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The physicochemical composition and sensory attributes of sponge cake fortification with date powder

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Abstract

The current study investigates the effect of replacing sugar with different concentrations (0, 25, 50, 75, and 100%) of date powder (DP) on the physicochemical and sensory quality attributes of sponge cake. The results showed that DP is rich source of carbohydrate (78.20 ± 0.53%), moisture (7.80 ± 0.20%), fiber (7.73 ± 0.20%) followed by protein (2.73 ± 0.12%), ash (2.54 ± 0.00%), fat (0.50 ± 0.01%), potassium (24.96 ± 1.58 µg/g), phosphorus (3.12 ± 0.15 µg/g), calcium (2.61 ± 0.00 µg/g), iron (0.9 ± 0.00 µg/g), and vitamin A (1.27 ± 0.05 µg/g). Incorporation of different concentrations of DP concurrently ($P \leq 0.05$) increased the weight, protein, fat, ash, fiber, moisture, minerals, and vitamin A and reduced the sponge cake's volume, specific weight, and carbohydrates contents. There are no significant differences between control and DP-containing cake in some sensory attributes. Overall, incorporating DP in sponge cake improved the nutritional and health quality attributes of the products without a major effect on its sensory attributes.

Keywords: date powder; sponge cake; physicochemical properties; sensory attributes.

Practical Application: Fortification sponge cake with date powder improved the nutritional and health quality attributes of the products without major effect on its sensory attributes.

1 Introduction

Date palm (*Phoenix dactylifera* L.) is an important fruit tree native to the hot arid regions of the world, grown mainly in the Arabian Peninsula, North Africa, and the Middle East, and it is known as *a tree of life* because of its multipurpose applications and tolerance to harsh environmental conditions (Al-Yahyai & Manickavasagan, 2012; Altamimi et al., 2020). Saudi Arabia is the second world producer of dates (Food and Agriculture Organization, 2020), with an annual production of about 1.54 million tons in 2019 from 118 thousand hectares of the harvested area and 31 million palm trees (National Center for Palm and Date, 2020). Dates represent the basic and nutritious staple food for a large segment of people in data-producing countries. They play significant roles in those areas' economy, culture, and environment and are marketed worldwide as high-value health-promoting fruits (Johnson et al., 2015). Dates are rich in carbohydrates, mainly a low glycemic index sugar fructose, good quality protein, macro, and micro minerals, vitamins, dietary fiber, carotenoids, polyphenols, mainly isoflavones, lignans and flavonoids, tannins, and sterols (AlFaris et al., 2022; Hussain et al., 2020; Bano et al., 2022). Due to these constituents, dates are considered nutritious and healthy food that could potentially be used to prevent cardiovascular diseases, cancers, and diabetes (Echegaray et al., 2020).

Dates are either directly served and consumed as fresh fruits or processed into numerous products such as dry dates, powders, bars, cubes, syrups, juice concentrates, jams, jellies, jars of butter, candies, chutney, relish, pickles, vinegar, and alcohol (Aleid et al., 2015, Vijayanand & Kulkarni, 2012). In addation, studies have used date to either improve of properties of products or enhance their nutritional value such as: Mostafa et al. (2021) produced probiotic juice and Safdar et al. (2022) made a functional bars from date. Of these products, date powder is a potential ingredient for supplementing bakery products as a replacer to sugar. In this regard, date powder has been used for the development of various food products as a sugar replacer in dairy desserts (Djaoud et al., 2020), biscuits (Sulieman et al., 2011) and rock buns (Barimah et al., 2015) in weaning food formulation (Raza et al., 2020), healthy bread (Messaoudi & Fahloul 2020), and fiber-rich cookies (Shabnam et al., 2020). The above studies indicated that incorporating date powder improved the physicochemical, nutritional, functional, and sensory attributes of developed food products.

Recently, there have been increasing consumer demands for food ingredients from natural sources to eliminate chronic degenerative diseases and promote overall human health (Sayas-Barberá et al., 2020). According to the world health organization, the consumption of refined sugar is linked to the development and progression of various chronic diseases such as diabetes, cancer, obesity, cardiovascular disease, and other health problems (Vita-Finzi, 2005; Weber & Clavien 2006). Sponge cake is one of the bakery products that, in its formulations, high amounts of refined sugar are added as a sweetener. Its consumption is greatly increased in recent years, increasing its risk of promoting the development of dangerous chronic diseases (Barimah et al.,

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2015). The incorporation of date powder in sponge cake as a sugar replacer reduces the negative effect of refined sugar on health. It increases the nutritional quality of the developed products as it contains substantial quantities of essential nutrients such as fiber, vitamins, minerals, and bioactive compounds (Barimah et al., 2015). Therefore, this study was conducted to investigate the effect of different levels of date powder, as a sugar replacer, on sponge cake's nutritional and sensory quality.

2 Materials and methods

2.1 Materials

The date powder was obtained from date farms and markets in Saudi Arabia. Fine wheat flour was purchased from the General Organization for Grain Silos and Flour Mills, Riyadh, Saudi Arabia. Other ingredients used in the cake formula were obtained from local supermarkets in Riyadh, Saudi Arabia. All chemicals used were analytical grades and obtained from Sigma Aldrich (Sigma, USA).

2.2 Preparation of sponge cake

The cake mixtures were formulated by substituting sucrose with different levels (0, 25, 50, 75, and 100%) of date powder (DP) in addition to the other ingredients (Table 1). Initially, the eggs were scrambled with a homogenizer to develop foams for 3 min, and then sugar was added in three portions with continuous mixing. The solid ingredients were mixed and added to the scrambled eggs-sugar mixture in four batches, continuously mixing to form a dough. The formed dough was poured into cake trays (11 cm × 21 cm) and baked in a preheated oven at 180 °C for 30 min. After cooling to room temperature, the physical properties were measured, the cake samples were cut into slices for sensory analysis, and parts were kept at -20 °C for further analysis.

2.3 Analysis of physical properties of sponge cake

The cake volume was measured using the seeds replacement method as described by Lin et al. (2003). Briefly, the volume of alfalfa seeds we measured and fixed as 100 $cm^{3,}$ and then the cake was put into a measuring cylinder, and the volume was completed with alfalfa seeds. The volume of the rest seeds was considered equal to the volume of the cake. The cake weight (g) was measured using a sensitive balance. The specific weight (cm^3/g) of the cake was calculated by dividing the cake volume (cm^3) by the cake weight (g).

Table 1. The ingredients used in the formulation of sponge cake with the substitution of sugar with different concentrations (0, 25, 50, 75, and 100%) of date powder (DP).

Ingredient (g)	Substitution of sugar with DP (%)				
	0	25	50	75	100
Flour	300	300	300	300	300
Egg	180	180	180	180	180
Sugar	330	247.5	165	82.5	0
Salt (NaCl)	4.8	4.8	4.8	4.8	4.8
Bread powder	24	24	24	24	24
Skimmed milk	42	42	42	42	42
Water	288	288	288	288	288
Vegetable Ghee	150	150	150	150	150
Vanilla	0.3	0.3	0.3	0.3	0.3
DP	0	82.5	165	247.5	330

2.4 Approximate composition

The proximate composition of DP and sponge cake supplemented with different levels of DP was determined using the official standard method (Association of Official Aalyntical Chemists, 2016). The moisture content was determined using oven drying at 100 °C for 24 h until a constant weight was achieved. The ash was determined by the dry ashing method in a muffle furnace (Typ MR 170 E, Heraeus, Germany) at 550 °C for 24 h. Fat content was determined after extracting it with a Soxhlet extractor (Soxtec System Ht. 1043, Tecator, Sweden) using petroleum ether for 16 h. The protein content was determined using Kjeldahel digestion and distillation system (Kjelte System 1026, Distilling Unite, Tecator Sweden). The factor 6.38 was used to convert the percentage of dissolved nitrogen to protein. The carbohydrate content was calculated by subtracting the sum of moisture, ash, protein, and fat from 100%.

2.5 Determination of fiber content

The fiber content of DP and sponge cake was determined using **American Association of Cereal Chemists (AACC)** official method (American Association of Cereal Chemists, 2011).

Determination of minerals and vitamin A

Mineral contents (potassium, calcium, phosphorus, and iron) and vitamin A of DP and sponge cake samples were determined using the standard method (Association of Official Analytical Chemists, 2002).

2.6 Sensory analysis

The sensory properties of cake samples were assessed using a scale of 1-4 (1; dislike, 2; like to some extent, 3; like, and 4; extremely like). The samples were coded and presented to the panelists in randomly. The panelists were given preliminary training sessions (n = 3) to increase their evaluation proficiency and familiarity with the samples and sensory attributes. The results were collected, averaged, and subjected to statistical analysis.

2.7 Statistical analysis

The data of triplicate samples were collected, averaged, and statistically analyzed using one-way analysis of variance (ANOVA) by using SPSS software. The means were separated using Duncan multiple range tests (DMRT), and significance was accepted at $P \leq 0.05$.

3 Results and discussion

3.1 Effect of different levels of date powder (DP) on the physical properties of cake

In this study, different concentrations (0, 25, 50, 75, and 100%) of DP were incorporated into sponge cake as a sugar replacer, and its impact on the physicochemical and sensory properties of the product was evaluated. The results in Table 2 show the physical properties of sponge cake as influenced by different levels of DP. The cake volume, weight, and specific weight were not affected by the addition of different levels of DP ($P \geq 0.05$). However, a slight concomitant increase in the weight and reduction in volume and specific weight were seen following the increase in the DP level ($P \geq 0.05$). The increase in the weight could be attributed to the increase in the total solids and fiber in the cake following the addition of DP. The reduction in volume and specific weight is likely due to the increased fiber content of the cake, which can increase the porosity of the cake and consequently reduce the ability to entrap air bubbles during baking processes (Salehi & Aghajanzadeh, 2020). Previous reports indicated that fortification of sponge cake with bottom mushroom (Arora et al., 2017) and apple pomace (Masooi et al., 2002) reduced the volume of the product.

3.2 Effect of DP on the chemical composition of sponge cake

The chemical composition of DP and sponge cake fortified with different levels of DP is shown in Table 3. The DP contains substantial amounts of carbohydrate (78.20 ± 0.53%), moisture (7.80 ± 0.20%), and fiber (7.73 ± 0.20%), followed by protein (2.73 ± 0.12%), ash (2.54 ± 0.00%), and fat (0.50 ± 0.01%). Previous studies showed partially similar results of the chemical composition of date powder (Sulieman et al., 2011; Barimah et al., 2015). Barimah et al. (2015) reported that the moisture, protein, ash, fat, fiber, and carbohydrate contents of DP were 9.56, 3.39, 2.45, 0.98, 1.47, and 82.15%, respectively. While observing that the moisture, protein, ash, fat, fiber, and carbohydrate contents of DP were 11.2, 1.96, 2.30, 0.50, 9.05, and 74.98%, respectively. The differences in the chemical composition of DP between these studies could be attributed to the variation in the date type, drying process, environmental and postharvest handling, and storage process. The incorporation of DP in sponge cake as a sugar replacer greatly affected the product's chemical composition ($P \leq 0.05$). DP addition significantly increased the sponge cake's protein, fat, ash, fiber, and moisture contents compared to the control one ($P \leq 0.05$). Increasing the concentration of DP in the formula concurrently increased the protein, fat, ash, fiber, and moisture levels to maximum values in cake fortified with 100%DP. The effect of DP on carbohydrate content showed a decreasing trend at a low substitution level (25%) and an increasing trend at a high concentration of DP. The increase in protein, fat, ash, fiber and moisture in sponge cake following DP addition could be attributed to high amounts of these chemical attributes in DP. The reduction in carbohydrate content is likely due to the proportional increase in the other components as the carbohydrate is calculated by the difference method (Barimah et al., 2015).

Similarly, previous studies reported that incorporating DP into bakery products increased the protein, fat, ash, fiber, and moisture content (Sulieman et al., 2011; Barimah et al., 2015; Shabnam et al., 2020). In addition, other studies also indicated that the incorporation of dried fruit powder affected the chemical composition (moisture, protein, ash, fiber, and fat) of cake due to the richness of fruit powders with these chemical components (Salehi & Aghajanzadeh, 2020). Overall, the findings of this study indicate that DP enhances the chemical composition of sponge cake.

Table 2. Physical characteristics of sponge cake supplemented with different levels of DP.

Cake sample	Volume (cm^3)	Weight (g)	Specific weight (cm^3 /g)
Control	870.00 ± 7.07 [a]	350.50 ± 27.58 [a]	2.49 ± 0.18 [a]
25% DP	850.50 ± 34.65 [a]	354.00 ± 5.66 [a]	2.41 ± 0.13 [a]
50% DP	830.50 ± 41.72 [a]	360.00 ± 42.43 [a]	2.32 ± 0.16 [a]
75% DP	800.00 ± 0.00 [a]	365.00 ± 38.18 [a]	2.21 ± 0.23 [a]
100% DP	793.00 ± 52.33 [a]	371.00 ± 24.04 [a]	2.14 ± 0.00 [a]

Values are means ± standard deviations (n = 3). Values in the same column with different letters indicate significant difference at P ≤ 0.05, according to Duncan's test.

3.3 Effect of DP on mineral and vitamin content of sponge cake

The mineral and vitamin A content of DP and sponge cake supplemented with different concentrations (0, 25, 50, 75, and 100%) of DP are presented in Table 4. The amounts of potassium (K), phosphorus (P), calcium (Ca), iron (Fe), and vitamin A in DP were 24.96 ± 1.58, 3.12 ± 0.15, 2.61 ± 0.00, 0.9 ± 0.00, and 1.27 ± 0.05 µg/g, respectively indicating the richness of DP in K, P, Ca, and vitamin A. Previous report indicated that date fruits are rich sources of minerals and vitamins (Hussain et al., 2020; Mohamed et al., 2014; Rambabu et al., 2020). However, the values of minerals and vitamins are differed between these studies due to the variation in the date variety, growing environment,

Table 3. Chemical composition (%) of DP and sponge cake supplemented with different concentration of DP.

Cake	Protein	Carbohydrate	Fat	Ash	Moisture	Fiber
Control	5.26 ± 0.25 [c]	73.07 ± 0.23 [a]	9.20 ± 0.20 [d]	0.71 ± 0.02 [e]	5.53 ± 0.15 [c]	1.17 ± 0.06 [b]
25% DP	5.60 ± 0.17 [c]	68.33 ± 0.42 [d]	10.00 ± 0.20 [c]	1.23 ± 0.04 [d]	6.50 ± 0.20 [b]	1.27 ± 0.12 [a b]
50% DP	6.27 ± 0.31 [b]	70.43 ± 0.40 [c]	10.13 ± 0.31 [c]	1.07 ± 0.11 [c]	7.03 ± 0.15 [a]	1.27 ± 0.06 [a b]
75% DP	6.43 ± 0.21[a b]	70.93 ± 0.31 [c]	10.60 ± 0.20 [b]	1.36 ± 0.05 [b]	6.93 ± 0.15 [a]	1.33 ± 0.06 [a]
100% DP	6.80 ± 0.20 [a]	72.17 ± 0.35 [a]	11.13 ± 0.31 [a]	1.48 ± 0.04 [a]	7.17 ± 0.15 [a]	1.30 ± 0.10 [a b]
*DP	2.73 ± 0.12	78.20 ± 0.53	0.50 ± 0.01	2.58 ± 0.00	7.80 ± 0.20	7.73 ± 0.20

Values are means ± standard deviations (n = 3). Values in the same column with different letters indicate significant difference at P ≤ 0.05, according to Duncan's test. *Date powder.

agronomical practices, maturity stage, and postharvest process conditions. Substitution of sugar with different concentrations of DP in cake formulation influenced the product's minerals and vitamin A contents. DP increased the contents of Ca, K, P, Fe, and vitamin A in the cake at different magnitudes ($P \leq 0.05$). The highest levels of K and Ca were found in the cake fortified with 100% DP, and the least values of these minerals were observed in the control cake ($P \leq 0.05$). In addition, the highest amounts of Fe, P, and vitamin A were found in cake fortified with 25% DP, 75% DP, and 50%, respectively. The increase in minerals and vitamin content in sponge cake following the incorporation of different concentrations of DP in the product could be attributed to the high contents of these minerals in the DP. In agreement with our results, incorporating DP increased the mineral contents of sponge cake (Ghasemi et al., 2020) and rock buns (Barimah et al., 2015). In addition, the addition of powder from different fruits also improved the mineral and vitamin contents of sponge cake due to the richness of fruits with these nutritional components (Salehi & Aghajanzadeh, 2020). The current study's findings indicated that incorporation of DP in sponge cake significantly enhanced the mineral and vitamin A contents of the product.

3.4 Effect of different concentrations of DP on the sensory attributes of sponge cake

The sensory attributes of sponge cake as affected by different concentrations (0, 25, 50, 75, and 100%) of DP are shown in Table 5. Generally, the control cake showed the highest scores of almost all the sensory attributes. However, there are no significant differences between control and DP-containing cake in some sensory attributes. The color preference was reduced as the substitution level of DP increased; however, the reduction was insignificant. The photographs of the cake mixture and baked cake also showed clear differences in color following the addition of DP (Figure 1). Increasing the concentration of DP in the mixture reduced the white color of the mixture and baked cake and gradually increased the brown color to the brownest color at 100%DP substitution. The flavor, softness under finger press, and degree of symmetry were also reduced following the addition of DP, with the highest values being observed in the control cake. However, increasing the concentration of DP didn't affect these attributes (Table 5). The softness of cake pulp, degree of pulp granularity, and degree of crowding was not affected by incorporating different levels of DP. The moisture content and thickness attributes showed fluctuated trend following the incorporation of different concentrations of DP. The effect of DP on the sensory attributes of sponge cake is likely due to the presence of some components in the DP affecting the color (carbohydrate and protein) through the Millard reaction, the taste from the phenolic compounds in the DP, and the overall all acceptance due to the other components in DP (Barimah et al., 2015).

Previous studies reported similar results as the incorporation of DP in bakery products affected the sensory attributes in different magnitudes, with the highest scores of most attributes being observed in the control samples (Sulieman et al., 2011; Barimah et al., 2015; Ghasemi et al., 2020; Shabnam et al., 2020). Overall, incorporating DP in sponge cake at low concentrations could not affect the sensory acceptability of the final product. Therefore, the Fortification sponge cake with date powder at low concentrations is recommended to contribute to the available cake product by improved the nutritional and health quality attributes of the products without major effect on its sensory attributes.

Table 4. Mineral (μg/g) and vitamin A (μg/g) content of DP and sponge cake supplemented with different concentration of DP.

Cake	Fe	Ca	K	P	*Vitamin A*
Control	0.11 ± 0.01 ^{b}	2.17 ± 0.04 ^{c}	4.79 ± 0.13 ^{e}	16.73 ± 0.39 ^{d}	0.64 ± 0.02 ^{c}
25% DP	0.22 ± 0.04 ^{a}	2.42 ± 0.07 ^{b}	8.25 ± 0.01 ^{d}	14.12 ± 0.04 ^{c}	0.71 ± 0.01^{b}
50% DP	0.12 ± 0.01 ^{b}	2.49 ± 0.03 ^{b}	10.73 ± 0.09 ^{c}	14.09 ± 0.09 ^{c}	0.74 ± 0.02 ^{a}
75% DP	0.11 ± 0.00 ^{b}	2.46 ± 0.05 ^{b}	13.56 ± 0.44 ^{b}	25.90 ± 0.87 ^{a}	0.71 ± 0.02 ^{b}
100% DP	0.12 ± 0.00 ^{b}	3.65 ± 0.02 ^{a}	17.58 ± 0.06 ^{a}	18.85 ± 0.09 ^{b}	0.66 ± 0.02 ^{c}
*DP	0.09 ± 0.00	2.61 ± 0.00	24.96 ± 1.58	3.12 ± 0.15	1.27 ± 0.05

Values are means ± standard deviations (n = 3). Values in the same column with different letters indicate significant difference at P ≤ 0.05, according to Duncan's test. *Date powder.

Table 5. Sensory acceptability of sponge cake supplemented with different concentrations of DP.

Cake sample	Color	Flavor	Softness of cake pulp	Softness under finger press	Moisture	Degree of pulp granularity	Thickness	Degree of crowding	Degree of symmetry
Control	3.18 ± 0.87 ^{a}	4.00 ± 0.00 ^{a}	2.82 ± 0.40 ^{a}	3.45 ± 0.52 ^{a}	2.82 ± 0.60 ^{a}	2.55 ± 0.69 ^{a}	2.6 ± 0.5 ^{a}	2.18 ± 0.87 ^{a}	2.82 ± 0.40^{a}
25% DP	2.64 ± 1.03 $^{a\,b}$	2.55 ± 1.21 ^{b}	2.64 ± 0.50 ^{a}	2.00 ± 0.63 ^{b}	2.36 ± 0.67 $^{a\,b}$	2.45 ± 0.52 ^{a}	2.3 ± 0.6 $^{a\,b}$	2.09 ± 0.83 ^{a}	2.91 ± 0.30^{a}
50% DP	2.91 ± 0.94 ^{a}	3.00 ± 1.10 ^{b}	2.36 ± 0.67 ^{a}	2.82 ± 0.60 ^{c}	2.00 ± 0.63 $^{a\,c}$	2.55 ± 0.52 ^{a}	2.6 ± 0.5 ^{a}	2.27 ± 0.65 ^{a}	2.27 ± 0.47 ^{b}
75% DP	3.00 ± 0.89 ^{a}	2.73 ± 1.19 ^{b}	2.45 ± 0.69 ^{a}	2.64 ± 0.50 ^{c}	2.64 ± 0.50 ^{a}	2.45 ± 0.69 ^{a}	2.3 ± 0.5 $^{a\,b}$	2.18 ± 0.75 ^{a}	2.64 ± 0.50 ^{b}
100% DP	2.00 ± 0.89 ^{b}	2.27 ± 1.19 ^{b}	2.27 ± 0.65 ^{a}	2.64 ± 0.81 ^{c}	1.55 ± 0.82 ^{c}	2.36 ± 0.67 ^{a}	2.0 ± 0.6 ^{b}	2.36 ± 0.81 ^{a}	2.18 ± 0.87 ^{b}

Values are means ± standard deviations (n = 11). Values in the same column with different letters indicate a significant difference at P ≤ 0.05, according to Duncan's test.

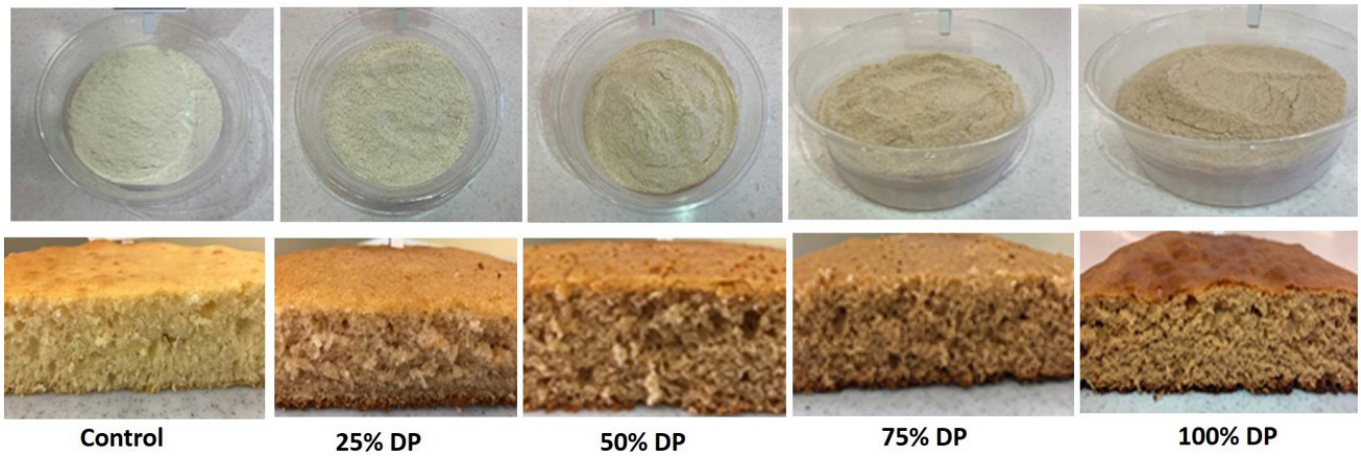

Figure 1. Photographs of supplemented flour mixture and sponge cake.

4 Conclusion

This study investigated the effect of incorporating different contractions of DP (0, 25, 50, 75, and 100%), as a replacer of refined sugar, on the physical, nutritional, and sensory quality of sponge cake. The findings of this study indicated that replacing refined sugar with DP improved the protein, ash, fiber, minerals, and vitamin A contents of the cake without major influence on the physical and sensory attributes of the product. Replacing refined sugar with DP in sponge cake preparation can improve the nutritional and health potentials of the product. The utilization of DP as a sweetener in sponge cake will help expand its applications and reduce the use of refined sugar, which is known for its contribution to the development of chronic disease. Therefore, the application of DP in sponge cake promotes the consumption of this product without major concerns about health-threatening problems.

Conflict of interest

There is no conflict of interest that I should disclose, having read the above statement.

Availability of data and material

The data used to support the findings of this study are included within the article.

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