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(Original Article)

Effect of Sugar Replacing with Various Proportions of Balady Date Powder on Biscuits Quality Properties

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Abstract

This research aims to evaluate how replacing sugar by Balady date powder (BDP) as a natural sweetener affect biscuits quality properties. The levels of replacement of BDP used in biscuits formulas were 5, 10, 20, 40, and 60%. BDP proximate chemical composition was determined. Its moisture percentage was 11.72±0.07%, whereas the levels of protein and fat observed were 3.15±0.15 and 1.62±0.08%, respectively. Ash and crude fiber were 2.74±0.05 and 2.84±0.12%, respectively. Total sugar content was 77.67±0.13% while non-reducing and reducing sugar contents were 39.85±0.15% and 37.82±0.18, respectively. The results indicated that increasing the BDP ratio led to increase in moisture, ash, crude fiber, minerals, and amino acids contents and a decrease in carbohydrate content of the biscuits. Moreover, physical properties of biscuits, such as diameter, and spread ratio, decreased with increasing levels of BDP. Partial replacement of sugar with BDP produced darker and reddish color biscuits. According to sensory evaluation results, texture was impacted at 40 and 60% of the BDP level, while color had a low score as the substitution ratio increased; they both had the lowest overall acceptability. On other hand, biscuits quality remained unaffected in terms of color, taste, texture, odor, and overall acceptability up to 20% substitution ratio, so it is suggested to use the BDP at a maximum rate of 20% of sugar ratio, which increases the nutritional value of the biscuits.

Keywords: *Balady date powder, Biscuits quality, Color, Sugar replacement.*

Introduction

In Egypt, the Arab and Islamic world, date fruit (*Phoenix dactylifera* L.) is an important food source and a valuable traditional crop. Due to its high nutritional content, date fruit is an excellent option to get important nutrients like vitamins, mineral, dietary fiber, carbohydrates, and other beneficial compounds (Amin *et al.,* 2019). Carbohydrates are the major compounds of date fruit (in particular, fructose, glucose, and sucrose), about 70-80% according to Nwanekezi *et al.,* (2015). Carbohydrates are rapidly broken and enter the bloodstream after eating dates and can be rapidly metabolized to produce energy for different cell activities (Shabnam *et al.,* 2020). AS dates have large fiber content; eating them can help diabetes patients controlling their lipid ratios, and glycemia (Saafi *et al.,* 2009). In

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addition to being an excellent supply of vital minerals like potassium, phosphorus, calcium, and iron, date fruit is also a significant source of essential amino acids (El-Sharabasy and Rizk, 2019). Date fruits are useful food supplement that are rich in minerals that can treat iron deficiency without causing any adverse side effects that may result when using chemical drugs. Mubarak *et al.,* (2022) study suggested that dates contain at least six vitamins: vitamin A, pyridoxine, thiamine, riboflavin, niacin, and ascorbic acid.

On the other hand, according to Alharbi *et al.* (2021), Egypt is the largest producer of dates. Egypt produced roughly 1.7 million metric tons of dates in 2019, which accounts for nearly 21% of the approximate 8 million tons produced worldwide. Despite this, Egypt's exports contribution to the global date market is limited. Due to the enormous potential for production of dates, these quantities from freshly harvested dates may not be able to be consumed in large amounts; therefore, research concentrated on improving date uses in food industry and developed functional foods (Handa *et al.,* 2012 and Dayang *et al.,* 2014). Therefore, dates should be better commercially utilized to produce food products with added value. Date fruit and its components have recently attracted more attention as a component of new food preparation and formula. Businesses that manufacture date natural products provide several date products, including date jam, date paste, date syrup, date plunge, date honey, and date vinegar (Mubarak *et al.,* 2022).

Raw date varies based on the cultivar and fruit grade. In grounded dry date powder, all nutrients and qualities of dates including their soluble sugars, fiber, polyphenols, vitamins, and minerals were preserved (Alfheeaid *et al.,* 2023). Nowadays, date powder may provide a healthier alternative nutritious and economical substitute to artificial sweeteners and white sugar (Barakat and Alfheeaid, 2023). It could also be added to a wide range of products, foods, and desserts due of its many benefits, as it is frequently used in many food industries as an alternative to sugar (Nadeem *et al.,* 2017 and Abd El-Hady *et al.,* 2022). Due to its high fiber content and quick-digesting sugar, date powder helps on lower blood cholesterol, prevents gallstones formation, prevents atherosclerosis, cancer of the large intestine, and hemorrhoids, and helps during pregnancy, childbirth, and puerperium (Vayalil, 2012 and Ali *et al.,* 2020).

One of the most widely popular bakery products is biscuits, which are consumed by people from all social classes. This is mostly because of its low cost, extended shelf life, good nutritional quality, ready-to-eat nature, and availability in many shapes (Sudha *et al.,* 2007 and Guo *et al.,* 2014). When it comes to health aspects by biscuits, their sugar level is normally large, whereas there is low antioxidant, mineral, and fiber content (Heo *et al.,* 2019). Date powder is a good source of natural sugar and bioactive components, minerals, and fiber, and it could be used to replace added sugar in different food recipes, like biscuits (El-Sharnouby *et al.,* 2012). Incorporating date powder to baked products would increase the nutritional value of the resulting biscuits by raising the content of dietary fiber, minerals, and antioxidants. Hence, incorporating date powder into biscuits can be acknowledged as a perfect method to lower costs while increasing quality and nutritional content. On the other hand, date powder has a moderate to low glycemic index; it might be a good healthier alternative (Miller *et al.,* 2003, Ali *et al.,* 2009 and Alkaabi *et al.,* 2011).

Moreover, the global epidemics of diabetes, cardiovascular disease, and glucose intolerance are aggravated by excessive levels of added sugar consumption. Therefore, the objective of this study was to produce date powder from low quality, hard-textured date cultivar (Balady date cultivar) and use it to prepare biscuits as an alternative to sugar in order to reduce sugar consumption and increase the dietary value for biscuits.

Materials and Methods

Materials

Balady date fruit (*Phoenix dactylifera* L.) was obtained from the local market in El-Kharja city, New-Valley governorate, Egypt during 2023 season. Other ingredients (wheat flour 72% extraction, sugar, shortening, salt, sodium bicarbonate, ammonium bicarbonate and baking powder) were obtained from local market in Assiut city, Egypt (Table 1). All chemicals and reagents used in the analytical methods were purchased from El-Gamhoria Trading Chemicals and Drugs co., Assiut city, Egypt.

Table 1. Biscuits formulas by replacing the sugar with BDP

Ingredients	Treatment					
	Control	F1	F2	F3	F4	F5
Wheat flour (%)	100	100	100	100	100	100
Sugar (g)	30	28.5	27	24	18	12
BDP (g)	-	1.5	3	6	12	18
Shortening (g)	20	20	20	20	20	20
Salt, NaCl (g)	1	1	1	1	1	1
Sodium bicarbonate (g)	0.5	0.5	0.5	0.5	0.5	0.5
Ammonium bicarbonate (g)	1	1	1	1	1	1
Baking powder (g)	0.3	0.3	0.3	0.3	0.3	0.3
Water (ml)	16	16	16	16	16	16

BDP: Balady date powder - Control: 100% sugar+0% BDP, F1: 95% sugar+5% BDP, F2: 90% sugar+10% BDP, F3: 80% sugar+20% BDP, F4: 60% sugar+40% BDP and F5: 40% sugar+60% BDP.

Technological methods

Preparation of BDP

Balady date fruits were subjected to initial treatment for the removal of inedible parts and any adhered foreign particles, washed, de-pitted, and flesh cut into small pieces. The small flesh pieces were dried at 60 °C until a constant weight in an oven. After that, dried samples were cooled; ground using hand milling for two min, the resulting powder was packed in zip-lock polyethylene bags and stored in a deep freezer at -20 °C until used.

Preparation of biscuits

Biscuits were prepared according to Sai Manoharm and Rao (1997) method, using the ingredients in Table 1 as follows:

Biscuits samples were made with BDP substituted for sugar at ratios of 5, 10, 20, 40, and 60% in the biscuits batter formula. After creaming sugar, fat, and date powder for ten minutes in a mixer, sodium bicarbonate, ammonium bicarbonate, and sodium chloride were added to the fat sugar cream after dissolving in approximately 16 ml of water. To create a uniform batter, the flour and baking powder were added to the mixture and stirred for five minutes. Using a wooden rolling pin, the dough was manually sheeted onto a steel pan to a height of 3.5 mm. A 4.5 cm diameter biscuits cutter was then used to cut the dough into circles shapes. To keep the dough from adhering to the rolling pin, aluminum foil was employed. The cut dough pieces were transferred and placed on an aluminum foil-lined baking pan. The biscuits were baked in an electric oven at 205°C for 10 min; cooled at room temperature for 30 min packed in polypropylene pouches, sealed, and stored until used.

Analytical methods

Chemical composition

Moisture, crude protein, crude fat, ash, crude fiber, and reducing and non-reducing sugars contents were determined according to AOAC (2019). Carbohydrate content was determined by difference [% Available carbohydrate = 100 - (moisture + crude protein + crude fat + ash + crude fiber). The energy values were calculated using 2 kcal/g for fiber, 4 kcal/g for protein and carbohydrates, and 9 kcal/g for fat (Maclean *et al*., 2003). The total phenolic compound (TPC) concentration was determined using Folin-Ciocalteu reagent according to Velioglu *et al*. (1998) method and expressed as gallic acid equivalent (mg/100g on dry weight basis (DWB)) according to Asami *et al*. (2003). Samples were extracted using methods described by Zieliński *et al*. (2007). The 2,2-Diphenyl-1-picrylhydrazyl (DPPH) assay was carried out according to the Lee *et al*. (2003) method.

Minerals composition

Minerals composition was determined through extraction from the biscuit's samples via dry ashing method (Jackosn, 1973). Atomic absorption spectrophotometry (Perkin-Elmer Model 5000, Germany) was used to quantify iron (Fe), zinc (Zn), copper (Cu), calcium (Ca), magnesium (Mg), and manganese (Mn). Sodium (Na) and potassium (K) were determined by flame photometric procedure (Corning instrument model 400) (Chapman *et al*., 1962), and phosphorus (P) was measured by ammonium molybdate method using a Philips PV 8650 spectrophotometer (AOAC, 2019).

Amino acids composition

The amino acids content was determined according to the method described by Pellet and Young (1980) with some modifications and can be summarized as follows: 200 mg of dried sample was hydrolyzed with 5 ml of 6 N HCL in a sealed tube at 110°C for 24 hours, after which the hydrolysate was filtered. The residue was washed with distilled water, and the filtrate was evaporated on water at 50°C. The residue was dissolved in 5 ml of loading buffer (sodium citrate buffer, pH 2.2). Analysis was performed at the Central Service Unit, National Research Center, Egypt, using a Beckman Amino Acids Analyzer model 119 CL. Tryptophan was colorimetric determined using the method described by Sastry (1985).

Physical properties of biscuits

Diameter (mm), thickness (mm), spread ratio (%), and spread factor (%) were determined for six biscuits, and averages were recorded. The spread ratio, and spread factor were calculated according to Sai Manoharm and Rao (1997) as follows:

$$\text{Spread ratio} = \frac{\text{Diameter}}{\text{Thickness}}$$

$$\text{Spread factor} = \frac{\text{Spread ratio of sample}}{\text{Spread ratio of control}} \times 100$$

Color determinations

The Color parameters of biscuits samples were determined using Hunter Lab (UltraScan PRO Spectrophotometer, USA). The instrument was calibrated each time with the Hunter white tile. The Color coordinates L^*, a^*, and b^* were measured according to the device formula. Hue and Chroma (the Color intensity) were calculated according to Palou *et al*. (1999). The values of ΔE (total Color difference) were calculated according to Marpalle *et al*. (2014) as follows:

Hue = tan-1 [b^*/a^*]

Chroma = 1/2 square root of [$a^{*2} + b^{*2}$]

$\Delta E = (L^{*2} + a^{*2} + b^{*2})^{1/2}$

Where ($a^*=a^*- a^*_0$), ($b^*=b^*- b^*_0$) and ($L^*=L^*- L^*_0$). Subscript "o" indicates the Color of the control.

Sensory evaluation

Biscuits samples in pouches with different numbers were presented to 10 trained panelists who were asked to rate biscuits samples by assigning a score from ten for Color, texture, appearance, odor, taste, and overall acceptability, using a hedonic scale as described by Sudha *et al*. (2007).

Statistical analysis

Data obtained from three replicates were analyzed by one-way analysis of variance (ANOVA) using SPSS 20.0 software statistical package program, and differences among the means were compared using Duncan's multiple range test

(SPSS, 2011). A significance level of 0.05 was chosen, and continuous variables were described by the mean, and standard deviation.

Results and discussion

Physical characteristics of Balady date fruits

The mean values of the physical characteristics of Balady date fruits at the Tamr stage are shown in Table 2. The Balady date fruits at Tamr stage were evaluated for their fruit number (204±5.91/Kg), average weight of fruit (4.90±0.12g), flesh (3.77±0.03g), pit (0.99±0.02g), and calyx (0.14±0.01g). In addition, the percentage of flesh/pits, flesh, pit, and calyx ratio (3.80±0.04, 76.97±0.21, 20.21±0.82, and 2.82±0.18%, respectively).

Table 2. Physical characteristics of Balady date fruits

Characteristics	Balady date fruits
Fruits number/Kg	204±5.91
Fruits weight	4.90±0.12g
Flesh weight	3.77±0.03g
Pit weight	0.99±0.02g
Calyx weight	0.14±0.01g
Flesh/pits ratio	3.80±0.04
Flesh	76.97±0.21%
Pit	20.21±0.82%
Calyx	2.82±0.18%
Insect infestation	22.00±0.25%
TSS	86.34±0.11%
pH value	5.73±0.02
Color (at 400nm as OD)	0.74±0.03

Values are the means of determinations conducted in triplicate using standard division.

Insect infestation percentage (22.00±0.25%), total soluble solids (86.34±0.11%), pH value (5.73±0.02), and Color (0.74±0.03) were evaluated. Data of physical measurements are in same ranges reported by Selim *et al*. (2012); Abdelmegiud (2016) and Ramadan *et al*. (2016). Numerous factors, including soil, fertilization, and other environmental circumstances, could be the causes of variation in physical characteristics of date fruits cultivated in different areas (Ramadan *et al*., 2017).

Chemical composition of wheat flour and BDP

Chemical composition of wheat flour (WF) and BDP is shown in Table 3. It observed that WF and BDP moisture contents were almost similar, 12.56±0.13 and 11.72±0.07%, respectively. The results demonstrated that the BDP was distinguished by its increased level of total, reducing, and non-reducing sugars being 77.67±0.13, 37.82±0.18, and 39.85±0.15, respectively, while in WF, the low levels were 2.98±0.11, 0.42±0.21, and 2.56±0.21%, respectively. Thus, these results agree with those of Osman (2008), and Sakr *et al*. (2010).

Table 3. Chemical composition of WF and BDP

Components (%)*	WF	BDP
Moisture	12.56±0.13[a]	11.72±0.07[b]
Total solids	87.44±0.13[b]	88.28±0.07[a]
Total sugars	2.98±0.11[b]	77.67±0.13[a]
Reducing sugars	0.42±0.21[b]	37.82±0.18[a]
Non-reducing sugars	2.56±0.21[b]	39.85±0.15[a]
Crude protein	11.75±0.35[a]	3.15±0.15[b]
Crude fiber	0.54±0.03[b]	2.84±0.12[a]
Ash	0.61±0.02[b]	2.74±0.05[a]
Crude fat	1.65±0.10[a]	1.62±0.08[a]
Carbohydrates**	72.89±0.16[b]	77.93±0.09[a]
Calorific value (Cal/100g)	354.49±0.16[a]	344.58±0.09[a]
TPC (mg GAE/100 g)	208.49±12.56[b]	499.35±11.85[a]
AA (% fresh weight)	4.54±0.27[b]	32.80±1.30[a]

*On dry weight basis, except moisture; **Carbohydrates calculated by difference; BDP: Balady date powder; TPC: Total phenolic compounds; AA: Antioxidant activity. Values are the means of determination conducted in triplicate using standard division. Different letters adjacent to values in the row indicate significant differences at $p \leq 0.05$ between samples, and the same letters indicate no significant differences.

Crude protein content was larger in WF of 11.75±0.35 while fiber content was observed to be large in BDP at 2.84±0.12%. Ash content was observed to be significantly different between WF and BDP; date powder contained 2.74±0.05%, whereas WF contained of 0.61±0.02%. No significant difference was observed in crude fat content and calorific value between WF and BDP (1.65±0.10 and 1.62±0.08%) and (354.49±0.16 and 344.58±0.09 Cal/100 g), respectively. As for carbohydrates, their contents were 72.89±0.16 and 77.93±0.09% for WF and BDP, respectively. The BDP exhibited the largest concentration of TPC and AA, measuring 499.35±11.85 mg GAE/100 g and 32.80±1.30%, respectively, while WF showed a significantly lower values (208.49±12.56 mg GAE/100 g and 4.54±0.27%, respectively).

Minerals composition of BDP

Minerals like calcium, magnesium, and iron are inadequate in food products. Dates can help to alleviate this shortage (Abdelmegiud, 2016). Due to its large mineral content, date fruit is practically a mine unto itself. These minerals are valuable and useful for the human body and the metabolic operation of human cells.

The average values of potassium, calcium, phosphorus, magnesium, sodium, iron, copper, zinc, and manganese in BDP are shown in Table 4 as mg/100g sample on DWB. Potassium was the predominant element present in BDP (576.37±1.29 mg/100g), followed by calcium (72.11±0.56 mg/100g) and phosphorus (66.35±0.42 mg/100g). The data also revealed that BDP contained 62.12±0.51 mg Mg/100g and 37.08±0.35 mg Na/100g. On the other hand, among the microelements, iron was the predominant element present in BDP (7.20±0.18 mg/100g). The levels of copper, zinc, and manganese were 1.12±0.07, 1.11±0.04, and 0.62±0.03 mg/100g, respectively. These data are in line with that reported by El-Sohaimy and Hafez (2010) and Ashraf and Hamidi-esfahani (2011).

Table 4. Minerals composition of BDP

Element	(mg/100 g sample on DWB)
K	576.37
Ca	72.11
P	66.35
Mg	62.12
Na	37.08
Fe	7.20
Cu	1.12
Zn	1.11
Mn	0.62

Amino acids composition of BDP

Table 5 displays amino acids composition of BDP by mg/100g sample on DWB. Although dates do not contain enough protein to be regarded as a significant nutritional source, they do contain essential amino acids, which the body needs but is unable to produce and must obtain through diet. Analysis of amino acids composition showed that the BDP contains large concentrations of glutamic, aspartic, proline, alanine, glycine, and leucine, but contains low levels of methionine, histidine, and tyrosine (Table 5). According to the data, BDP has a large nutritional value because it includes appropriate amounts of all essential amino acids. Results of this study comply with Al-Showiman (1998).

Table 5. Amino acids composition of BDP

Amino acid	(mg/100g sample on DWB)
Valine	64.17
Methionine	21.48
Isoleucine	39.50
Leucine	71.33
Phenylalanine	49.77
Lysine	56.77
Threonine	49.03
Tryptophan	32.30
Aspartic	145.53
Serine	58.30
Glutamic	203.30
Proline	92.62
Glycine	88.23
Histidine	22.30
Alanine	90.07
Tyrosin	23.17
Arginine	59.77
Cysteine	31.43

Chemical composition of biscuits

Table 6 depicts the effect of different replacement ratios of BDP (0, 5, 10, 20, 40, and 60% from sugar) on the chemical composition of prepared biscuits samples. It was evident that when the substitution of date powder increased, the moisture content increased as well. Moisture content varied from 5.02±0.16 to 6.65±0.16% for the control and 60% BDP substitution biscuits samples, respectively. The biscuits formula contained 18g BDP had the biggest moisture content. This is because of the high sugar and fiber content of BDP bind water in this biscuit's formula. These findings are in line with those of Abd El-Lateef (2003) and Handa *et al*. (2012). When compared to the control sample, the protein content of the biscuit's samples did not significantly increase upon the inclusion of 5 % date powder. However, there was a significant ($p<0.05$) increase in the protein content when date powder was added by 10% or more. The addition of BDP was responsible for the steady rise in protein content (Table 6) from 7.25±0.34 (control) to 8.37±0.20% (60% substitution). The results closely correspond with those of Banureka and Mahendran (2009).

Table 6. Effect of different levels of BDP on chemical composition and caloric value of biscuits (g/100g on DWB, except moisture)

Treatment	Moisture	Protein	Crude fat	Ash	Crude fiber	Carbohydrates*	Caloric value (Cal/100g)*
Control	5.02±0.17[f]	7.25±0.34[ef]	14.28±0.22[f]	1.43±0.05[f]	0.62±0.03[f]	71.40±0.19[a]	444.36±1.20[a]
F1	5.24±0.12[e]	7.37±0.13[e]	14.42±0.31[e]	1.56±0.02[e]	0.81±0.04[e]	70.60±0.26[b]	443.28±1.13[b]
F2	5.51±0.15[d]	7.49±0.24[d]	14.58±0.15[d]	1.65±0.03[d]	1.04±0.11[d]	69.73±0.17[c]	442.18±0.73[b]
F3	6.03±0.11[c]	7.72±0.17[c]	14.81±0.19[c]	1.85±0.01[c]	1.29±0.07[c]	68.30±0.19[d]	439.95±0.39[d]
F4	6.36±0.13[b]	8.02±0.12[b]	15.23±0.11[b]	2.18±0.01[b]	1.82±0.09[b]	66.39±0.21[e]	438.35±0.43[c]
F5	6.65±0.16[a]	8.37±0.20[a]	15.49±0.07[a]	2.51±0.04[a]	2.43±0.06[a]	64.55±0.15[f]	435.95±0.57[c]

*Carbohydrates calculated by difference. Table 1 footnote includes the abbreviations for the control, F1, F2, F3, F4, and F symbols 5. Values are the means of determination conducted in triplicate using standard division. Different letters adjacent to values in the column indicate significant differences at $p\leq0.05$ between samples, and the same letters indicate no significant differences. 139.41+4.86

Fat content increases with increasing substitution BDP levels. The biscuits prepared with 60% BDP had the largest fat content (15.49±0.07%), while the control sample had the lowest one (14.28±0.22). These outcomes are consistent with El-Sharnouby *et al*. (2012) study. BDP is richer in ash content than that of sugar. Thus, the biscuits prepared with the largest (60%) substitution level have the largest ash content (2.51±0.04%), whereas the control sample has a minimum ash content (1.43±0.05%). El-Sharnouby *et al*. (2012) also noted a comparable increase in the ash content of the biscuits, because date powder and wheat bran were added to the biscuits.

The lowest fiber content (0.62±0.03%) was found in the control sample. The inclusion of date powder led to a substantial ($p\leq0.05$) augmentation in the fiber content of the biscuits. The retracement of 60% BDP resulted in biscuits with the highest crude fiber content (2.43±0.06%) between samples. El-Sharnouby *et al.* (2012) also observed comparable alterations in the crude fiber content of the biscuits when wheat bran and date powder were used. The enriched biscuits samples with varied levels of BDP exhibited a contrasting pattern in terms of total carbohydrates. The utilization of date powder as a replacement for sugar resulted in a decrease in carbohydrates with an increase in the substitution ratio. The results obtained align with those of Peter Ikechukwu *et al*. (2017). It could be said that adding date powder to biscuits has nutritious value for kids and other potential consumers (Sudha *et al*., 2007 and Guo *et al*., 2014).

Mineral composition of biscuits

Mineral composition of manufactured biscuits samples with different ratios of BDP is displayed in Table 7 as mg/100g sample on DWB. The macro-elements increased with increasing the BDP replacement ratio. The largest content of the macro-elements was recorded in biscuits prepared at a 60% BDP replacement level, while the lowest values were observed in the control sample. Potassium value was the predominant element present in all biscuit's samples, followed by phosphorus, and calcium. The lowest recorded values were for magnesium and sodium in all biscuit samples (Table 7). Potassium, the most common minerals and magnesium, the second most abundant element in the human body, both have a beneficial impact on lowering the risk of stroke and platelet aggregation (Kaur *et al*., 2017).

Table 7. Effect of the different levels of BDP on minerals composition of biscuits (mg/100g sample on DWB)

Treatment	Macro-elements					Micro-elements		
	K	**P**	**Na**	**Ca**	**Mg**	**Fe**	**Zn**	**Cu**
Control	165.80	72.43	54.38	51.25	26.11	6.02	1.68	1.57
F1	194.62	75.71	56.23	54.86	29.22	6.38	1.74	1.63
F2	223.44	79.07	58.09	58.46	32.16	6.71	1.80	1.68
F3	281.07	85.70	61.80	65.67	38.53	7.46	1.90	1.79
F4	396.35	98.92	68.21	80.09	50.96	8.90	2.12	2.01
F5	511.62	112.24	75.63	94.52	63.38	10.34	2.35	2.24
Children RDA* (mg/day)	3000	460-500	1000	500-800	80-170	7-10	3-5	0.50
Adults RDA* (mg/day)	3800	700-1250	1500	800-1200	350-420	10-15	8-12	0.7-0.9

*Recommended Dietary Allowances (2004).
Table 1 footnote includes the abbreviations for the control, F1, F2, F3, F4, and F5 symbols.

By increasing the BDP replacement ratio, microelements including iron, zinc, and copper were increased. Compared to biscuits made with sucrose sugar, those prepared with date powder will be healthier to consume. Therefore, it could partially provide children and adults with their daily requirements of potassium, phosphorus, calcium, magnesium, iron, zinc, and cupper by consuming these types of biscuits. The results obtained are consistent with those of Hashem *et al*. (2004) and Bilgiçli *et al*. (2007). Biscuits using date fruit powder had higher levels of iron, zinc, and copper, according to El-Sharnouby *et al*. (2012). Finally, the manufactured biscuits samples of date powder could be recommended as sources of various minerals in comparison with the control sample. Therefore, date powder can play a considerable role in enriching biscuits with minerals.

Amino acids composition of biscuits

Amino acids composition of manufactured biscuits samples with different ratios of BDP is shown in Table 8 as mg/100g sample on DWB. The number and amounts of essential amino acids judge the value of food quality. The nutritional value of protein is amounted by the levels of essential amino acids, which must be obtained from diet since they are not generated by the body (Vega-Galvez *et al*., 2010).

All manufactured biscuits samples with different ratios of BDP were superior in their content of essential amino acids compared to the control biscuits sample. On the other hand, glutamine was the largest amount among all amino acids in all biscuit's samples, followed by proline and leucine, while the lowest values were observed in tryptophan, followed by methionine and histidine (Table 8). These results are in agreement with that reported by Vita Sterna *et al*. (2015).

Table 8. Effect of the different levels of BDP on amino acids composition of biscuits (mg/100g sample on DWB)

Amino acid	Treatment					
	Control	F1	F2	F3	F4	F5
Valine	41.66	44.86	48.07	54.49	67.32	80.16
Methionine	15.15	16.22	17.30	19.44	23.74	28.04
Isoleucine	36.61	38.58	40.56	44.51	52.41	60.31
Leucine	69.43	72.99	76.56	83.69	97.96	112.23
Phenylalanine	50.49	52.98	55.47	60.45	70.40	80.35
Lysine	20.20	23.04	25.87	31.55	42.90	54.26
Threonine	27.77	30.22	32.67	37.58	47.38	57.19
Tryptophan	6.31	7.93	9.54	12.77	19.23	25.69
Aspartic	47.97	55.24	62.52	77.07	106.18	135.29
Serine	39.13	42.05	44.96	50.79	62.45	74.11
Glutamic	357.24	367.40	377.57	397.90	438.56	479.22
Proline	112.35	116.98	121.61	130.87	149.39	167.92
Glycine	37.87	42.28	46.69	55.52	73.16	90.81
Histidine	22.72	23.84	24.95	27.18	31.64	36.10
Alanine	30.30	34.80	39.30	48.31	66.32	84.34
Tyrosine	31.56	32.72	33.87	36.19	40.82	45.46
Arginine	37.87	40.86	43.85	49.82	61.78	73.73
Cysteine	30.30	31.87	33.44	36.58	42.87	49.16

Table 1 footnote includes the abbreviations for the control, F1, F2, F3, F4, and F5 symbols.

Physical properties of biscuits

Table 9 displays the average physical property values for biscuits samples prepared by using BDP in place of sugar at various levels. The addition of the BDP caused a reduction in the biscuit's diameter. The control sample biscuits were observed to have the largest diameter of 47.78±0.13 mm. The diameter of biscuits prepared from BDP was significantly reduced from 46.17±0.12 to 41.05±0.13 mm at a 5 to 60% replacement level. This may be the result of the high-fiber date powder interfering with the natural leavening process, which results in a reduction in the diameter of the biscuits. Sievert *et al*. (1990) similarly reported a comparable decrease in biscuits diameter with an increase in bran incorporation. These results agreed with those of Kulthe *et al*. (2014). Table 9 indicates that although biscuits thickness rose with replacement level, there was no significant difference ($p>0.05$) in thickness between the control and samples with 20, 40%, and 60% date powder addition. The thickness of the samples was increased to offset the reduction in diameter. The outcomes closely align with the research carried out by El-Sharnouby *et al*. (2012) concerning biscuits prepared with wheat bran and date powder.

The biscuits spread ratio can be calculated by dividing the diameter by thickness. According to Table 9, the control sample achieved the largest spread ratio since it had the largest diameter. There was no significant difference between the control and 5 and 10% substitution samples, and the spread ratio generally decreased as substitution increased. In contrast to the control sample, the spread ratio changed significantly upon adding 40% and 60% of the BDP. It is worthwhile noting that biscuits with a higher spread ratio are regarded as having the best qualities; therefore, samples with 5 and 10% substitution were the most desirable. These findings are in harmony with those of Peter Ikechukwu *et al*. (2017) and

Karra *et al*. (2020). The biscuits spread factor represents a ratio of the spread ratio of the sample to the spread ratio of the control multiplied by 100. Spread factor values gradually decreased with an increase in substitution level. Because of the interaction between fiber and gluten and the dilution of gluten protein, fiber generally has a negative impact on the creation of the gluten network (Arshad *et al*., 2007 and Wang *et al*., 2016).

Table 9. Effect of the different levels of BDP on physical properties of biscuits

Treatment	Diameter (mm)	Thickness (mm)	Spread ratio (%)	Spread factor (%)
Control	47.78±0.13^{a}	6.85±0.04^{a}	6.97±0.18^{a}	100±0.00^{a}
F1	46.17±0.12^{ab}	6.68±0.06^{b}	6.91±0.22^{a}	99.13±0.25^{ab}
F2	45.37±0.14^{c}	6.70±0.05^{b}	6.77±0.15^{ab}	97.13±0.17^{c}
F3	44.13±0.14^{d}	6.75±0.06^{ab}	6.54±0.28^{c}	93.83±0.27^{d}
F4	42.61±0.15^{e}	6.78±0.04^{ab}	6.28±0.31^{d}	90.10±0.38^{e}
F5	41.05±0.13^{f}	6.81±0.04^{ab}	6.03±0.36^{e}	86.51±0.45^{f}

Values are the means of determinations conducted in triplicate using standard division. Table 1 footnote includes the abbreviations for the control, F1, F2, F3, F4, and F5 symbols. Different letters adjacent to values in the column indicate significant differences at p≤0.05 between samples, and the same letters indicate no significant differences.

Color parameters of biscuits

The Color of the biscuits is one of the factors that influence the consumer's perception of quality. Table 10 showed the Color parameters L^*, a^*, b^*, Hue angle, and Chroma for the biscuits. The lightness of the samples is indicated by the *L*-values; lower *L*-values indicate a darker surface Color. The degree of redness or greenness is indicated by the *a*-values, where positive values denote redness and negative values denote greenness. The degree of yellowness or blueness is indicated by the *b*-values, positive values denote yellowness, while negative values denote blueness. When 5% of the sugar in the control biscuits sample was substituted with date powder, the samples lightness (*L*-value) decreased from 74.16 to 66.52. It was observed that there was a significant decrease (p≤0.05) in biscuits L^* and Hue angle values with the increase in BDP levels compared to the control sample, indicating that the biscuits made with date powder had a darker Color than the control. Correspondingly, Chroma values were reduced from a level of 40.12 to a lower value 25.21 by replacing 60% of sugar with powder date. In addition, as the BDP level increased an increase in the *a*- values was observed. The biscuits with date powder fortification may have had a darker Color due to Millard browning reactions during baking, as seen by the lower *L*-values and larger *a*-values that were seen. Similar findings were also discovered by Singh and Mohamed (2007), Khouryieh and Aramouni (2012) and Yamsaengsung *et al*. (2012).

The *b*-values for the biscuits prepared were 38.78 at control sample and 37.54 at 5% date powder, respectively. At substitution levels 10, 20, 40, and 60%, the *b*-values of the prepared biscuits were reduced progressively (Table 10). Rich in polyphenols, date powder may also include trace amounts of low-activity polyphenol oxidase and peroxidase. As a result, the *b*-values may decrease because of the enzymatic browning activity. The Ajila *et al*. (2008) study also reported on this occurrence. Changes in total Color index (ΔE) for the treated biscuits samples showed less biscuits Color than that of control sample. The control biscuits sample

Hue value (Hue=75.15) indicated a yellow Color, but this Color type was skewed towards a yellow-orange hue as the Hue-value decreased to 49.20 when 60% of the sugar was substituted with BDP. The results that were found are consistent with the findings of Alsenaien *et al*. (2015) and Karra *et al*. (2020). The authors observed a decrease in *L*, *b*, *c*, and Hue-values and an increase in a-values when BDP was substituted for part of the flour or sugar in the biscuit's formulation. It should be noted that the induced Color darkness can be partly attributed by direct sugar caramelization and oxidation brought on by the phenolic components of the date powder added to the biscuit's formula, in addition to the Millard browning reactions (Alsenaien *et al*., 2015).

Table 10. Effect of the different levels of BDP on Color parameters of biscuits

Treatment	L^*	a^*	b^*	Chroma	Hue	ΔE
Control	74.16±0.16[a]	10.28±0.08[f]	38.78±0.28[a]	40.12	75.15	-
F1	66.52±0.10[b]	11.26±0.06[e]	37.54±0.24[b]	39.19	73.30	7.80
F2	64.81±0.19[c]	13.38±0.08[d]	36.33±0.13[c]	38.72	69.78	10.15
F3	61.17±0.17[d]	14.28±0.10[c]	33.74±0.20[d]	36.64	67.06	14.50
F4	59.15±0.15[e]	15.68±0.20[b]	22.07±0.07[e]	27.07	54.61	23.10
F5	56.63±0.13[f]	16.47±0.44[a]	19.08±0.08[f]	25.21	49.20	27.09

Values are the means of determinations conducted in triplicate using standard division.
Table 1 footnote includes the abbreviations for the control, F1, F2, F3, F4, and F5 symbols.
Different letters adjacent to values in the column indicate significant differences at p≤0.05 between samples, and the same letters indicate no significant differences.

Sensory attributes of biscuits

The effect of substituting sugar with BDP on sensory attributes of the biscuits is presented in Table 11. It could be mentioned that samples with 5 and 10% BDP revealed the largest scores for most sensory attributes as shown in Table 11 in comparison with the control sample with no significant differences. That said, replacement of 60% BDP for sugar greatly impacted the biscuits sensory qualities, which decreased significantly from 7.70±0.20 to 6.57±0.10 (Color), 7.65±0.15 to 6.30±0.30 (texture), 7.64±0.14 to 6.53±0.13 (appearance), 7.63±0.13 to 6.81±0.11 (taste), and 8.50±0.25 to 6.68±0.18 (overall acceptability) compared to control sample. As a result, the biscuits prepared with 60% date powder received the lowest sensory evaluation. These results are consistent with the findings of Handa *et al*. (2012) and El-Sharnouby *et al*. (2012). They reported that the sensory qualities of the product improved to a 30% replacement ratio when date powder was added to the biscuits as a sugar substitute. Likewise, Alsenaien *et al*. (2015) proposed that date powder might be utilized commercially to prepare biscuits with dates.

The addition of the date powder caused for the biscuits Color darkening. Substitution rates above 20% resulted in low scores for Color. In general, the consumers' acceptance of biscuits is greatly influenced by their texture (Man *et al*., 2021). The obtained results revealed that increasing BDP level decreased the biscuits texture, 5% BDP biscuits sample recorded the largest score for texture. In contrast, 60% BDP biscuits sample was the lowest score in texture evaluation. Regarding appearance, Table 11 demonstrates that the control biscuits sample and the biscuits sample with 5% BDP substitution earned a considerably higher score than the samples with 40% and 60%. The biscuits samples had surface cracks developing in them. The date powder larger fiber content could be the reason for the cracks in biscuits samples. In addition, increasing BDP in biscuits improves the odor and taste, but it has a negative impact on the texture and Color acceptance as we mentioned.

For overall acceptability, the 5% BDP biscuits and the control sample were rated with the largest scores, followed by the 10 and 20% substituted BDP biscuits samples, respectively. Based on the evaluation above, it can be found that biscuits with a formula that contains up to 20% BDP will not affect any of its sensory quality properties. The results obtained agree with what has been concluded of El-Sharnouby *et al*. (2012).

Table 11. Effect of the different levels of BDP on sensory attributes of biscuits

Treatment	Color	Texture	Appearance	Odor	Taste	Overall acceptability
Control	7.70±0.20^{a}	7.65±0.15^{a}	7.64±0.14^{a}	7.44±0.14^{d}	7.63±0.13^{c}	8.50±0.25^{a}
F1	7.57±0.17^{a}	7.47±0.07^{ab}	7.49±0.19^{ab}	7.63±0.13^{cd}	7.91±0.11^{b}	8.24±0.20^{ab}
F2	7.48±0.08^{a}	7.32±0.12^{b}	7.36±0.16^{b}	7.72±0.12^{bc}	8.12±0.12^{a}	8.02±0.13^{bc}
F3	7.17±0.17^{b}	6.86±0.16^{c}	7.04±0.10^{c}	7.84±0.14^{abc}	7.44±0.14^{c}	7.81±0.11^{c}
F4	6.81±0.11^{c}	6.63±0.13^{c}	6.79±0.09^{d}	7.93±0.13^{ab}	7.08±0.08^{d}	7.35±0.15^{d}
F5	6.57±0.10^{c}	6.30±0.30^{d}	6.53±0.13^{e}	8.05±0.10^{a}	6.81±0.11^{e}	6.68±0.18^{e}

Values are the means of determinations conducted in triplicate using standard division. Table 1 footnote includes the abbreviations for the control, F1, F2, F3, F4, and F5 symbols. Different letters adjacent to values in the column indicate significant differences at $p \leq 0.05$ between samples, and the same letters indicate no significant differences.

Conclusion

The results mentioned above suggest that the physical and sensory properties of the biscuits have been modified by the addition of date powder. The general acceptability of the biscuits increased by up to 20% increase in the date powder content. Furthermore, it resulted in an improvement in the nutritional value of the biscuits through an increase in fiber, amino acids, and minerals content, especially potassium, calcium, phosphorus, and iron. This study demonstrates the possibility of creating biscuits that are high in fiber to boost diets and meet the dietary fiber needs of consumers.

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تأثير استبدال السكر بنسب مختلفة من مسحوق التمر البلدي على خصائص جودة البسكويت

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الملخص

يهدف هذه البحث إلى تقييم مدى تأثير استخدام مسحوق ثمار التمر البلدي (BDP) كمحلي طبيعي بدلاً من السكر على خصائص جودة البسكويت. كانت مستويات استبدال الـــ BDP المستخدمة في تركيبة البسكويت 5، 10، 20، 40، 60% من نسبة السكر. تم تحديد التركيب الكيميائي التقريبي لـــ BDP. لوحظ أن نسبة الرطوبة كانت 11.72±0.07%، في حين لوحظ أن مستويات البروتين والدهون منخفضة، حيث بلغت 3.15±0.15 ، 1.62±0.08%، على التوالي. بينما شَكَلَ الرماد والألياف الخام 2.74±0.05، 2.84±0.12%، على التوالي. تم تحديد السكريات الكلية بنسبة 77.67±0.13%؛ وتم تحديد السكريات المختزلة وغير المختزلة بنسبة 37.82±0.18، 39.85±0.15%، على التوالي. وأظهرت النتائج التي تم الحصول عليها من البسكويت أن زيادة نسبة الـــ BDP أدت إلى زيادة محتوى الرطوبة، الرماد، الألياف الخام، والمعادن، والأحماض الأمينية وانخفاض محتوى الكربوهيدرات. علاوة على ذلك، انخفضت الخصائص الفيزيائية للبسكويت، مثل القطر ونسبة الانتشار مع زيادة مستويات الـ BDP. أدى الاستبدال الجزئي للسكر بالـ BDP إلى إنتاج بسكويت بلون أغمق وأكثر احمرارا. ووفقًا لنتائج التقييم الحسي، تأثر الملمس عند 40 و60% من مستوى الـــ BDP، بينما حصل اللون على درجة منخفضة مع زيادة نسبة الاستبدال؛ وكان كلاهما لديه أدنى قبول عام. من ناحية أخرى، ظلت جودة البسكويت غير متأثرة من حيث اللون، الطعم، الملمس، الرائحة والقبول العام حتى نسبة استبدال 20%، لذلك اقترح استخدام الـ BDP حتى نسبة 20% من السكر، مما يزيد من القيمة الغذائية للبسكويت.

الكلمات المفتاحية: *استبدال السكر، جودة البسكويت، اللون، مسحوق التمر البلدي.*