caramelization reactions. However, this result may be due to the original yellow pigment (*i.e.*, carotenoid pigments) of the soybean flour used.

The *a** value of all the sponge cakes crumb were negative, which indicates the present of green colour (Table 6). The results presented a significantly (p<0.05) different in crumb greenness value of the various sponge cakes. The replacement of soybean flour for all-purpose flour at highest level (20%) and maltitol for sucrose (50%) resulted in significantly (p<0.05) lower *a** values (-2.85) than the control, SBC1, and SBC3 (-4.76, -4.20, and -4.28, respectively). However, SBC2 showed a significant (p<0.05) higher of *b** value (32.57) compared to other sponge cakes (26.72, 30.17, and 29.35, for control, SBC1, and SBC3, respectively). This was attributed to the yellow pigment presents in soybean flour. According to Monma et al., (1994), the xanthophylls, which derived through the oxygenation of carotenoids are found in most of the soybeans. Thus, the higher substitution of soybean flour for all-purpose flour in sponge cake making gave a higher value of yellow colour to the crumb. As a conclusion, the sponge cake prepared by partial substitution of soybean flour for all-purpose flour at 20% and isomalt for sucrose at 50% (SBC2) showed significant lower *L**, *a**, but higher *b** values than the other sponge cakes in crumb. Therefore, SBC2 had notably darker, less greenish, but yellowish than the other sponge cakes.

Table 6; Colour characteristics of sponge cakes.

Parameter	Control	SBC1	SBC2	SBC3
Crust				
L*	51.05 ± 0.83^{a}	47.74 ± 1.13^{a}	41.25 ± 4.09^{b}	48.16 ± 1.65^{a}
a*	13.24 ± 0.49^{b}	16.15 ± 0.36^{a}	15.78 ± 0.27^{a}	13.08 ± 1.28^{b}
b*	33.44 ± 0.34^{c}	37.01 ± 0.89^{b}	39.76 ± 1.51^{a}	35.71 ± 0.81^{b}
Crumb				
L*	84.94 ± 0.53^{a}	77.37 ± 0.63^{b}	70.58 ± 1.05^{c}	78.09 ± 0.47^{b}
a*	-4.76 ± 0.05^{c}	-4.20 ± 0.14^{b}	-2.85 ± 0.05^{a}	-4.28 ± 0.42^{b}
b*	26.72 ± 0.57^{c}	30.17 ± 1.14^{b}	32.57 ± 0.52^{a}	29.35 ± 0.85^{b}

Values with different superscripts within the same row are statistically significant from each other (p<0.05)
Presented data are mean value of three replication ± standard deviation.
SBC1, all-purpose flour and sugar replaced by 10% soybean flour and 50% isomalt, respectively; SBC2, all-purpose flour and sugar replaced by 20% soybean flour and 50% isomalt, respectively; SBC3, all-purpose flour and sugar replaced by 10% soybean flour and 100% isomalt, respectively.

Table 7; Sensory evaluation scores of sponge cakes.

Attribute	Control	SBC1	SBC2	SBC3
Crust Colour	6.43 ± 0.87^{a}	5.80 ± 1.18^{b}	5.75 ± 0.95^{b}	5.73 ± 1.20^{b}
Crumb Colour	6.20 ± 0.99^{a}	6.00 ± 0.88^{a}	5.78 ± 1.00^{ab}	5.38 ± 1.21^{b}
Aroma	5.80 ± 1.04^{a}	5.95 ± 0.78^{a}	5.65 ± 1.03^{a}	5.63 ± 1.15^{a}
Sweetness	6.03 ± 1.12^{a}	5.73 ± 1.26^{ab}	5.68 ± 1.16^{ab}	5.15 ± 1.58^{b}
Hardness	6.23 ± 0.83^{a}	6.03 ± 0.89^{ab}	5.75 ± 0.87^{b}	5.23 ± 1.23^{c}
Gumminess	6.28 ± 0.91^{a}	5.93 ± 0.86^{a}	5.93 ± 0.83^{a}	5.15 ± 1.27^{b}
Overall Acceptability	6.35 ± 0.95^{a}	5.95 ± 0.99^{a}	5.88 ± 0.88^{a}	4.98 ± 1.40^{b}

Values with different superscripts within the same row are statistically significant from each other ($p<0.05$)
Presented data are mean value of three replication ± standard deviation.
SBC1, all-purpose flour and sugar replaced by 10% soybean flour and 50% isomalt, respectively; SBC2, all-purpose flour and sugar replaced by 20% soybean flour and 50% isomalt, respectively; SBC3, all-purpose flour and sugar replaced by 10% soybean flour and 100% isomalt, respectively.

Sensory attributes of sponge cakes

The average results of the sensory attributes of sponge cakes are shown in Table 7. All of the sponge cakes containing soybean flour and isomalt received significantly ($p<0.05$) lower scores in crust colour than the control. For crumb colour, the SBC3 received the significantly ($p<0.05$) lowest score (5.38). The lower acceptance of sponge cakes with soybean flour and isomalt could be explained by its darker crust and crumb colour (Table 6). This indicates that, panelists preferred sponge cake without the soybean flour and isomalt, which would be light in colour. In addition, the lower acceptability in crumb colour was possibly due to the pale-look colour of the crumb as a result of the formation of sugar crystal. This was supported by the report from Lee et al., (2008) whereby a low solubility and hygroscopicity properties of isomalt result in a formation of crystals on the crumb. However, the crust and crumb colour of all the sponge cakes were considered acceptable by panelists as their mean scores for the crust and crumb colour attributes were greater than 4 (‘neither like nor dislike’).

The incorporation of soybean flour and isomalt into the formulation did not significantly impact the aroma attribute. The control sponge cake and sponge cakes containing soybean flour and isomalt (SBC1, SBC2, and SBC3) emitted the ‘like slightly’ (5.63-5.95) acceptable aroma. This result is similar to that obtained by Ho et al., (2017), who reported that sponge cakes made of sweet potato flour (*i.e.*, VitAto, orange-fleshed sweet potato, and purple-fleshed sweet potato) received insignificant aroma score with the control sponge cake during evaluation.

Regarding to sweetness attribute, the replacement of soybean flour at up to 20% for all-purpose flour and isomalt for sucrose at 50% (SBC1 and SBC2) did not influence the sweetness score (5.68-6.03) during consumption. However, the degree of liking was observed to decrease as the sponge cake prepared by incorporation of soybean flour at 10% and completely substitution of isomalt for sucrose (SBC3).

The substitution of soybean flour for all-purpose flour at 10% and completely replacement of isomalt for sucrose (SBC3) significantly reduced the acceptance level for hardness by panellists. This result was attributed to the dense and compactness of the sponge cake crumb (Table 5), which resulted from a high density and low volume obtained from the SBC3, as mentioned earlier (Table 3).

There were significant ($p<0.05$) differences found between SBC3 with the other sponge cakes (control, SBC1, and SBC2) in crumb gumminess. SBC3 showed to receive a significant ($p<0.05$) lowest score in gumminess. This indicates that the panelists dislike adherence of crumb to teeth and palate during chewing as caused by higher starch content of the soybean flour as compared to all-purpose flour. The present obtained result is supported by the result obtained in texture profile analysis (Table 5), whereby partial substitution of soybean flour for all-purpose flour at 20% and completely substitution of isomalt for sucrose resulted in an increase of gumminess value.

The overall acceptability is one of the vital sensory attributes. It is related to the textural and sensorial properties of end products. A good sensory property remain a key priority to be a first choice criterion among the consumers (Ho et al., 2017). For overall acceptability, there were no significant ($p<0.05$) differences between control (6.35) with SBC1 (5.95) and SBC2 (5.88). This indicates that the formulation of sponge cake replaced with soybean flour at 20% level and isomalt replaced for sucrose up to 50% level were comparable to the control sponge cake. However, SBC3 received the lowest score for overall acceptability (4.98). Therefore, isomalt can be used at up to 50% level to replace for sucrose in order to achieve the acceptability as the control sponge cake by consumers.

CONCLUSION

These findings revealed that soybean flour and isomalt significantly improved the nutritional values such as crude protein, crude fiber, and ash contents, but lower the carbohydrate and calorie values of the sponge cakes. Sponge cakes prepared with partial substitution of soybean flour for all-purpose flour up to 20% and isomalt for sucrose up to 10% were found to have enhanced the physical properties (*i.e.*, weight, yield, volume, specific volume, and density), and physical indices (*i.e.*, volume index, symmetric index, and uniformity index), but the texture of the sponge cakes containing soybean flour and isomalt were harder than the control sponge cake. On the basis of the colour of the sponge cakes, sponge cake containing 100% of isomalt showed higher lightness values of crust and crumb colour. Based on the results of sensory evaluation, the sponge cakes could be prepared by partial replacement of soybean flour for all-purpose flour at level up to 20% and isomalt for sucrose at level up to 50%. Hence, the approach from this present study serves as the first step to the production of other bakery products such as bread, cookies, muffin, etc. with functional benefits.

CONFLICT OF INTEREST

All the authors declared that present study was performed in absence of any conflict of interest.

ACKNOWLEGEMENT

The authors would like to thank Universiti Sultan Zainal Abidin (UniSZA) for the facilities and the Science Officers for their technical support.

AUTHOR CONTRIBUTIONS

L.-H. Ho: wrote and reviewed the manuscript. Nur Eliya, M.H.: conducted the experiment, wrote and reviewed the manuscript. All authors read and approved the final version.

REFERENCES

AACC, 1999. Approved Methods of AACC, American Association of Cereal Chemists. Ed 11. American Association of Cereal Chemists, Minnesota, United States.

AACC, 2000. Approved Methods of AACC, American Association of Cereal Chemists. American Association of Cereal Chemists, Minnesota, United States.

Abioye V, Ade-Omowaye B, Babarinde G, Adesigbin M, 2011. Chemical, Physico-Chemical And Sensory Properties Of Soy-Plantain Flour. Afr J Food Sci 5: 176–180.

Ahmad A, Hayat I, Arif S, Masud T, Khalid N, Ahmed A, 2014. Mechanisms Involved In The Therapeutic Effects Of Soybean (*Glycine max*). Int J Food Prop 17: 1332–1354.

Alsuhaibani AMA, Al-Kuraieef AN, 2018. Effect Of Low-Calorie Pumpkin Jams Fortified With Soybean On Diabetic Rats: Study Of Chemical And Sensory Properties. J Food Qual 2018: 1–7.

Amin T, Bashir A, Dar BN, Naik HR, 2016. Development Of High Protein And Sugar-Free Cookies Fortified With Pea (*Pisum sativum* L.) Flour, Soya Bean (*Glycine max* L.) Flour And Oat (*Avena sativa* L.) Flakes. Int Food Res J 23(10): 72–76.

AOAC, 2005. Official Methods of Analysis of AOAC International. AOAC International, Gaithersburg, United States.

Awasthi I, Siraj P, Tripathi M, Tripathi V, 2012. Development Of Soy Fortified High Protein And High Calorie Supplementary Biscuits. Indian J Sci Res 3: 51–58.

Ayo J, Ayo V, Popoola C, Omosebi M, Joseph L, 2014. Production And Evaluation Of Malted Soybean- Acha Composite Flour Bread And Biscuit. Afr J Food Sci Technol 5: 21–28.

BeMiller JN, Low NH, 1998. Carbohydrate analysis. In SS Nielsen, eds, Food Analysis, Ed 2. An Aspen Publication, Gaithersburg, United States, pp.169.

Cavalcante RS, Silva CEM, 2015. Effects Of Sucrose Reduction On The Structural

Characteristics Of Sponge Cake. Rev Cienc Agron 46: 718–723.

Chaiya B, Pongsawatmanit R, 2011. Quality Of Batter And Sponge Cake Prepared From Wheat-Tapioca Flour Blends. Kasetsart J (Nat Sci) 45: 305–313.

Farzana T, Mohajan S, 2015. Effect Of Incorporation Of Soy Flour To Wheat Flour On Nutritional And Sensory Quality Of Biscuits Fortified With Mushroom. Food Sci and Nutr 3: 363–369.

Gelinas P, Roy G, Guillet M, 1999. Relative Effects Of Ingredients On Cake Staling Based On Accelerated Shelf Life Test. J Food Sci 64: 937–940.

Ghosh S, Sudha ML, 2012. A Review On Polyols: New Frontiers For Health-Based Bakery Products. Int J Food Sci Nutr 63(3): 372–379.

Gómez M, Oliete B, Rosell CM, Pando V, Fernández E, 2008. Studies On Cake Quality Made Of Wheat-Chickpea Flour Blends. LWT–Food Sci and Technol 41: 1701–1709.

Ho L-H, Anwar NZR, Suhaimi MA, Rosli MAS, Tang JYH, 2017. Nutritional, Physical And Sensory Quality Evaluation Of Sponge Cake Prepared By Substitution Of Wheat Flour By Sweet Potato (*Ipomoea* spp.) Flours. World Appl Sci J 35(8): 1348–1360.

Hou H, Chang K, 2004. Structural Characteristics Of Purified β- conglycinin From Soybeans Stored Under Four Conditions. J Agric and Food Chem 52: 7931–7937.

Hou JW, Yu RC, Chou CC, 2000. Changes In Some Components Of Soymilk During Fermentation With Bifidobacteria. Food Res Int 33: 393–397.

Islam T, Chowdhury A, Islam M, Islam S, 2007. Standardization Of Bread Preparation From Soy Flour. Int J Sustain Crop Prod 2: 15–20.

Lee CC, Wang HF, Lin SD, 2008. Effect Of Isomaltooligosaccharide Syrup On Quality Characteristics Of Sponge Cake. Cereal Chem 85(4): 515–521.

Li JY, Yeh AI, Fan KL, 2007. Gelation Characteristics And Morphology Of Corn Starch/Soy Protein Concentrate Composites During Heating. J Food Eng 78: 1240–1247.

Lim ASL., Rabeta MS, 2013. Proximate Analysis, Mineral Content And Antioxidant Capacity Of Milk Apple, Malay Apple And Water Apple. Int Food Res J 20(2): 673–679.

Lim JY, Wan Rosli WI, 2013. The Ability Of *Zea mays ear* (Young Corn) Powder In Enhancing Nutritional Composition And Changing Textural Properties And Sensory Acceptability Of Yeast Bread. Int Food Res J 20: 799-804.

Lin SD, Hwang CF, Yeh CH, 2003. Physical And Sensory Characteristics Of Chiffon Cake Prepared With Erythritol As Replacement For Sucrose. J Food Sci 68(6): 211–217.

Liu K, 2004. Soybean As Functional Foods And Ingredients. AOCS Press, Champaign Ill, United States, pp 1–51.

Livesey G, 2003. Health Potential Of Polyols As Sugar Replacers, With Emphasis On Low-Glycaemic Properties. Nutr Res Rev 16: 163–191.

Majzoobi M, Ghiasi F, Habibi M, Hedayati S, Farahnaky A, 2013. Influence Of Soy Protein Isolate On The Quality Of Batter And Sponge Cake. J Food Process Preserv 38: 1164–1170.

Małgorzata G, 2015. Sugar Alcohols—Their Role In The Modern World Of Sweeteners: A Review. Eur Food Res Technol 241: 1–14.

Matsakidou A, Blekas G, Paraskevopoulou A, 2010. Aroma And Physical Characteristics Of Cakes Prepared By Replacing Margarine With Extra Virgin Olive Oil. LWT–Food Sci and Technol 43(6): 949–957.

Moiraghi M, Hera DLE, Pérez GT, Gómez M, 2012. Effect Of Wheat Flour Characteristics On Sponge Cake Quality. J Sci Food Agric 93(3): 542–549.

Monma M, Ito M, Saito M, Chikuni K, 1994. Carotenoid Components In Soybean Seeds Varying With Seed Color And Maturation Stage. Biosci, Biotechnol, Biochem 58(5): 926–930.

Natal DIG, Dantas MIDS, Vidigal MCTR, Ribeiro SMR, Silva RR, Martino HSD, 2013. Physical And Sensorial Properties Of Potato Breads Fortified With Whole Soybean Flour. Rev Chil Nutr 40(1): 62–71.

Ndife J, Abdulraheem LO, Zakari UM, 2011. Evaluation Of The Nutritional And Sensory Quality Of Functional Breads Produced From Whole Wheat And Soy Bean Flour Blends. Afr J Food Sci 5: 466–472.

Nielsen SS, 1998. Nutrition labeling. In SS Nielsen, ed, Food Analysis, Ed 2. An Aspen Publication, Gaithersburg, United States, pp 44.

Nilufer D, Boyagioglu D, Vodovotz Y, 2008.

Functionality Of Soymilk Powder And Its Components In Fresh Soy Bread. J Food Sci 73(4): C278–C281.
Ortolan F, Steel, JC, 2017. Protein Characteristics That Affect The Quality Of Vital Wheat Gluten To Be Used In Baking: A Review. Compr Rev Food Sci Food Saf 16: 369–381.
Rakcejeva T, Galoburda R, Cude L, Strautniece, E, 2011. Use Of Dried Pumpkins In Wheat Bread Production. Procedia Food Sci 1: 441–447.
Riaz MN, 1999. Healthy Baking With Soy Ingredients. Cereal Food World 44: 136–139.
Rodge AB, Sonkamble SM, Salve RV, Hashmi SI, 2012. Effect Of Hydrocolloid (Guar Gum) Incorporation On The Quality Characteristics Of Bread. J Food Process Technol 3(2): 1000136.
Rodríguez-García J, Salvador A, Hernando I, 2014. Replacing Fat And Sugar With Inulin In Cakes: Bubble Size Distribution, Physical And Sensory Properties. Food Bioprocess Tech 7: 964–974.
Salvador A, Martínez-cervera S, Sanz T, 2013. Comparison Of Different Polyols As Total Sucrose Replacers In Muffins: Thermal, Rheological, Texture And Acceptability Properties. Food Hydrocoll 35: 1–8.
Sana M, Xhabiri G, Seferi E, Sinani A, 2012. Influence Of Soy Flour In Baked Products. Albanian J Agric Sci 11(4): 255–259.
Sentko A, Bernard J, 2012. Isomalt, In LB Nabors, ed, Alternative Sweeteners, Ed 4. CRC Press, Boca Raton, United States, pp.291.
Sentko A, Willibald-Ettle I, 2012. Isomalt. In K O'Donnell, M Kearsley, eds, Sweeteners And Sugar Alternatives In Food Technology. Wiley-Blackwell, New Delhi, India, pp.32.
Serrem C, Kock H, Taylor J, 2011. Nutritional Quality, Sensory Quality And Consumer Acceptability Of Sorghum And Bread Wheat Biscuits Fortified With Defatted Soy Flour. Int J Food Sci Technol 46: 74–83.
Shahraki R, Firouzi M, Harati H, Hesari J, Najafi, MA. 2013. Fortification Of Cake With Soy Flour As A Functional Food. J Basic Appl Sci Res 3: 336–341.
Shankar P, Ahuja S, Sriram K, 2013. Non-Nutritive Sweeteners: Review And Update. Nut 29: 1293–1299.
Siti Faridah MA, Noor Aziah AA, 2012. Development Of Reduced Calorie Chocolate Cake With Jackfruit Seed (*Artocarpus heterophyllus Lam*.) Flour And Polydextrose Using Response Surface Methodology (RSM). Int Food Res J 19(2): 515–519.
Struck S, Jaros D, Brennan CS, Rohm H, 2014. Sugar Replacement In Sweetened Bakery Goods. Int J Food Sci Technol 20: 1–14.
Sutwal R, Dhankhar J, Kindu P, Mehla R, 2019. Development Of Low Calorie Jam By Replacement Of Sugar With Natural Sweetener Stevia. Int J Cur Res Rev 11(4): 9–16.
Tharise N, Julianti E, Nurminah M, 2014. Evaluation Of Physicochemical And Functional Properties Of Composite Flour From Cassava, Rice, Potato, Soybean, And Xanthan Gum As Alternative Of Wheat Flour. Int Food Res J 21(4): 1641–1649.
Wang YC, Yu RC, Yang HY, Chou CC, 2003. Sugar And Acid Contents In Soymilk Fermented With Lactic Acid Bacteria Alone Or Simultaneously With Bifidobacteria. Food Microbiol 20: 333–338.
Watts BM, Ylimaki GL, Jeffery LE, 1989. Basic Sensory Methods For Food Evaluation. The International Development Research Centre, Ottawa, Canada.
Wohlfarth C, 2006. CRC Handbook Of Enthalpy Data Of Polymer-Solvent Systems. CRC Press, Boca Raton, United States.
Zhao Q, Selomuly C, Xiong H, Chen XD, Li X, Wang S, Sun W, 2014. Rice Dreg Protein As An Alternative To Soy Protein Isolate: Comparison Of Nutritional Properties. Int J Food Prop 17: 1791–1804.