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The effect of adding date kernel powder on the qualitative and sensory properties of spongy cake

Elham Ghasemi, Somayyeh Loghmanifar* and Shahram Salar

PhD student, Department of Food Science and Technology, Nour Branch of Islamic Azad University, Nour, Iran

***Corresponding author*:** Somayyeh Loghmanifar

ABSTRACT: Date kernel powder is one of the waste products of the agricultural sector and food industry, which, after processing, can be used as a functional additive to constitute part of human and animal food. Date kernel powder contains significant amounts of dietary fiber, a component which has an important role in disease prevention. Because Iran is one of the major producers of dates in the world and because of the nutritional value of date kernel, its use as a byproduct of the date industry in human and animal nutrition has attracted much attention. Phenols are beneficial compounds in the date kernel that usually show high antioxidant activity. The purpose of this study was to determine nutritional values and amounts of functional compounds in cake enriched with date kernel powder and to investigate changes in some important physicochemical properties of the new product and its acceptability by consumers. Date kernel powder in amounts of 5% and 10% was added to sponge cake formulation and compared with the control sample in terms of texture (hardness, cohesiveness, gumminess, flexibility, elasticity, and chewiness), antioxidant properties (total phenol content and DPPH free radical scavenging), drainage rate, as well as mineral salts, protein, fat, and fiber content and sensory evaluation. The results showed that different levels of date kernel powder have a significant effect on the level of gumminess, hardness, and cohesiveness. The amount of total phenol, and consequently the percentage of free radical scavenging, as well as minerals, protein, and fiber content, increased with the increase in the amount of date pit powder in the sponge cake. The results of the tests showed that 10% date kernel powder in sponge cake has the highest level of overall acceptability in terms of sensory evaluation. It is concluded that date kernel powder has high amounts of fiber, protein, and minerals content, as well as a high level of antioxidant activity, and has a good potential as a valuable and economical food ingredient to be used in food products and can be used in food formulations and also as a functional food.

***Keywords*:** Date kernel, Spongy cake, Waste, Functional food**.**

Practical Applications

- date kernel powder has high amounts of fiber, protein, and fat and has high potentials as a valuable and economical ingredient for use in food products.
- sponge cake containing date kernel powder, with its desirable quality parameters such as high levels of fiber, protein, and minerals, high antioxidant activity and free radical scavenging, and optimal texture and organoleptic evaluation results, can be introduced as a functional food.

Because of its low price, availability, and desirable nutritional composition (particularly in terms of carbohydrates, dietary fiber, protein, minerals, and oils), date kernel can be used to enrich food products.

INTRODUCTION

Date plant grows in many parts of the world, particularly in the desert areas of the Middle East. Human use of the date as a valuable food source dates back to six thousand years BC (Ashrafjahani, 2003). Several researchers have studied the chemical composition and nutritional value of the eatable part of the date fruit (Keramat and

Khorvash, 2003). However, little information is available on the chemical composition and nutritional quality of the date pit, which forms about 10% of the whole fruit (El-shurfa et al., 1982). Date kernel is one of the waste products of the agricultural sector and food industry, which, after processing, can be used as a functional additive to constitute part of human and animal food. Date kernel contains significant amounts of dietary fiber and micronutrients such as selenium, iron, calcium, as well as phenolic compounds, sterols, tocopherols, metallic ions, and essential amino acids. The phenolic compounds of date kernel include mainly phenolic acids and flavonoids, which have been reported to have attributes of functional foods (antioxidant and anti-cancer properties and prevention of cardiovascular disease). Because of the beneficial effects of date pit, this food item, as an industrial waste resulting from the production of date juice, paste, and chips or in the factories producing pitted dates, can be used in the production of functional foods (Emmanuel et al., 2008).

Polyphenols are antioxidant compounds capable of absorbing free radicals. They play an important role in protecting the body against diseases and shield body tissues against oxidative stress, LDL oxidation, and cancers such as prostate, breast, skin, and colon cancer (Jassimand Mazen, 2010). Phenolic compounds are usually multifunctional and can act as agents for reducing free radical amounts, chelating metals, and suppressing mono-oxygen molecules. Studies have shown that foods rich in phenolic compounds have antioxidant, antimicrobial, antimutagenic, lipoprotein oxidation and platelet aggregation inhibitory, and anti-inflammatory physiological properties (Bauza, 2002). The effect of date products on bread properties has been investigated in numerous studies. Almana and Mahmood evaluated date pit as an alternative to the dietary fiber of wheat bran in bread production and suggested that date pit could be a valuable source of dietary fiber (Almana and Mahmoud, 1994).

In a study by Karimi et al. (2013), date kernel flour was added to wheat flour of bread at three weight levels of 5, 10, and 15%, and the rheological and physicochemical properties of bread were investigated. The results showed that water absorption and stability time and farinograph quality number of the dough increased and its ripening time and degree of slacking decreased with the addition of date kernel flour to wheat flour. The hardness of bread increased with the increase in the amount of the date kernel flour. Furthermore, values for L* (the degree of the lightness of the color) and b* (the scale for assessing the color from blue to yellow) decreased, and the value for a* (the scale for assessing the color from green to red) increased. In the sensory test, the panelists gave lower ratings for the flavor and aroma, hardness and softness, general appearance, and porosity of the bread with increasing percentages of date kernel flour. The results of this study showed that date kernel flour can be used in bread making, and a maximum of 5% of wheat flour should be replaced with date kernel flour for this purpose because using higher levels of date pit flour causes stiffness and change the appearance, taste, and color of the product (Karimi et al., 2014). In 2015, Nabi et al. studied the efficiency of the extraction of soluble and insoluble fiber from date kernel powder and rice bran by the enzymatic method. The efficiency of dietary fiber extraction by the enzymatic method from rice bran and date kernel was 61% 38.8% by weight, respectively. As it is known, in the chemical method, the use of stronger acids in treatment or the longer acid treatment times result in a decrease in the amount of insoluble fiber and an increase in the amount of soluble fiber, and this phenomenon happened with both date kernel powder and rice bran (Nabi et al., 2016). The study by Hojjati (2008) showed that date kernel oil, which can be produced in the amount of about 2000 tons annually in the country, can be used in cosmetic, health, medical, and food products (Hojati, 2009). In 2010, Fahlool et al. substituted date powder for sucrose in 0, 20, 40, and 60% quantities in cookie production, and evaluated the produced cookies in terms of moisture content, ultimate water activity, color, and hardness. The results showed that the substituting date powder had no effect on the moisture content but reduced the hardness of cookies and increased their color (Fahloul, et al., 2010). In 2015, Majzoobi et al. added date kernel powder at different levels of 0, 5, 10, and 15% of the weight of the flour to cookie dough and examined the rheological properties of the dough and the physical and sensory properties of the produced cookies. Farinograph results showed that the percentage of water absorption by the dough increased, and its consistency and slacking decreased with increasing the percentage of date kernel powder, Texture analyzer results showed that the hardness of the cookie texture increased with increasing percentages of date kernel powder. These changes were significantly different in 10 and 15% levels of date kernel powder compared to 0 and 5% levels. Adding less than 15% of date kernel powder resulted in products with desirable sensory taste properties. According to the results, the addition of less than 15% of date kernel resulted in the production of cookies with nutritional values and fiber content higher than ordinary cookies while maintaining their sensory taste characteristics (Majzubi et al., 2016).

In 2008, Elleuch et al. Reviewed fiber-rich by-products and evaluated their chemical and functional applications. According to their study, the amount of dietary fiber in date by-products was higher than many fruits, oilseeds, vegetables, and grains (Elleuch et al., 2008)

Bakery products are among the foods with the highest consumption in the world. Of these products, cakes have a special reputation and are valued by consumers as delicious products with distinct organoleptic properties. Cakes are made using large quantities of fat, and because of their high levels of energy and calories and the presence of

large amounts of sugar and fat in their formulation, their continued and long-term consumption leads to obesity and subsequent health problems (Ronda et al., 2005). Given the high nutritional value of date kernel and the fact that this product is discarded as waste, in this study, the possibility of producing sponge cake enriched with date kernel as a product with high nutritional value was investigated to be compared with the control sample in terms of antioxidant, sensory and textural properties so that, ultimately, it can be introduced as a functional food product.

Materials and methods

Materials and equipments

2,2-diphenyl1- picryl hydrazyl (DPPH), the Folin–Ciocâlteu reagent (FCR), standard gallic acid (from Sigma Aldrich, Germany), methanol, sulfuric acid, hydrochloric acid, and hexane (from Merck, Darmstadt, Germany) were obtained. All the solutions were prepared using deionized water. Equipment included a Labnics spectrophotometer, an AG-A20 hammer mill, a Van Soest fiber analyzer model of 1991, and a Brookfield texture analyzer.

Cake formulation

After provision, date kernel samples were washed and cleaned, and, after removing impurities and the eatable part of the fruit, were soaked in water for 24 hours. Then, after drying at room temperature, they were ground by a hammer mill (AG-A20 model, made in China) to be passed through one-millimeter sieves. The resulting powder was stored at refrigerator temperature until the time of the test. To prepare the sponge cake, ingredients were weighed according to the formulation on a digital scale. Cake ingredients, including flour, eggs, baking powder, sugar, oil, vanilla, and boiling water, were mixed by a home mixer. The prepared dough was then molded in equal weights into a cake pan and baked in the oven at 175 ° C for 20 minutes. The prepared sample was designated as the control sample, and then sponge cakes with 5% and 10% date kernel powder substituted for flour were prepared. Because more than this amount will affect the color of the product and will dry the texture.

Performing assays on the cake

Fiber measurement

One gram of each cake was taken and its protein and fat were removed using appropriate solvents. Then, the amount of total raw fiber in the sample was measured by weighing the remainder, using a fiber analyzer (Van Soest 1991, made in Sweden), and calculating the weight difference after drying and ashing it at 550 ° C for 12 hours in an electric oven (AOAC, 2002).

Protein measurement

Protein measurement was performed according to national standard No. 104 by oxidizing the organic compounds of the sample by concentrated sulfuric acid and converting total nitrogen to ammonium sulfate and finally calculating the amount of the ammonia released in titration (AOAC, 2002; Standard 104, 2012).

Measurement of mineral salts

Zinc, iron, potassium, and sodium were measured by spectrophotometry (Standard 8623, 2005). while magnesium and calcium minerals were measured by atomic absorption spectroscopy (Standard 7183, 2016).

Textural measurement of spongy cake

Texture changes were assessed by a Brookfield texture analyzer (made in the USA) connected to a computer. For this purpose, each of the samples was examined under the TA25/ 1000 probe, with a speed of 1 mm per second and a probe penetration depth of 40 mm into the cake, by texture profile analysis (TPA test) and Trigger Load of 5 g, and the results were calculated. (Ronda, 2005). This test was performed to measure the parameters of hardness, flexibility, chewiness, adhesiveness, springiness, and cohesiveness of the cakes.

Scavenging activity to DPPH radical

The antioxidant activity of the cake extracts was measured by the 2,2 diphenyl picrylhydrazyl method based on the percentage of free radical scavenging. First, 0.5 g of each cake was dissolved in 100 ml of methanol. Then, the extract was centrifuged for 15 minutes. Concentrations of 0.5, 0.2, 0.1, 0.01 and 0.02 were prepared from this extract. Then, 200 µL of 0.06 mM diphenyl picrylhydrazyl solution was added to 4 ml of the extract and the absorbance of the sample was read by spectrophotometer at 517 nm using methanol as the control. The percentage of free radical scavenging was calculated through the following formula (Singh et al., 2002; Soleimani et al., 2017).

$$\%RSC=(A_{blank}- A_{sample})/(A_{blank})\times100 \qquad (Eq.1)$$

Total phenol determination

Total phenolic compounds were measured according to the method of Petropoulos et al. (2017). A quantity of 1 ml of the stock prepared from each cake during the previous test was added to 5 ml of the Folin–Ciocâlteu reagent and after 5 minutes, 4 ml of 7.5% sodium carbonate was added to it. After 60 minutes in the dark, the light absorption of the tubes was measured by a spectrophotometer at 765 nm, and the total phenol content was calculated using the equation obtained from the standard curve of gallic acid. The results were expressed as milligrams of gallic acid per gram of the dry weight of the sample (Petropoulos, et al., 2017).

Sensory evaluation

The sensory properties of the samples, including aroma and smell, taste, texture, color, and general acceptability were evaluated by 23 panelists using a five-point hedonic scoring method. On the scale of 5 to 1, 5 denoted very good, 4 good, 3 average, 2 poor, and 1 very poor (Ronda et al., 2005).

Standard spongy cake assays

For the control and other treatments, pH test was performed according to national standard No. 37 (1999). the acidity of the extracted fat test according to national standard No. 37 (1999), peroxide of the extracted fat test according to national standard No. 37 (1999), Acid-insoluble ash test according to national standard No. 37 (1999), moisture test according to national standard No. 2705 (1995), mold and yeast tests according to national standard No. 997 (2013) and Staphylococcus coagulase-positive test according to national standard No. 6806 (2003) Results were compared to the acceptable ranges of the relevant standards.

Statistical analysis

Data were analyzed by the Duncan test at the 95% significance level ($p < 0.05$), using SPSS 22 software. Excel 2007 software was used to draw graphs. IC50 values were calculated using Graph Pad Prism 8 software. All tests were performed in three replications.

Results and discussion

Results on protein, fiber, and fat content

The results on the protein and fiber content of cake samples (containing 0%, 5%, and 10% of date kernel powder) are given in Figure 1.

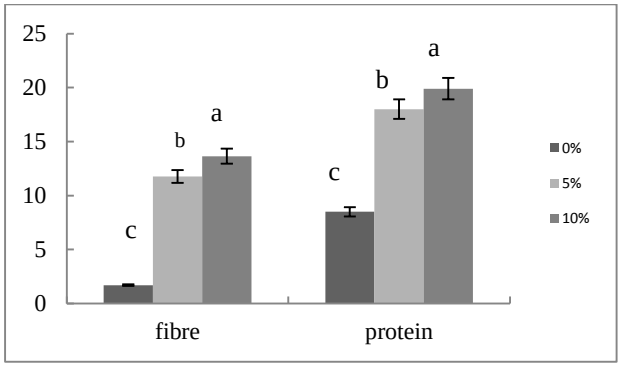

Figure 1. Evaluation of fiber and protein of Sponge cakes containing 0%, 5% and 10% date kernel powder
*Different small letters indicate a statistically significant difference ($P < 0.05$).

As shown, the control sample contains small amounts of fiber (1.7%) and protein (8.5%), which are significantly different from those in the samples containing date kernel powder. In the sample with 10% of date kernel powder, there is a significant difference between the results obtained from protein (19.9%) and fiber (13.65%). In the study by Peighambar-Doost et al. (2016), the amount of fiber in the chocolate sample containing 20% date kernel powder was reported to be more than in the control sample. While the percentage of fiber in the control chocolate sample was 0.4%, the amount of fiber increased significantly with the addition of date kernel powder and sesame seeds to milk chocolate formula (Peighambardoost et al., 2016). Nasehi and Asgharipour (2019) showed that with increasing the amount of date kernel flour in cookies, its fiber amount increases significantly [26]. Moreover, the study by Asgharipour et al. (2018) showed that an increase in the level of date kernel flour in puff formula increases the amount of raw fiber in the product (Asghari-pour et al., 2018).

Results on mineral salts content

Table 1 shows the average content of minerals in the samples. Comparison of the means values by Tukey test showed that the level of minerals significantly increased in the 10% treatment, and the highest increase was seen in the amounts of potassium (3894 mg/ kg) and sodium (178 mg/kg). Consistent with the results of the present study, almost all previous reports indicate that potassium has the highest concentration among macro minerals (AL- Hooti, 1998). The results of the present study showed that iron has the highest concentration in terms of micro minerals.

Table 1. Comparison of mineral solids content in Sponge cakes containing 0%, 5%, and 10% date kernel powder

Sample	0%	5%	10%
Na(mg/kg)	2^{c}	166^{b}	178^{a}
Zn(mg/kg)	4.1^{c}	9.53^{b}	10.55^{a}
Mg(mg/kg)	3.4^{c}	20.02^{b}	22.88^{a}
Ca(mg/kg)	1^{c}	1.8^{b}	2.4^{a}
Fe(mg/kg)	0^{c}	6.76^{b}	7.77^{a}
K(mg/kg)	41^{c}	3680^{b}	3894^{a}

*Different small letters indicate a statistically significant difference (P <0.05).

Results on texture evaluation

The results of evaluating the texture of the cakes are shown in Figure 2. The results show that there is no significant difference between treatments in terms of flexibility, elasticity, and chewiness; however, different levels of date kernel powder have a significant effect on the gumminess, cohesiveness and hardness of the texture of the cake (P <0.05) so that with increasing the amount of date kernel powder (10%), the sponge cake becomes harder and more cohesive than the other samples. Increasing cohesiveness indicates high cohesion of the texture and capability to maintain the internal structure against the application of force.

These results are in agreement with the results of Nasehi and Asgharipour (2019) who reported an increase in the hardness of the samples with increasing the amount of date kernel flour in cookies from 0 to 30% (Nassehi and Asghari Pour, 2019). Al-Farsi and Li (2011) pointed to the negative correlation between the moisture content and kernel hardness in cereal products and stated that the increase in the hardness of cookie samples can be attributed to their low moisture content. It should be noted that palm pit fiber does not have a strong affinity to water. Increased hardness of cereal products as a result of the addition of dietary fiber has been reported in other studies, too (Al –Farsi and Lee, 2011).

The study of technological and physicochemical properties of fortified whole-grain bread showed that increasing the amount of whole grain flour in the formula results in increased hardness because adding bran and gluten-free ingredients to bread weaken the gluten network and decrease the capacity of the dough to retain gas, and consequently, the texture of the bread hardens (Ktenioudaki, and Gallagher, 2012). Moreover, Asgharipour et al. (2018) reported that enriching puffs with date kernel flour increase their hardness, probably due to the thickening of the cell wall during the formation of air bubbles. It is known that fiber interferes with the formation of air bubbles and increases the thickness of the cell wall (Asghari-pour et al., 2018). Karimi et al. (2013) performed the farinograph test on the dough and reported that the water absorption index increases and the dough ripening time and the degree of slacking decreases with increasing date kernel flour (Karimi et al., 2014). Furthermore, Blourian (2004) showed that water absorption and dough efficiency increase by adding date kernel powder to bread (Blourian, 2004). The results of the study by Ziadol et al. (2004) showed a direct relationship between protein content and the ripening time of various kinds of flour (Zaidul et al., 2004).

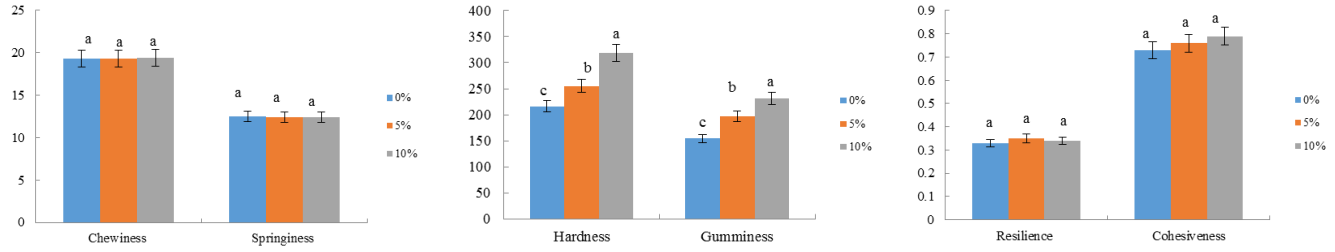

Figure 2. Influence of different levels of date kernel powder on (a) texture springiness and Chewiness b) Hardness and Gumminess c) Cohesiveness and Resilience of Sponge cake

*Different small letters indicate a statistically significant difference (P <0.05).

Results on the antioxidant properties of sponge

The results on the level of total phenol, expressed in gallic acid in milligram per gram of dry weight, are given in Table 2, and the results on the free radical scavenging of the samples are shown in Figure 3.

As shown, the percentage of inhibition in the sample with 10% concentration was higher than in the 5% sample and the control ($P < 0.05$). The high level of free radical scavenging of DPPH in these methods reflects the high content of phenolic and tocopherol compounds. The inhibitory power of different extracts depends, to a large extent, on the number and position of hydroxyl groups and the molecular weight of phenolic compounds (Najafi, 2010). As in other studies, the results of the present study show that treatments with higher levels of phenolic compounds have higher anti-radical activity (Maleki et al., 2015).

The results for IC50 values are shown in Table 3. As expected, the lowest IC50 values were seen in the 10% date kernel treatment (477.3 µg/mL). Antioxidant properties are related to the level of phenolic compounds and increase with increasing levels of phenolic compounds. This fact explains the lower IC50 value for the 10% date kernel treatment (Pinelo, et al., 2005).

Evaluation of the results given in Table 3 shows that there is a significant difference ($P < 0.05$) between the control and samples containing date kernel powder. In fact, this increase is due to the presence of polyphenols in date kernel powder. Asgharipour et al. (2018) proved that adding date kernel flour has a significant effect ($P < 0.05$) on the level of total phenol compounds, and the level of total phenolic compounds in the optimized snack is increased compared to the control sample (Asghari-pour, et al., 2018). The same results were reached in the study by Anwar et al. (2018), in which phenolic compounds in the optimized cookies containing carrot pulp powder were much higher than in the control sample (Anvar et al., 2018). Platat et al. mentioned that the levels of polyphenols and antioxidant activity in date kernel are much higher than in date fruit and are comparable to those in tea extract and grape seed (Platat et al., 2014). Furthermore, the study by Alfarsi and Li (2008) on the level of total phenolic compounds and antioxidant capacity of date juice, residual waste of date juice processing, and date pit showed that date kernel and date juice had the highest levels of total phenolic compounds and antioxidant activity, respectively. (AL-Farsi and Lee, 2008). In past studies, the antioxidant activity of polysaccharides has been linked to their structural properties, including the type of constituent monosaccharides and glycosidic bonds, molecular weight, and the presence of certain groups, such as carbonyl, sulfonyl, amino, and carboxyl groups (Turabi et al., 2010; Yang et al., 2011).

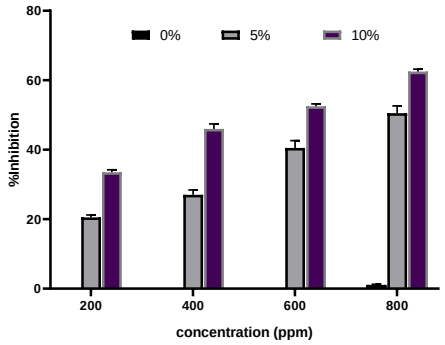

Figure 3. Effect of Sponge cake containing date core powder on DPPH Free Radical Inhibition Percentage

Table 2. Total phenol content of 0%, 5% and 10% of Sponge cake containing 0%, 5%, and 10% date kernel powder

Sample	Total phenol
0%	0^{c}
5%	29.34^{b}
10%	38.53^{a}

*Different small letters indicate a statistically significant difference ($P < 0.05$).

Table 3. Comparison of IC50 Sponge cake containing 0%, 5%, and 10% date kernel powder

Sample	0%	5%	10%
IC50	-	844.7^{b}	477.3^{a}

*Different small letters indicate a statistically significant difference ($P < 0.05$).

Results of sensory evaluation of sponge cake

The results of the sensory evaluation, depicted in Figure 4, showed that the sample containing 10% date kernel powder had an acceptable aroma, taste, texture. and color, and, even compared to the control sample, its general acceptability had a higher score ($P < 0.05$). No significant difference was found between the 5% sample and the control in terms of overall acceptability.

Results of microbial and chemical tests of the samples based on the standards for sponge cake

The results of the assays based on the standard are given in Table 4. As can be seen from the results, all treatments were in the range of standard and no change was observed in the range of results by increasing date kernel powder.

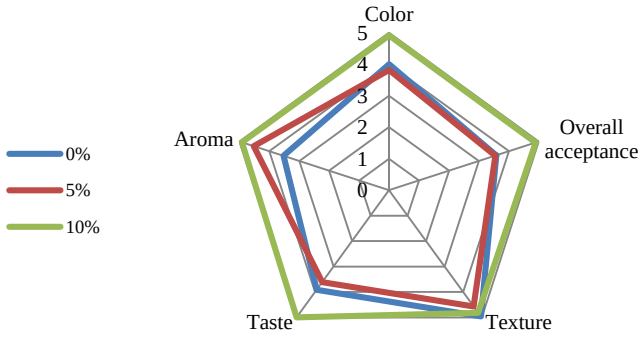

Figure 4. Comparison of sensory evaluation of Sponge cake containing 0%, 5% and 10% date kernel powder

Table 4. Results of microbial and chemical tests of Sponge cake treatments containing date core powder

Test	0%	5%	10%	Standard limits
Moisture (%w)	20.6 ± 0.2	20.4 ± 0.5	20.4 ±0.6	16- 22
Index of extracted fat peroxide	0.96 ± 0.5	0.94 ± 0.1	0.95 ± 0.05	Maximum 2
extracted fat acidity in terms of oleic acid	0.21± 0.04	0.19 ± 0.04	0.20 ± 0.05	Maximum 0.4
Acid-insoluble ash	0.04	0.04	0.04	Maximum 0.05
pH	0.11 ± 6.77	0.06 ± 6.59	0.1 ± 6.30	6- 7
E-coli	-	-	-	Negative
Mold and yeast	0	0	0	Maximum 10^2
Staphylococcus	-	-	-	Negative

Conclusion

In the present study, the use of date pit powder in levels of 0%, 5%, and 10% in the production of sponge cake was investigated, and various quality parameters of this functional food product were assessed. According to the results of chemical tests performed on date kernel powder, this food item has high amounts of fiber, protein, and fat and has high potentials as a valuable and economical ingredient for use in food products. Overall, the results of the present study showed that sponge cake containing date kernel powder, with its desirable quality parameters such as high levels of fiber, protein, and minerals, high antioxidant activity and free radical scavenging, and optimal texture and organoleptic evaluation results, can be introduced as a functional food. Because of its low price, availability, and desirable nutritional composition (particularly in terms of carbohydrates, dietary fiber, protein, minerals, and oils), date kernel can be used to enrich food products.

Availability of data and materials

Research data have been provided in the manuscript and supporting information.

Competing interests

The authors declare that they have no competing interests

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Authors' contributions

All authors equally contributed in this work.

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Not applicable

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