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Research paper



Effect of Maltodextrin Substitution on Physicochemical and Sensorial Properties of Malay Traditional Cake 'Bahulu'

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Abstract

Although Malaysia is not a wheat-producing country, most Malaysian traditional foods uses wheat flour as its main ingredient. One ingredient substitution for wheat flour is modified starch, maltodextrin. The aim of this study was to assess the effects of wheat flour substitution with maltodextrin on physicochemical and sensorial properties of a Malay traditional cake, 'bahulu'. Changes in the viscosity of batter, water activity (a_w), specific volume, colour, texture profile and sensorial preference of 'bahulu' with 5% (M5), 10% (M10) and 15% (M15) maltodextrin substitution were measured. The results showed that with increase substitution of maltodextrin, batter viscosity, specific volume and a_w values decreased. However, redness (+a*) of crust and yellowness (+b*) of crust and crumb, hardness, springiness, gumminess and chewiness of 'bahulu' increased. No significant difference was observed for L* (lightness) and –a* (greenness) of crumb, adhesiveness and cohesiveness. Compared to control, 'bahulu' with maltodextrin substitution showed reduction in degree of preference for sensory score except for texture attribute. This study indicates that replacement of wheat flour is possible at a certain level of substitution, however, further improvements are required in order to maintain the quality of the Malaysian heritage food.

Keywords: *Traditional food; 'bahulu'; maltodextrin; texture profile.*

1. Introduction

In Malaysia, various traditional foods are served daily or available only during festive seasons. 'Bahulu' is one of the traditional Malay snack foods and recognised as a heritage food of Malaysia [1]. Basically, 'bahulu' is a type of sponge cake which relies on incorporation of air for its texture and volume. It is made of three main ingredients which are wheat flour, sugar and eggs. This traditional cake has a springy, dry texture, sweet taste and is golden brown in colour.

Like many other Malaysian traditional foods, wheat flour is the principal ingredient ranging from 20 to 80% of the total ingredients used. Other food types utilising wheat flour such as noodles, biscuits, bread, pastries and other wheat-based products are also on the rise. Nationwide, Malaysian consume 960,000 tonnes of wheat flour annually [2]. This creates great demand for wheat imports for Malaysia. Australia is the major exporter of wheat grain to Malaysia, supplying about 60% of total wheat grain imported, the remaining comes from India, Pakistan, Russia and Ukraine. In order to reduce the high dependency of wheat in Malaysia, an alternative ingredients with similar functional properties to wheat flour must be acquired. Substitution of this ingredient must be able to maintain the quality attributes of the product. If the alteration is noticeable, the new taste and texture have to be accepted by the consumers.

Wheat grain undergo several stages of breaking, grinding and sieving processes before becoming flour. Hard wheat flour which contains 11 to 18% protein is used for making bread, noodle and pasta while soft wheat flour which contains 7 to 8.5% protein is used for making for cakes and pastries [3]. The lower amount of gluten protein and smaller particle size results in an elevated volume, soft texture and spongy cake [4].

Maltodextrin is a modified starch produced through starch hydrolysis that causes conversion or rearrangement of the α-1,4 glycosidic linkages into a form of 1,2-, 1,3-, and 1,4-α or β glycosidic linkages. The derivatisation process involves the reaction of both starch transglucosidation and hydrolysis of starch or known as dextrinisation process [5]. The functional properties of maltodextrin produced may vary based on the starch hydrolysis technique, either using acid or enzyme, and also by the source and type of starch being utilised in the production either from cassava, rice, potato, corn, low-waxy or high-waxy starch [6]. In general, maltodextrin has a bland taste and contain lower amount of dextrose. In food applications, maltodextrin is used as a bulking agent to increase viscosity, helps in reducing browning reaction, retaining moisture or reducing the hygroscopicity of food products and contributes to a good acceptability. Maltodextrin is resistant towards further hydrolysis reactions in the digestive system therefore it can be categorised as dietary fiber rather than as starch derivative. Maltodextrin is also used as a fat replacer since it has health beneficial effects such as reducing triglycerides and serum cholesterol levels, enhancing the intestinal functions and performance as well as controlling and regulating the level of postprandial blood glucose in the body [5].

In this study, substitution of wheat flour with maltodextrin was tested on a traditional Malay food. The aim of this study were to evaluate the changes on physicochemical properties and the acceptability of maltodextrin substituted 'bahulu". The information obtained from this study will give an insight on the effects of wheat flour substitution towards the quality of a product.

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2. Methodology

2.1. Materials

Food grade ingredients for preparation of 'bahulu' consists of wheat flour (FFM Berhad, Pelabuhan Klang, Selangor), grade B eggs, sugar (Malayan Sugar, Prai, Penang), vanilla essence (Star Brand, PPB Group, Kuala Lumpur) and maltodextrin with DE<20 (Meilun Food Chemical Sdn Bhd, Klang, Selangor, Malaysia).

2.2. Preparation of 'Bahulu'

One batch of 'bahulu' was made using 300 g of wheat flour, 450 g of sugar, 400 g of whole eggs and 5 ml of vanilla essence. A total of 12 batches were prepared consisting of triplicate batches for each control, 5% (M5), 10% (M10) and 15% (M15) maltodextrin substituted 'bahulu'. The percentage of maltodextrin substitutions were calculated based on the total amount of wheat flour.
Firstly, whole eggs were whipped at high speed for 10 mins using a bowl mixer (Chef Classic, Kenwood, UK). Then, sugar was added and the beating was continued for 5 mins at medium speed to dissolve the sugar. At this stage, the sugar-egg mixture became thick, pale and sticky. After that, 5 ml of vanilla essence was added and the mixing continued for 1 min at low speed to homogenise the essence into the mixture. Next, still at low speed, wheat flour was added slowly until the mixture became homogenous and well mixed. Prior to baking, the 'bahulu' moulds were preheated at 240°C for 5 mins. The 'bahulu' batter (15 g) was placed in each individual mould then baked using electrical deck oven (Revent International, Sweden) at 240°C for 5 mins. The baked "bahulu" was removed from the mould and allowed to cool to room temperature (2 hrs) prior to analysis.

2.3. Batter viscosity

Prior to baking, sample of batters were tested for viscosity using a digital rotational viscometer (DV-III, Brookfield Engineering Laboratories, Stoughton, MA). Each batters sample (200 g) was placed in a beaker and measured with spindle No.3 at rotating speed of 20 rpm at room temperature (28±1°C).

2.4. Water activity (a_w)

The measurement for a_w was performed using water activity instrument (Dew Point Water Activity Meter 4TE, AquaLab, USA). The instrument was calibrated using standard salt solution (KCl, 0.5 molality, a_w 0.984±0.003) before placing the grounded "bahulu" sample (5 g) in a_w sample cup.

2.5. Colour

The colour of 'bahulu' crust and crumb was analysed using a chromameter (CR 400, Konica Minolta Sensing Inc, Osaka, Japan). The CIE L*a*b* colour system was used where L* indicates the degree of lightness ranging from 0 to 100, a* represents redness or greenness hue range from -80 to +80, while b* represents yellowness or blueness hue range from -80 and +80.

2.6. Specific volume

The specific volume was analysed using rapeseed displacement method 10-05.01 [7] for baking quality.

2.7. Texture profile

Two-bite test of texture profile was conducted using texture analyser (TA.XTplus, Stable Microsystems, Surrey, UK). The values for each textural attributes were calculated using the instrument accompanied software "Texture Expert". Double compression of 50% deformation using platen's probe of 75 mm diameter with 2 mm/s of probe speed were used. The texture parameters recorded were hardness, adhesiveness, springiness, cohesiveness, gumminess and chewiness.

2.8. Sensory evaluation

Sensory analysis was performed by using the 9-point hedonic scale with dislike extremely (scale 1) to like extremely (scale 9). Relevant quality attributes of 'bahulu' such as appearance, colour, texture, taste and overall acceptability were evaluated. This was conducted in the sensory laboratory involving 30 untrained panelists comprising of staff and students of the Faculty of Applied Sciences, UiTM Shah Alam, Selangor, Malaysia. Panellists were given coded samples and instructed to rinse their mouths with plain water between samples to minimise any residual effects.

2.9. Statistical analysis

All analysis was conducted in triplicates except for sensory evaluation and data were reported in mean ± standard deviation. The data were analysed using one way analysis of variance (ANOVA) statistical analysis with Statistical Package for the Social Science (SPSS Inc., Chicago, Illinois, USA) version 19.0. Duncan's multiple range tests were used to determine significant differences among means at $p<0.05$.

3. Results and Discussion

3.1. Effects of maltodextrin substitution on the viscosity of batter, a_w, specific volume and colour of 'bahulu'

The mean values of the batter viscosity, specific volume and colour of the 'bahulu' obtained from the substitution of varying amounts of maltodextrin with wheat flour, in comparison to the original 'bahulu' (control) are presented in Table 1. Fig. 1 shows the appearance of the Malaysian traditional 'bahulu' samples.
As seen, substitution of maltodextrin significantly decreased the viscosity of the batters. The 'bahulu' batter viscosity was significantly reduced by 19% for M5 compared to control and was further decreased by 23% and 26% for M10 and M15 respectively. No significant difference was observed in the batter viscosity between M10 and M15 maltodextrin-substituted 'bahulu'.
A similar trend was observed in the study conducted by Laksminarayan et al. of pound cake [8]. Their study showed that batter viscosity had gradually decreased with the increase in maltodextrin substitution. According to them, high viscosity of batter is essential to slow down the air bubbles migration and diffusion of gas from the batter system. In fact, through reduction of the migration of air bubbles from an adequately high viscous batter, its stability can be enhanced.
Based on the result of this study, batter viscosity of control 'bahulu' is more stable compared to the other samples as it displayed higher batter viscosity value. The decrease in batter viscosity of maltodextrin-substituted 'bahulu' is due to insufficient formation of air cells and inability of the batter to entrap these air cells during mixing.

Table 1: Effect of maltodextrin substitution on batter viscosity, aw and colour of 'bahulu'

Parameters	Control	Percentage of maltodextrin substitution with wheat flour		
		M5	M10	M15
Batter viscosity (mPa.s)	8186.67 ± 23.09[a]	6573.33 ± 83.27[b]	6306.67 ± 52.08[c]	6066.57 ± 93.02[c]
a_w	0.7352 ± 0.0019[a]	0.7147 ± 0.0018[b]	0.7115 ± 0.0012[c]	0.7051 ± 0.0010[d]
Specific vol-	27.67 ±	24.10 ±	20.08 ±	17.67 ±

ume (cm^3)	0.58[a]	0.83[b]	0.98[c]	0.57[d]
Crust colour				
L*	61.34 ± 3.55[a]	55.19 ± 2.97[b]	56.98 ± 0.82[a,b]	55.04 ± 3.73[b]
a*	12.64 ± 1.18[c]	17.25 ± 0.56[a]	16.65 ± 0.69[a,b]	15.14 ± 1.02[b]
b*	39.15 ± 0.58[c]	41.10 ± 0.74[b]	44.97 ± 0.55[a]	42.11 ± 1.00[b]
Crumb colour				
L*	78.69 ± 0.42[a]	78.95 ± 1.79[a]	78.28 ± 1.05[a]	77.23 ± 0.85[a]
a*	-0.23 ± 0.06[b]	0.08 ± 0.17[a]	-0.24 ± 0.17[b]	0.05 ± 0.05[a]
b*	25.25 ± 0.29[b]	26.25 ± 0.08[a]	26.54 ± 0.70[a]	26.78 ± 0.44[a]

Means followed by different small letters of a to d superscripts in the same row were significantly different at $p<0.05$

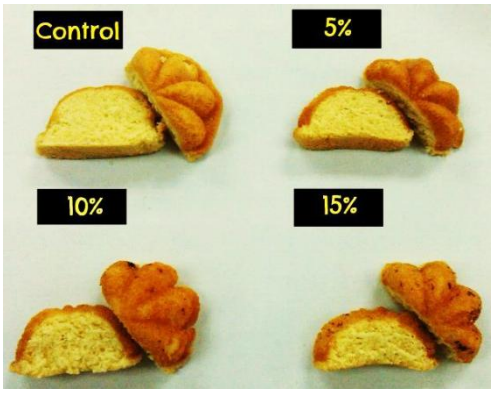


Fig.1: Photo of Malaysian traditional cake 'bahulu'

Other findings have shown that a good cake batter must retain sufficient viscosity to prevent the incorporated air bubbles from rising to the surface and being lost during initial heating [9],[10] . The cake setting must be timed so the air bubbles can be properly expanded by the CO_2 gas and water vapour before the cake sets. Thus, the resulting cake structure becomes highly aerated and has a more defined structure.

Depending on the properties of the ingredient substituted or added, batter viscosity of bakery and cake products may be increased or decreased accordingly based on the functional properties that it is expected to represent. In some studies, addition of maltodextrin in bakery products helps in contribution to a creamy mouthfeel and increase in viscosity [8]. In contrast with the finding of this study, a higher viscosity of batter was obtained when maltodextrin was substituted with shortening in yellow layer cakes [11]. Study by DeFouw et al. reported an increase in batter viscosity when 15% wheat flour was replaced with either unheated or roasted navy bean hulls in layer cakes [12]. Similarly, Masood et al. also reported that batter viscosity of cake increased with increasing apple pomace level and decreasing particle size [13]. However, Gomez et al. found that addition of starch fraction of pea flour instead of wheat flour into sponge cake results in either a slight reduction or no change in the viscosity of batter [14].

Water activity (a_w) in food systems is the single most important property of water. It describes the degree of water bound in food and its availability to act as solvent and to take part in physical, chemical and microbiological reactions. Addition of other ingredients such as sugars, salts, humectants or other sweeteners (synthetic sugar, sugar alcohol etc.) will influence a_w of the food product [15].

In this study, a significant decrease in a_w was observed with the increase of maltodextrin substitution in 'bahulu'. This observation is expected since maltodextrin is known to act as humectant. The common level of a_w of bakery products are in the range of 0.75 to 0.85 but the a_w level can be higher if the product was not adequately cooled before packing since this will result in moisture build-up in the package [16]. Study by Lu et al. had reported a high a_w of 0.907 in their control sponge cake [17]. Typically, a sponge cake is produced using several ingredients which are wheat flour, sucrose, eggs, oil, milk and water. 'Bahulu' is categorised as a sponge cake due to its texture and appearance but it's a_w is lower than normal sponge cake. This is because of its high sugar content which can make up to 40% of the total ingredients used and with the substitution of maltodextrin, a_w of 'bahulu' was becomes further reduced. This traditional food is also known for its stability during storage. Vast majority of spoilage bacteria will grow at about 0.90 a_w, most yeasts at a_w 0.91 to 0.87 except osmophilic yeasts which can grow at a_w of 0.65 to 0.60, while most moulds grow at a_w 0.87 to 0.80 except for xerophilic moulds which can grow at a_w 0.75 to 0.65 [18]. The values of a_w obtained in this study indicate that 'bahulu' is a very stable cake but may be susceptible to osmophilic yeasts and xerophilic moulds. It was reported that the shelf life of a product can be extended by lowering a_w, however the quality of cakes and bakery products may be affected in terms of texture, volume and shape [19].

Similar with a_w, specific volume of 'bahulu' decreases significantly with the increase substitution of maltodextrin. This can be observed in Fig. 1. The size of 'bahulu' seems to be slightly reduced in height compared to control and the air cells appeared to be affected too.

According to Masood et al., batter viscosity plays a role in development of the cake's internal structure and its volume through retaining of the gas produced [13]. Apart from that, the consistency of batter also must be adequate in order for the gases to be sufficiently retained in the batter system during the process of baking to produce the right volume. During baking, the processes of coagulation of protein and gelatinisation of starch results in the conversion of batter to a porous semisolid structure and contributes to an increment in the cake volume [20].

In this study, 'bahulu' batter viscosity was reduced with maltodextrin substitution and its effects are reflected by the reduction in specific volume of the baked 'bahulu'. Since the maltodextrin substituted 'bahulu' has lower batter viscosity, this resulted in a rapid escape of air bubbles from the batter and subsequently lead to a poor volume of 'bahulu'. Similarly, Sudha et al. reported a decrease in sponge cake volume with increasing apple pomace contents [13]. The increase replacement of flour with cellulose weakens the gluten matrix responsible for retaining gases as well as the ability of apple pomace to retain water. Others explained that poor cake volume may be resulted from the delay in process of starch gelatinisation when the components of bran in wheat retain water and cause interaction with the starch component in the flour [20]. Touma stated that the final volume of cake is directly influenced by the quantity of bound water remained in the cake after completion of baking process in which increase amount of free water in the batter results in reduction of cake volume [22]. In this study, maltodextrin may be responsible for water absorption that interacts with the starch in the flour, causing delay in the starch gelatinisation process. This lowers the a_w and subsequently resulting in the decrease of 'bahulu' volume.

Maltodextrin substitution in cakes have been shown to assist in development of better colour formation [8]. In this study, the lightness (L*) of 'bahulu' crust showed no significant difference between control and M10 sample, while redness (+a*) and yellowness (+b*) values were significantly increased compared to control. For crumb colour, there was no significant difference among all samples for L*. A significant difference was observed between control and M5 and M15 for a* value while +b* showed significant increase between the control and all maltodextrin-substituted 'bahulu'. Since the crumb colour of 'bahulu' control and M10 showed negative value for a*, this indicates that the crumb colour displayed a slightly greenish hue.

In baked products, the darker colour of crust is a result of the Maillard reaction when the surface of product is subjected to a temperature above 100°C. Greater oven temperature in a shorter baking time will cause a more humid and thinner crust product [23]. According to Majzoobi et al. caramelisation and Maillard reactions influence the crust colour of cake while, the ingredients

used in cake formulation influence the colour of the cake's crumb [24].

3.2. Texture profile

Textural characteristics of food product are the essential properties which reflect the acceptability by the consumer. The measurements of quantified texture attributes of control and maltodextrin-substituted 'bahulu' are presented in Table 2. Substitution of maltodextrin in 'bahulu' causes a significant decrease in hardness, gumminess and chewiness. For springiness, M5 showed no significant difference with control but decreased with further increment in maltodextrin substitution. No significant difference in adhesiveness and cohesiveness were observed among all samples.

Table 2: Effect of maltodextrin substitution on texture attributes of 'bahulu'

Attributes	Control	Percentage of maltodextrin substitution with wheat flour		
		5%	10%	15%
Hardness (g)	1117.02 ± 29.69^{a}	803.58 ± 25.60^{c}	1015.55 ± 32.98^{b}	856.99 ± 44.11^{c}
Adhesiveness (g/s)	0.00 ± 0.00^{a}	-0.63 ± 1.10^{a}	-0.45 ± 0.48^{a}	-0.47 ± 0.19^{a}
Springiness	0.85 ± 0.01^{a}	0.85 ± 0.01^{a}	0.80 ± 0.02^{b}	0.76 ± 0.03^{c}
Cohesiveness	0.72 ± 0.06^{a}	0.70 ± 0.02^{a}	0.68 ± 0.01^{a}	0.67 ± 0.01^{a}
Gumminess (g)	813.55 ± 67.23^{a}	556.82 ± 40.17^{c}	686.65 ± 24.50^{b}	572.71 ± 36.60^{c}
Chewiness (g)	683.27 ± 80.06^{a}	472.30 ± 42.97^{b,c}	549.92 ± 17.46^{b}	434.46 ± 12.94^{c}

Means with different small letters in a to c superscript of the same row are significantly different ($p<0.05$)

Hardness is a measure of maximum force required for food compression at specific length for a specific rate. Food products like cakes and bread tend to deteriorate through the loss of moisture resulting in the hard texture of the product. The hardening of bread products involves two separate processes. Firstly, the effect of hardness is due to the transfer of moisture from the crumb to the crust and, secondly the internal hardness of cell wall during storage followed by the retrogradation of starch [25], [26]. In most conditions hardness is directly proportional to volume. This is reflected by the results of this study in which both hardness and volume decreases with higher substitution of maltodextrin. The direct proportionality between hardness and volume was also reported in other studies [17], [25].

Adhesiveness is the negative force area between the first and second compression by which the food product is described as highly adhesive if it displays a larger negative value. Since the result in this study showed no significant difference among samples therefore this indicates that maltodextrin does not contribute to stickiness of 'bahulu'.

Springiness is quantified by the elasticity and determined by calculating the degree of recovery between the first and second compressions. According to Majzoobi et al., springiness value also reflects the degree of difficulty towards re-establishment of the cake's original size after it is subjected to the mouth or hand pressed [26]. A study by Touma showed that the amount of bound water in batter and in baked cakes had significant correlations with volume, hardness and springiness [22]. This is in agreement with the results of this study, decrease in a_w and volume caused the decrease in hardness and springiness of the maltodextrin-substituted 'bahulu'.

For a certain type of cake such as sponge cake, the quality depends on the aeration properties and freshness which are indicated through the high springiness value [27]. The decrease in springiness of 'bahulu' with increment of maltodextrin implies poor aeration characteristics. On the other hand, the reduction in springiness of cakes may also be caused by an increase in the quantity of free water in both cake and batter. This is because, if excess free water is present in in the cake batter, it will interfere with the structure of protein, causing the formation of soggy cakes and subsequently leads to the reduction in springiness of cake [22].

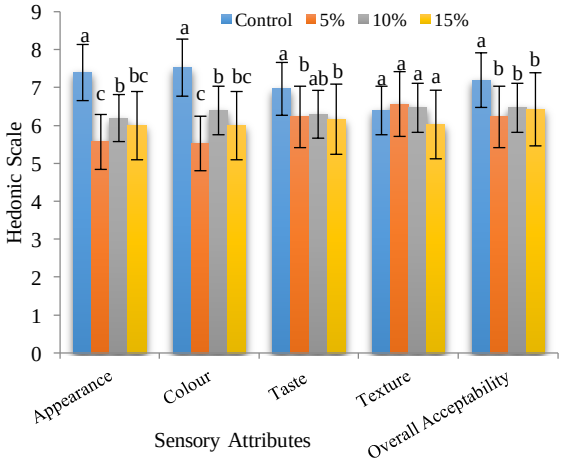
Cohesiveness is a measure of internal resistance in structure of food and indicates the extent of cake deformation prior to its breakage [26]. In this study, no significant difference in cohesiveness was observed among all samples. According to Rodrigues-Garcia et al., greater value of cohesiveness is resulted from an uneven cell structure of the crumb due to the presence of condensed crumb areas and bigger air cells [28]. Apart from that, reduction in cohesiveness may also be resulted from the lack of of intramolecular interaction between the ingredients, drying or product deterioration during storage [29].

Gumminess is calculated by hardness multiplied by cohesiveness, whereas chewiness is calculated by gumminess multiplied by springiness. Chewiness also represents the amount of energy needed to disintegrate a food for swallowing. Since the calculation of both gumminess and chewiness involve the multiplication of hardness value, therefore both values were affected by it. In this study, decrease in hardness values of all samples were reflected by the decrease in gumminess and chewiness results obtained.

3.3. Acceptability of 'bahulu'

The sensorial perception of food products is an essential aspect which defines the food's appreciation and will directly affect the purchasing behaviour by consumer. Fig. 2 shows the result on acceptability of 'bahulu' for the attributes of appearance, colour, taste, texture and overall acceptability.

For sensory attributes of appearance, colour and overall acceptability, the control 'bahulu' obtained the highest likeness by the panelists compared to all samples of maltodextrin substituted 'bahulu'. There was no significant difference in terms of taste between control and M10, while the texture attribute showed no significant difference among all samples. In general, the panelists were able to detect the maltodextrin-substituted 'bahulu' which is reflected by the lesser score for sensory perception. This is most probably due to the observable shrinkage appearance of the samples, slightly darker colour of crust and denser structure (Fig.1).



Different small letters of the same sensory attribute indicates significant difference at $p<0.5$

Fig. 2: Sensory attributes preference score of 'bahulu'

For a successful acceptance by consumers, a new product should obtain a minimum mean score of 7.00 for sensory results. In this study, control 'bahulu' obtained mean score range from 6.4 to 7.5, M5 mean score range from 5.5 to 6.6, M10 mean score range from 6.2 to 6.5 and M15 mean score range from 6.0 to 6.5. These results indicate that only control 'bahulu' was within like moderately score while maltodextrin-substituted 'bahulu' of M10 and M15

were within like slightly. Sample M5 obtained the lowest mean score of below 6.0 which indicates neither like nor dislike.
Therefore, further improvements in the quality of 'bahulu' is necessary for a successful substitution of wheat flour with maltodextrin such as addition of gums or hydrocolloids to avoid shrinkage and to retain the spongy structure of the traditional cake.

4. Conclusion

The substitution of maltodextrin for wheat flour was evaluated on Malay heritage food 'bahulu'. Quality properties such as batter viscosity, a_w, specific volume, colour, texture profile and sensory preference were affected by the substitution resulting in lower evaluation scores. However, reduction of a_w due to the hygroscopic nature of maltodextrin was a good enhancement for the product. Further studies are required to improve the physical and textural quality of 'bahulu' in order to gain higher acceptance by the consumers.

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References

[1] Mudor H (2010) Comparison of quality perception: an analysis of local traditional snack food in Penang, Kedah and Perlis. Ph.D. Thesis. Universiti Sains Malaysia, Pulau Pinang, Malaysia.
[2] http://www.world-grain.com/Departments/Country-Focus/Country-Focus-Home/Focus-on-Malaysia.aspx?cck=1 retrieved online on 10.08.2018
[3] Vaclavik VA & Christian EW (2014) Essentials of food science (4th ed). Springer Science Business Media, New York.
[4] Moiraghi M, Hera EDL, Perez GT & Gomez M (2013) Effect of wheat flour characteristics on sponge cake quality. *Journal of the Science of Food and Agriculture* 93(3), 542-549.
[5] Cho SS & Samuel P (2009) Fiber Ingredients: Food Applications and Health Benefits. CRC Press, USA.
[6] Hull P (2010) Glucose Syrups: Technology and Applications. Blackwell Publishing, USA.
[7] AACC International (1999) Approved Methods of Analysis, 11th Ed. Method 10-05.01. Measurement of volume by rapeseed displacement. Baking Quality. AACC International, St. Paul, MN, U.S.A.
[8] Lakshminarayan SM, Rathinam V & KrishnaRau L (2006) Effect of maltodextrin and emulsifiers on the viscosity of cake batter and on the quality of cakes. *Journal of the Science of Food and Agriculture* 86, 706-712.
[9] Ngo WH & Taranto MV (1986) Effect of sucrose level on the rheological properties of cake batters. *Cereal Foods World* 31, 317–322.
[10] Paton D, Larocque GM & Holme J (1981) Development of cake structure: Influence of ingredients on the measurement of cohesive force during baking. *Cereal Chemistry* 58, 527–529.
[11] Kim HYL, Yeom HW, Lim HS, Lim ST (2001) Replacement of shortening in yellow layer cakes by corn dextrins. *Cereal Chemistry*, 78, 267-271.
[12] De Fouw C, Zabik ME, Uebersa MA & Aguilera JM (1982) Use of unheated and heat treated navy bean hulls as a source of dietary fiber in spice flavoured layer cakes. *Cereal Chemistry* 59, 22–230.
[13] Masood FA, Sharma B & Chauhan GS (2002) Use of apple as a source of dietary fiber in cakes. *Plant Foods for Human Nutrition* 57, 121–128.
[14] Gomez M, Doyague MJ & Hera EDL (2012) Addition of pin-milled flour and air-classified fractions in layer and sponge cakes. *Journal of Food Science and Technology* 46, 142- 147.
[15] Ergun R, Lietha R & Hartel RW (2010) Moisture and shelf life in sugar confections. *Critical Reviews in Food Science and Nutrition* 50(2), 162-192.
[16] Guynot ME, Ramos AJ, Sala D, Sanchis V & Marin S (2002) Combined effects of weak acid preservatives, pH and water activity on growth of Eurotium species on a sponge cake. *International Journal of Food Microbiology* 76(1), 39-46.
[17] Lu TM, Lee CC, Mau JL & Lin SD (2010) Quality and antioxidant property of green tea sponge cake. *Food Chemistry* 119: 1090-1095.
[18] Beuchat LR (1981) Microbial stability as affected by water activity. *Cereal Foods* 26(7), 345-349.
[19] Saranraj P & Geetha M (2012) Microbial spoilage of bakery products and its control by preservatives. *International Journal of Pharmaceutical & Biological Archives* 3(1), 38-48.
[20] Majzoobi M, Ghiasi F, Habibi M, Hedayati S & Farahnaky A (2014) Influence of soy protein isolate on the quality of batter and sponge cake. *Journal of Food Processing and Preservation* 38(3), 1164-1170.
[21] Sudha, M. L., Baskaran, V. and Leelavathi, K. (2007). Apple Pomace as a Source of Dietary Fiber and Polyphenols and Its Effect on the Rheological Characteristics and Cake Making. Food Chemistry. 104: 686-692.
[22] Touma DE (1997). Formulation of a Sugar Free Fat Free Cake: Role of Water and Functional Properties of Fat Replacers and Bulking Agents. Ph.D. Thesis. Auburn University, Alabama, US.
[23] Ureta MM, Olivera DF & Salvadori VO (2014) Quality attributes of muffins: Effect of baking operative conditions. *Food Bioprocess Technology* 7, 463-470.
[24] Majzoobi M, Darabzadeh N & Farahnaky A (2012) Effects of percentage and particle size of wheat germ on some properties of batter and cake. *Journal of Agricultural Science and Technology* 14, 827-836.
[25] Lee CC & Lin SD (2008) Effect of GABA tea on quality characteristics of chiffon cake. *Cereal Chemistry* 85, 31–38.
[26] Majzoobi M, Habibi M, Hedayati S, Ghiasi F & Farahnaky A (2015) Effects of commercial oat fiber on characteristics of batter and sponge cake. *Journal of Agricultural Science and Technology* 17, 99-107.
[27] Sanz T, Salvador A, Baixauli R & Fiszman SM (2009) Evaluation of four types of resistant starch in muffins. II. Effects in texture, colour and consumer response. *Journal of European Food Research and Technology* 229: 197-204.
[28] Rodriguez-Garcia J, Puig A, Salvador A & Hernando I (2013) Functionality of several cake ingredients: A comprehensive approach. *Czech Journal of Food Sciences* 31, 355-360.
[29] Ronda F, Gomez R, Caballero PA, Oliete B & Blanco CA (2009) Improvement of quality of gluten free layer cakes. *Food Science and Technology International* 15(2), 193-202.