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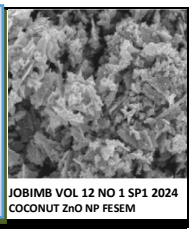

Effect of Partial Replacement of Sucrose with Sorbitol on the Quality Characteristics of Traditional Malaysian Sponge Cake (*Bahulu*)

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ABSTRACT

Bahulu, the traditional Malaysian sponge cake, is one of the most popular local desserts. During extended storage, the cake typically experiences undesirable physical changes such as dry and crumbly texture. Polyols are widely used in bakery products due to their effectiveness as humectants while reducing overall calorie content. This study investigated the effects of partial replacement of sucrose with different levels of sorbitol; 4, 8, 12 % (w/w) on the *bahulu* batter and the final product's properties. The batter's specific gravity decreased with sorbitol, implying a better retention of air cells during the whipping process.cIn contrast, the viscosity of the batter decreased with the addition of sorbitol. The weight loss and water activity decreased, while the moisture content increased with sorbitol level, which is due to the higher ability of the polyol to bind water, resulting in a moister cake with a higher bound water content. The cake volume decreased, while the density increased with increasing sorbitol concentration. The polyol resulted in *bahulu* with a lighter crust color. The partially replaced sugar with sorbitol resulted in *bahulu* with a less crumbly texture and improved microbial stability.

INTRODUCTION

Bahulu is one of the local foods listed as Malaysian national heritage by the Ministry of Unity, Culture, Arts and Heritage [1]. It can be described as a traditional Malay sponge cake that combines crispy crust and soft crumb. A large amount of egg and sugar is used to prepare *bahulu* to achieve good aeration and, thus, the desired texture. However, this results in a product with a high-calorie content. In addition, the starch retrogradation of *bahulu* during storage results in a product with undesirable characteristics such as a dry and crumbly texture.

Replacement of sugar with polyols in the formulation of bakery products is one approach to reducing the calorie content. The incorporation of polyols in cake formulation has been associated with a change in the cake's rheological, microstructural and textural properties [2-3]. In addition, the retrogradation of starch is inhibited, reducing the hardness and moisture migration in the product during storage [4]. Nevertheless, replacing sugar with polyols presents a considerable challenge due to diverse functionalities offered by sucrose. Therefore, this study aims to investigate the effects of sorbitol content on the quality characteristics of *bahulu*.

MATERIALS AND METHODS

Bahulu preparation

The Malaysian sponge cake (*bahulu*) was made from 120 g wheat flour (10 % protein), sucrose and eggs (250 g). For the control sample (S0), 200 g of sucrose was used, while for the sugar-reduced sample (15 % reduction), the sugar was fixed at 170 g and liquid sorbitol was added at 4, 8 and 12 % (w/w, based on the weight of sucrose), and the samples were designated S4, S8 and S12, respectively. Eggs and sucrose were mixed for 45 minutes at speed 2 (Kenwood, UK). Flour was added gradually, followed by the addition of sorbitol. The batter (10 g) was poured into muffin tins (2.5 cm bottom diameter x 2 cm height) and baked for 12 minutes at an oven temperature of 165ºC (bottom temperature) and 195ºC (top temperature).

Characterization of bahulu batter

The specific gravity was measured by calculating the ratio between the batter's weight and distilled water's weight in a container of known volume [5]. The viscosity of the batter was measured using a rheometer (Anton Paar, USA) using a coaxial cup (C25). The test was performed at 100 s^{-1} and 25 ºC.

Characterization of baked bahulu

The water activity and moisture content of *bahulu* were measured using water activity meter and oven method (AOAC method number. 952.45) [6], respectively. The height in the centre of the baked *bahulu* was determined with a vernier calliper. The weight loss of the *bahulu* was calculated by dividing the difference between the batter and the cake by the weight of the batter [7]

$$\text{Weight loss (\%)} = \frac{Weight\ of\ batter\ (g) - Weight\ of\ bahulu\ (g)}{Weight\ of\ batter\ (g)} \text{ x } 100$$

The volume of *bahulu* was determined according to the seed displacement method [8] with some modifications. The sample was placed in a known volume (V1) container, then sago seeds were poured into the container, tapped, and leveled over the top with a spatula. The sample was removed and the volume of sago was recorded (V_2). The volume of *bahulu* was calculated by subtracting the volume of the sago seeds from the volume of the container. Density was determined by calculating the ratio of *bahulu* weight to cake volume.

Statistical analysis

All data were analyzed using one-way ANOVA, Minitab, version 19. Differences between means were compared using Tukey's test ($p<0.05$). Two batches were prepared for each treatment, and triplicate analyses were performed for each batch.

RESULT AND DISCUSSION

Characterization of batter

The properties of the batter are closely related to the final quality of the baked products. With the addition of sorbitol, a thinner *bahulu* dough was obtained, with viscosity decreasing further with increasing sorbitol content (**Table 1**). Similarly, previous authors [2,9] reported decreased viscosity and consistency index of cake batter when sorbitol replaced sucrose. Although sorbitol is known to have a higher water binding capacity than sucrose, the liquid form of sorbitol used in this study resulted in a lower batter viscosity.

Table 1. The properties of *bahulu* batter made with different levels of sorbitol.

Samples	Level of sorbitol (%)	Viscosity (cP)	Specific gravity
S0	0	3316.1 ± 153.1^a	1.675 ± 0.013^a
S4	4	2402.4 ± 116.1^b	1.587 ± 0.050^b
S8	8	1742.7 ± 321.4^c	1.553 ± 0.008^b
S12	12	1241.5 ± 187.4^c	1.445 ± 0.116^c

Superscripts with different letters within the same column indicate means are significantly different at $p<0.05$.

The specific gravity of the *bahulu* batter significantly decreased with the addition of sorbitol. Increasing the sorbitol content further decrease the specific gravity. Specific gravity reflects the capacity of air retention in the batter and inversely correlates with the number of air cells [10] and greatly influences the volume and texture of the cake [11]. The addition of sorbitol increased the aeration properties of the batter, implying that more air cells can be retained in the batter.

Characterization of bahulu

The weight loss indicates the degree of water evaporated from the sample matrix during baking. The weight loss decreased with the addition of sorbitol (**Table 2**). Increasing sorbitol concentration resulted in a lower weight loss, indicating that more water was retained in the sample. This could be due to the presence of a higher number of hydroxyl groups in the polyol, which leads to a higher water binding capacity [12], allowing more water to be retained in the baked sample. This finding correlates with the moisture content results, where the sorbitol-added sample had a significantly higher moisture content, with a higher sorbitol content resulting in a much moister product.

Table 2. Properties of *bahulu* made with different levels of sorbitol.

Samples	Weight loss (%)	Moisture content (%)	Water activity
S0	15.02 ± 0.51^a	12.24 ± 0.10^c	0.825 ± 0.004^a
S4	12.73 ± 1.96^a	16.44 ± 0.12^b	0.768 ± 0.005^b
S8	7.35 ± 1.04^b	16.88 ± 0.21^a	0.754 ± 0.003^c
S12	5.87 ± 1.40^b	17.10 ± 0.20^a	0.730 ± 0.003^d

Superscripts with different letters within the same column indicate means are significantly different at $p<0.05$.

The addition of sorbitol resulted in a significant reduction in water activity (a_w), indicating that although the sorbitol-added *bahulu* has a higher moisture content, a larger amount of the water molecules is present as bound water. Polyols are associated with the ability to bind free water more than sucrose, resulting in a lower a_w [12], attributed to the lower molecular weight of sorbitol (182.2 g/mol) compared to sucrose (342.3 g/mol) [13]. The lower a_w of the sorbitol incorporated-*bahulu* increases the microbial stability of the product.

Increasing sorbitol level resulted in *bahulu* with a lighter crust color (**Fig. 1**). The darkening of the sample with 100 % sugar is attributed to the Maillard reaction, attributed to the hydrolysis of sucrose into glucose and fructose with increasing baking time. In contrast, the increasing lightness of the sorbitol-added sample, is due to the non-reducing property of the polyol, which is due to the lack of also and keto groups [14].

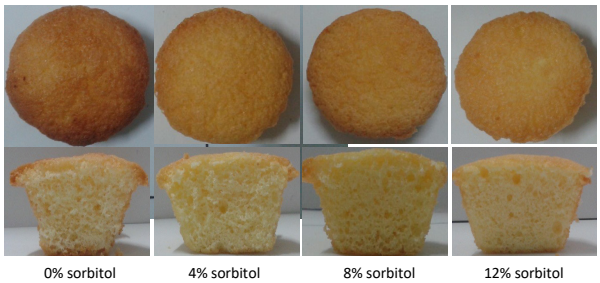

Fig. 1. Top view and cross-section of *bahulu* made with different levels of sorbitol.

The height and volume of the *bahulu* decreased with increasing sorbitol level (**Fig. 2**). The volume negatively correlated (-0.997) with the density of the sample, implying that a lower cake volume resulted in a denser matrix, indicative that sample cannot retain enough air cells during the baking process. The cross-sectional image of the product showed that the sample with 0% sorbitol had a higher porosity, while S12 showed a denser matrix. It is evident that the porosity of the *bahulu* is not only influenced by the batter properties.

The addition of sorbitol is associated with a faster rate of starch gelatinization, leading to the formation of premature starch matrices before the air cells are fully developed, resulting in lower cake volume [9].

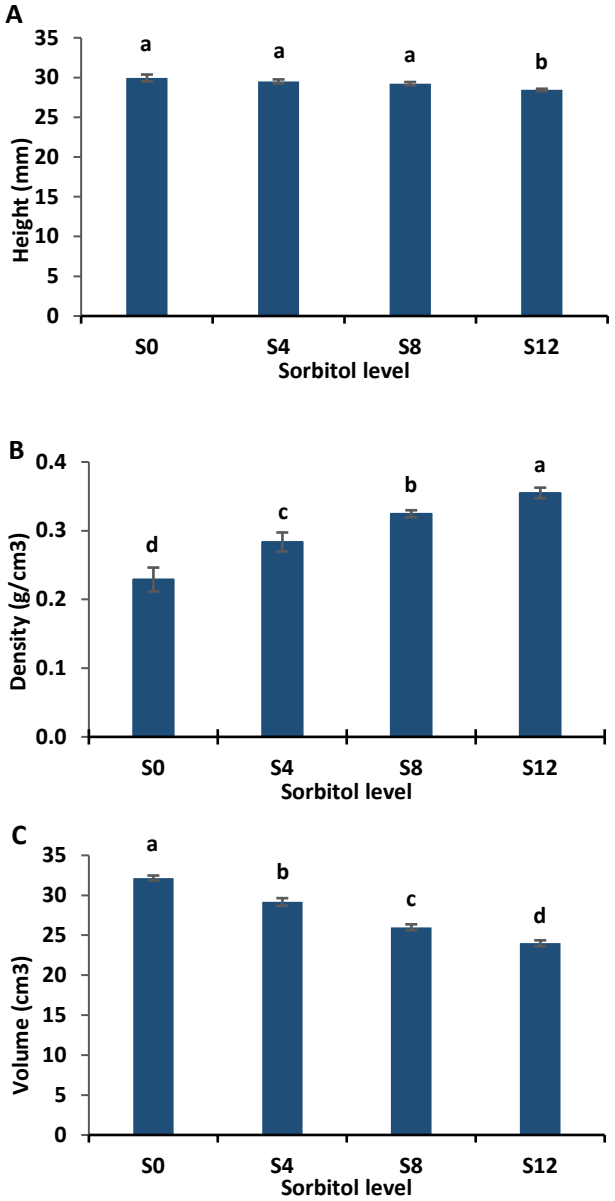

Fig. 2. The (a) height, (b) density, and (c) volume of *bahulu* formulated with different levels of sorbitol.

CONCLUSION

The partial replacement of sorbitol in traditional Malaysian sponge cake (*bahulu*) changed both the batter and final product properties. Sorbitol improved the aeration properties of the batter, allowing more air cells to be retained. The alteration in batter viscosity and possibly starch gelatinization characteristics resulted in sorbitol-added *bahulu* with a lower volume and denser matrix. Nevertheless, the higher water-binding capacity of sorbitol resulted in improved product moistness, as shown by the higher moisture content and lower weight loss, which could delay the formation of a crumbly texture of the product during storage. The reduction of water activity in sorbitol-added *bahulu* could potentially increase the microbial stability of the product. A higher level of sorbitol could positively improve the shelf-life of the product but had a slightly negative impact on the physical quality of the final product.

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REFERENCES

1. Abdul Wahid W. Heritage Food Tourism: Bahulu Attracts? In: Mohamed B, Sirat M, editors. Proceedings of 2nd International Symposium on Tourism Research; 2009 July 18; Penang, Malaysia. Penang: Cluster of Tourism Research; 2009. p. 203-209.
2. Manisha G, Soumya C, Indrani D. Studies on interaction between stevioside, liquid sorbitol, hydrocolloids and emulsifiers for replacement of sugar in cakes. Food Hydrocoll. 2012;29(2):363-373.
3. Marzec A, Kowalska J, Domian E, Galus S, Ciurzyńska A, Kowalska H. Characteristics of dough rheology and the structural, mechanical, and sensory properties of sponge cakes with sweeteners. Molecules. 2021;26:6638.
4. Yang H, Tang M, Wu W, Ding W, Ding B, Wang X. Study on inhibition effects and mechanism of wheat starch retrogradation by polyols. Food Hydrocoll. 2021;121:106996.
5. Hosseinvand A, Sorkhineja A. Determination of unripe banana flour as functional ingredient on physical properties of cake batter. J. Food Process Technol. 2018;9(3):1000723.
6. AOAC. Official Methods of Analysis. 17th ed. Gaithersburg: Association of Official Analytical Chemists; 2000.
7. Liu Y, Guan E, Li M, Bian K, Wen J, Ren C. Improvement of cake quality by superheated steam treatment of wheat. J. Cereal Sci. 2020;95:103046.
8. Lee CC, Wang HF, Lin SD. Effect of isomaltooligosaccharide syrup on quality characteristics of sponge cake. Cereal Chem. 2008;85(4):515-521.
9. Psimouli V, Oreopoulou V. The effect of alternative sweeteners on batter rheology and cake properties. J. Sci. Food Agric. 2012;92(1):99-105.
10. Goswami D, Gupta RK, Mridula D, Sharma M, Tyagi SK. Barnyard millet based muffins: Physical, textural and sensory properties. LWT Food Sci. Technol. 2015;64(1):374-380.
11. Kim JH, Lee HJ, Lee HS, Lim EJ, Imm JY, Suh HJ. Physical and sensory characteristics of fibre-enriched sponge cakes made with Opuntia humifusa. LWT Food Sci. Technol. 2012;47(2):478-484.
12. Ding S, Yang J. The effects of sugar alcohols on rheological properties, functionalities, and texture in baked products – A review. Trends Food Sci. Technol. 2021;111:670-679.
13. Rahman MS. Data and models of water activity. I: solutions and liquid foods. In: Food Properties Handbook. Boca Raton: CRC Press; 2009. p. 49-82.
14. Ghosh S, Sudha ML. A review on polyols: New frontiers for health-based bakery products. Int. J. Food Sci. Nutr. 2012;63:372-379.