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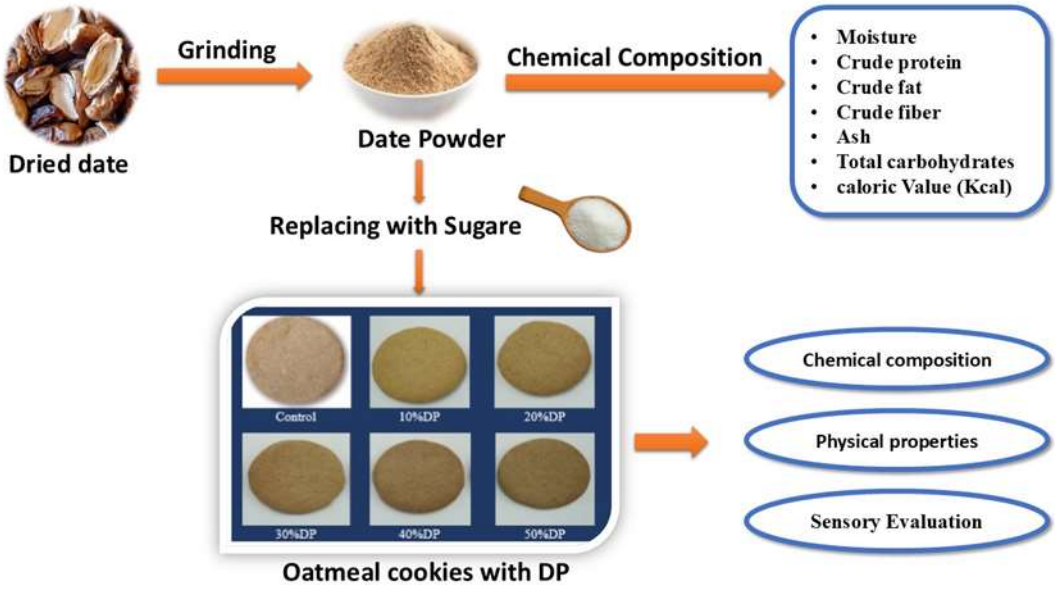
Abstract

Fresh date commercialization leads to significant waste, with approximately 30% of dates discarded due to low-grade classification. To combat food waste, date powder can be used in functional foods as a natural alternative to sucrose, which may be suitable for diabetics and those with food allergies. So, the present study was carried out to evaluate the effect of date powder as a natural sweetener instead of sucrose on the proximate chemical composition, physical properties and sensory characterizations of oatmeal cookies. However, the levels of replacement of date powder, which was used in the cookie's formula were 10, 20, 30, 40 and 50%. The proximate chemical composition of date powder was determined. It was noticed that the moisture percentage was 9.18%, while crude fat, and ash contents were found at low levels being 1.81%, and 1.61% respectively. The crude protein, crude fiber and total carbohydrates constituted 2.64, 4.81% and 84.76%, respectively. The chemical components result indicated that increasing the DP ratio of oatmeal cookies led to an increase in the moisture, crude protein, crude fat, crude fiber, and ash contents and a decrease in carbohydrate and total calorie content ($p \leq 0.05$) of the cookies compared to the control. Physical properties including weight, thickness, diameter, spread ratio and hardness in cookies up to 30% DP didn't differ significantly compared to the control; these ratios recorded the best results. Partial replacement of sucrose with DP produced darker and reddish-colored cookies compared with the control. The total score for overall palatability was acceptable for all cookies, but samples of cookies containing up to 30% date powder had a higher total score than the other samples. In conclusion, this study confirms that date powder can be incorporated at levels of up to 30% in cookie production while preserving and enhancing the nutritional, sensory, and physicochemical qualities of the final products.

Keywords: Oatmeal, Date powder, Cookies, Gluten-free, Functional food.

Graphical Abstract:



تأثير إضافة مسحوق التمر على الخصائص الكيميائية، والفيزيائية، والحسية لكوكيز الشوفان

الملخص :

تؤدي تجارة التمور الطازجة إلى هدر كبير، حيث يتم التخلص من حوالي ٣٠% من التمور بسبب تصنيفها منخفض الجودة. ولمكافحة هدر الغذاء، يمكن استخدام مسحوق التمر في الأغذية الوظيفية كبديل طبيعي للسكروز، وهو مناسب لمرضى السكري ومن يعانون من حساسية تجاه الطعام. لذا، أُجريت هذه الدراسة لتقييم تأثير مسحوق التمر كمُحلي طبيعي بدلاً من السكروز على التركيب الكيميائي التقريبي، والخصائص الفيزيائية، والخصائص الحسية لكوكيز الشوفان. وقد تراوحت نسب استبدال مسحوق التمر المستخدم في تركيبة الكوكيز ١٠%، و٢٠%، و٣٠%، و٤٠%، و٥٠%. تم تحديد التركيب الكيميائي التقريبي لمسحوق التمر. وقد لوحظ أن نسبة الرطوبة كانت ٩.١٨%، بينما وُجد محتوى الدهون الخام والرماد بمستويات منخفضة بلغت ١.٨١% و١.٦١% على التوالي. وكانت نسبة البروتين الخام والألياف الخام والكربوهيدرات الكلية ٢.٦٤% و٤.٨١% و٨٤.٧٦% على التوالي. أشارت نتائج المكونات الكيميائية إلى أن زيادة نسبة مسحوق التمر في كوكيز الشوفان أدى إلى زيادة في محتوى الرطوبة، والبروتين الخام ، والدهون الخام والألياف الخام ، والرماد وانخفاض محتوى الكربوهيدرات والسعرات الحرارية الكلية ($p < 0.05$) في الكوكيز مقارنة بالمجموعة الضابطة. ولم تختلف الخصائص الفيزيائية بما في ذلك الوزن والسمك والقطر ونسبة الإنتشار والصلابة في الكوكيز حتى ٣٠٪ DP بشكل كبير مقارنة بالمجموعة الضابطة؛ وقد سجلت هذه النسبة أفضل النتائج. أدى الإستبدال الجزئي للسكروز بمسحوق التمر (DP) إلى إنتاج كوكيزداكنة ومحمرة اللون مقارنةً بالمجموعة الضابطة. كانت النتيجة الكلية لجودة الطعم مقبولة لجميع أنواع الكوكيز، إلا أن عينات الكوكيز التي تحتوي على نسبة تصل إلى ٣٠% من مسحوق التمر حصلت على نتيجة كلية أعلى من العينات الأخرى. في الختام، تؤكد هذه الدراسة أنه يمكن دمج مسحوق التمر بمستويات تصل إلى ٣٠٪ في إنتاج الكوكيز مع الحفاظ على الخصائص الغذائية والحسية والفيزيائية والكيميائية للمنتجات النهائية وتعزيزها.

الكلمات المفتاحية: دقيق الشوفان، مسحوق التمر، الكوكيز، خالي من الجلوتين، الأغذية الوظيفية.

Introduction

Promoting the development of healthy and sustainable foods is one of the major challenges facing the food industry currently. The food industry aims to generate fewer waste products and to valorize the co-products generated during food production and processing. Furthermore, these new foods should help reduce the risk of several illnesses, particularly non-communicable chronic diseases associated with modern lifestyles, such as diabetes and hypertension, and food allergies such as sucrose intolerance, gluten intolerance, and celiac disease **(Munoz-Bas *et al.* 2025)** For example, 1.5 million deaths are directly attributed to diabetes each year **(WHO, 2024)**. Over the past few decades, both the incidence and prevalence of these diseases have consistently risen.

Celiac disease is also witnessing a rise in its incidence rate worldwide with reported annual values in recent years of 21.3 people with celiac disease per 100,000 persons among children and 12.9 per 100,000 persons among adults. The CD results from the interplay between genetic and environmental factors **(Younes *et al.* 2020).** It is an enteropathy of the small intestine. It is triggered by exposure to gluten in the diet of susceptible people. This condition is characterized as an anomaly in the intestinal mucosa that improves morphologically when treated with a gluten-free diet but worsens when gluten is reintroduced. Non-tropical sprue and gluten-sensitive enteropathy are other names for it. Due to the harmful action of gluten, which destroys the villi of the small intestine, this condition is associated with poor digestion and absorption of nutrients such as vitamins and minerals in the gastrointestinal system **(Tamai & Ihara, 2023; Gromny& Neubauer, 2023).** Therefore, it is necessary to adhere to a gluten-free diet to relieve symptoms and prevent long-term complications. Bread and bakery products are an essential part of the daily diet **(Cahyana *et al.* 2020; Šmídová & Rysová, 2022).**

The international Codex Alimentarius defines gluten-free' foods as having less than 20 ppm of gluten **(Bascunan *et al.* 2017).** Food industries have been recently engaged in the development of functional foods that are safe for ingestion and have health benefits. One such development is the production of gluten-free products. Consumption of cookies is quite frequent all over the world due to their low moisture content, ready-to-eat form, rich nutrient content, long shelf life, availability of many varieties to meet the demands of consumers **(Acun & Gül, 2014; Gül *et al.* 2017).** Cookies are preferred by every age group of the consumer as tasty and hearty snacks **(Gül *et al.* 2016).**

Most of the people with celiac disease tolerate oats well **(AOECS, 2016)**. Therefore, oats can be used as an ingredient in gluten-free products. Oat grain is considered a functional ingredient. According to the USDA **(USDA, 2022)**, the average values of the main chemical components per 100 g of oats are the following: carbohydrates 69.9 g, proteins 13.2 g, total dietary fibers 12.9 g, and lipids 6.31 g, varying with the genetic features and growing conditions of the oats. The major fraction of oat proteins consists of globulins (70–80%), and, compared to other cereals, this fraction, together with albumin, has a higher lysine concentration (**Mao**

***et al.* 2022)**. Oats have a low glycemic index because they include high amounts of resistant starch (25%), followed by slowly digestible starch (22%) and only a small amount of rapidly digestible starch (7%). Also, oats are a good source of soluble β-glucans. The importance of oat β-glucan is reinforced by the EFSA health claims regarding balancing blood glucose, increasing fecal bulk, and reducing blood cholesterol. Additional heart and vascular system health claims have been assigned to high amounts of unsaturated fatty acids, residing mainly in oat grain endosperm. A whole-grain diet based on oats is also recommended because of its important contents of polyphenols and avenanthramides, with antioxidant and anti-inflammatory properties **(Smulders *et al.* 2018; Mao *et al.* 2022)**. Oat has picked up extensive consideration for its high content of proteins and its unsaturated fatty acids. Oats also have folates, zinc, iron, selenium, copper, manganese, carotenoids, betaine, and choline, as the vitamin E-like compounds, tocotrienols, and tocopherols (**Bocchi *et al.* 2021).**

The date is one of the most abundant fruits in the world. Hundreds of varieties having different textures, colors, and flavors are available. It's also rich in dietary fiber and phenolic antioxidants which makes it a special food **(Ghnimi *et al.* 2017 & Maqsood *et al.* 2020).** Dates are also rich in mineral sources such as magnesium, iron, potassium, calcium, and copper and minor sources of vitamin A (retinol) and B2 **(Benmeziane-Derradji, 2019).** The cultivation of date palm has expanded in recent decades to areas beyond its traditional growing desert and semi-desert regions in the Middle East and North Africa; it is an important economically efficient crop to produce highly nutritious fruits **(Fernández-López *et al.* 2022).** Dates in Egypt are considered a strategic crop in the past and the future. Egypt currently ranks first in the world in date production, with an estimated annual production of 1.4 million tons, equivalent to 17.7% of the world's estimated production of 7.5 million tons. Damietta Governorate is one of the most important governorates in Egypt in palm production, as the number of palm trees in Damietta is approximately one million, most of which are concentrated in villages. The inhabitants of these villages depend on palm cultivation to produce dates, in addition to complementary industries **(Elsbeay & Ragab,2021).**

Dates are rich in carbohydrates, mainly a low glycemic index sugar called fructose, good quality protein, vitamins, macro- and micro-minerals, dietary fiber, polyphenols (mainly isoflavones, lignans, and flavonoids), tannins, carotenoids, and sterols **(El-Far *et al.* 2019; AlFaris *et al.* 2022; Hussain *et al.* 2020; Bano *et al.* 2022 and Muñoz-Bas *et al.* 2023).** As date fruit contains several essential nutrients, it is highly perishable in its fresh form; thus, it needs special handling, storage, and processing treatments **(Abdel-Rahman *et al.* 2022).**

On the other hand, the commercialization of fresh dates results in a significant amount of waste, with approximately 30 % of dates being discarded due to low-grade classification which usually end up as waste to be disposed of, with the consequent environmental risk. To combat food waste, value-added products, such as previously dried and milled date powder, co-products use environmentally friendly processes. Date powder proved to be valuable by-products developed to combat food waste and

date powder can add economic value and increase the technological applicability of dates in various products **(Manickavasagan *et al.* 2015 & Munoz-Bas *et al.* 2025).** In this regard, date powder has been used for the development of various food products as a sugar replacer in weaning food formulation, custard, porridge, dairy desserts, biscuits, rock buns, healthy bread, and fiber-rich cookies **(Djaoud *et al.* 2020; Sulieman *et al.* 2011; Barimah *et al.* 2015; Raza *et al.* 2020; Messaoudi& Fahloul 2020; Shabnam *et al.* 2020).** The above studies indicated that incorporating date powder improved the physicochemical, nutritional, functional, and sensory attributes of developed food products. Additionally, **Alkehayez *et al.* (2022)** showed that date powder (DP) is a rich source 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%), 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). Also, incorporating DP in sponge cake improved the nutritional and health quality attributes of the products without a major effect on their sensory attributes.

Utilization of accommodation snacks is growing recently, due to hustle and bustle in developing countries ways of life and financial developments **(Abdullah *et al.* 2016).** Cookies have thus become one of the most desirable snacks in these nations. Considering all that, the aim of the present study is the development of a high-nutrition cookie formulation containing oats and date powder as an alternative to sucrose and the evaluation the effect of adding various amounts of dates powder on the physicochemical and sensory characteristics of the gluten-free cookies.

Material and methods

Materials

- Date palm fruits (Phoenix dactylifera L.) of El Sakkoti varieties were obtained from local market from Damietta Governorate, Egypt.
- All ingredients used in the cookies' formulation (oatmeal flour, sugar powder, butter, eggs, flavor vanilla and baking powder) were commercially available and obtained from a local market in Damietta Governorate, Egypt.

Methods

Preparation of date powder

The dates were cleaned and pitted, and the calyxes were removed. The dates were dried at 60 ˚C for 10-12 h in an oven (Model SM-60IT, SINMAG, Japan). The dried samples were cooled and ground in a grinder (Model HL 1632, Philips India) and the ground samples were passed through a sieve (20 mesh size). This mixture of date powder was packed in polyethylene (HDPE) bags and stored in a cool place until further work **(El-Sharnouby *et al.* 2009).**

Formulation and Preparation of oatmeal cookies

The cookies were prepared with slight modification by using the method **(AACC, 2000).** The control and the other experimental formulations were prepared as shown in table (1). In a large mixing bowl, the butter and powdered sugar were mixed by an electric mixer on medium speed for 30 seconds, then the beaten eggs and vanilla flavoring were added until mixed. Add flour and baking powder until the

dough is combined. Refrigerate the dough for at least 1 hour. The dough was sheeted to a uniform thickness of 5 mm and cut into circular shapes of 60 mm diameter. Baking was carried out at 180°C for 15 min. Cookie samples were cooled and stored in airtight containers prior to physical and chemical evaluation. We made cookies using oatmeal flour as a control. Five formulations (F1, F2, F3, F4, and F5) were developed by replacing sugar with date powder (DP). The replacements were done at the ratios of 10%, 20%, 30%, 40%, and 50%.

Table (I): Formulation of oatmeal cookies

Ingredients (g)	Control	F1	F2	F3	F4	F5
Oat flour	٢٠٠	200	200	200	200	200
Sugar	60	54	48	42	36	30
Date powder	-	6	12	18	24	30
Butter	١٠٠	100	100	100	100	100
Egg	٦٠	60	60	60	60	60
Baking powder	٢	2	2	2	2	2
Flavor vanilla	٢	2	2	2	2	2

Determination of gross chemical composition

Date powder was analyzed for moisture, ash, total protein, crude fiber and fat contents, while total carbohydrates were calculated by difference according to **AOAC (2016)**. A sample was taken from the same cookies that were used for physical characteristics; the proximate chemical composition of oatmeal cookies samples was determined for moisture, protein, crude fat, crude fiber and ash by the **AOAC (2016).** Caloric value was calculated according to the following equation: Caloric value = 4 (protein %+ carbohydrates %) + 9 (fat %).

Physical evaluation of oatmeal cookies

The physical parameters of five cookies were evaluated in terms of weight, diameter (D), thickness (T), and spread ratio (diameter/thickness) according to the standard method. After cooling the cookies for 30 min, diameter and thickness measurements were taken using a vernier caliper. Then cookies were put in plastic bags and kept in a freezer at -18ºC for further physical and chemical analysis.

Hardness

The hardness of the cookies was measured using a Texture Analyzer (Comtech, B type, Taiwan). A test speed of 1 mm/s was used for all tests. Three replicates of each formulation were conducted. breaking strength. Cookies were broken using the three-point bending rig probe. The experimental conditions were supports: 50mm apart, and a 20mm probe travel distance. The force at break (N) was measured **(Bourne, 2003)**.

Color analysis

The colors of five cookies were measured with a Minolta Spectrophotometer CM-3600d (Osaka, Japan). The colorimeter was calibrated using a standard white plate. The dimension L∗ means lightness, with 100 for white and 0 for black; a∗ indicates redness when high positive and greenness when high negative; b∗ indicates yellowness when high positive and blueness when negative.

Sensory properties of oatmeal cookies

Sensory evaluation was participated in by invited staff panelists from the Home Economic Department, Faculty of Specific Education, Damietta University, Damietta, Egypt. Samples of the oatmeal cookies were prepared one day earlier before evaluation and cooled for 1-2h at room temperature (25±3ºC). Sensory attributes for color, taste, flavor, texture, and overall acceptability were evaluated according to **Abd El-Latif, (2018).** Water served for cleaning the mouth between samples.

Statistical Analysis

The data obtained were statistically analyzed using a computer. The results were expressed as mean ± standard deviation (SD) and tested for significance using the one-way analysis of variance (ANOVA) test, according to Duncan's multiple range test at ($P \leq 0.05$) probability. According to the method described by **Armitage & Berry (1987).**

Results and Discussion

Chemical composition and caloric value of date powder

The obtained results are presented in Table 2 and it could be observed that date powder (DP) contained moisture (9.18%), crude protein (2.64%), crude fat (1.81%), crude fiber (4.81%), ash (1.61%), total carbohydrates (84.76%), and caloric value (365.89 kcal/100g). The results are in agreement with **Assous *et al.* (2021)** who showed that date powder contains 13.19% moisture, 2.13% protein, 2.16% fat, 4.85% fiber, 1.82% ash, and 87.07% total sugars. While **SM *et al.* (2021)** found that the moisture**,** protein, fiber, lipids, ash, and total sugars of DP were 8.9 %, 2.20%, 2.59%, 0.98%, 1.46 and 80.67%, respectively. Also, **Kenawi *et al.* (2016)** showed that the chemical composition of El Sakkoti date powders was 4.43, 1.40, 1.62, 1.62, 3.90 and 91.62% for the moisture, ash, protein, crude fat, crude fiber and carbohydrates; respectively.

Moreover, **Dayang *et al.* (2014)** showed that the dates contain a high percentage of carbohydrate (total sugars, 44-88%), fat (0.2-0.5%), protein (2.3-5.6%) and a high percentage of dietary fiber (6.4-11.5%) as well as a high concentration of minerals and vitamins. On the other hand, given the high production potential of dates worldwide, studies try to enhance their applications in food industries and develop functional foods.

Table 2. Gross chemical composition of date Powder (% On dry weight basis).

Components	DP
Moisture content	9.18±0.70
Crude protein	2.64±0.26
Crude fat	1.81±0.17
Crude fiber	4.81±0.37
Ash	1.61±0.21
Total carbohydrates*	84.76
caloric Value (Kcal)	365.89

Each value represents the mean ± SD. **DP:** Date Powder

* Total carbohydrates were calculated by differences.

Gross chemical composition of oatmeal cookies supplemented with date powder

Results presented in Table 3 showed the gross chemical composition of the control (oatmeal cookies) and formulas (oatmeal cookies with date powder DP). It was found that moisture contents of the control were less than formulas F1, F2, F3, F4 and F5 (3.50, 3.78, 4.05, 4.33, 4.60 and 4.88 %, respectively). The same table 3 showed that the crude protein content of the control (19.55 %), F1 (19.63 %), F2 (19.708 %), F3 (19.79 %), F4 (19.87%), and F5 (19.95 %) while the crude fat content of the control was less than treatments F1, F2, F3, F4 and F5 which were 24.85, 24.91, 24.959, 25.01, 25.07 and 25.12 %, respectively. From the same Table, it could be observed that the ash content was 1.65, 1.٧٠, 1.7٥, 1.79, 1.84 and 1.89 % for control, F1, F2, F3, F4 and F5, respectively. The data in Table 3 showed that crude fiber contents of control were less than formulas F1, F2, F3, F4 and F5 (10.32, 10.46, 10.6١, 10.75, 10.9٢ and 11.04 %, respectively). Meanwhile, the content of total carbohydrates in control and cookies formulas were 50.34, 49.98, 49.63, 49.27, 48.91 and 48.55% for control, F1, F2, F3, F4 and F5, respectively. On the other hand, the caloric value of control was 503.21 kcal/100g while it ranged from 500.08 to 502.63 kcal/100g in different cookies formulas. Concerning the previous results, it should be noticed that the increase of DP in oatmeal cookies led the increased proportion of moisture, crude protein, crude fat, crude fiber, Ash while, decreased proportion of total carbohydrate, and calorie compared to control.

The Codex Alimentarius Commission specifies that white sugar is purified and crystallized sucrose, with a minimum purity level of 99.7%. Overindulgence in sweetened beverages is linked to metabolic disorders, including type 2 diabetes mellitus (T2DM), obesity, and cardiovascular diseases **(Baroyi *et al.* 2024).** The World Health Organization (WHO) advises that the daily intake of sugars should not exceed 5% -10% of the total daily caloric intake **(WHO,2015).** On the other hand, date powder is a natural sweetener with a high sugar content. It has a low to medium glycemic index, which means it does not cause blood sugar spikes, making it a suitable option for those concerned about sugar intake **(George *et al.* 2020).** Additionally, date sugar is high in fiber, antioxidants, and various minerals such as potassium, magnesium, selenium and copper **(Chandrasekaran & Bahkali, 2013).** These nutrients contribute to improved digestion, bone health, and overall well-being. Date sugar is considered a healthier alternative to refined sugars due to its naturalness and nutrient density. It can be used as a substitute for white or brown sugar in recipes, offering a sweet taste along with its health benefits (**Ghnimi *et al.* 2017**).

Table 3. Gross chemical composition of oatmeal cookies supplemented with date powder (% On dry weight basis).

Components (%)	Control cookies (100% sugar)	Formulas cookies with DP (%)				
		F1	F2	F3	F4	F5
Moisture content	3.50±0.11	3.78±1.1	4.05±0.10	4.33±0.07	4.60±0.12	4.88±0.23

Crude protein	19.55±0.31	19.63±0.29	19.708±0.34	19.79±0.32	19.87±0.18	19.95±0.25
Crude fat	24.85±0.51	24.91±0.55	24.959±0.48	25.01±0.38	25.07±0.52	25.12±0.31
Crude fiber	10.32±0.19	10.46±0.11	10.6١±0.15	10.75±0.14	10.9٢±0.21	11.04±٠.١٨
Ash	1.65±0.12	1.٧٠±0.08	1.7٥±0.06	1.79±0.05	1.84±0.05	1.89±0.07
Total carbohydrates*	50.34±0.41	49.98±0.52	49.63±0.43	49.27±0.61	48.91±0.62	48.55±0.57
Caloric value (kcal)	503.21±0.71	502.63±0.45	502±0.51	501.33±0.62	500.75±0.35	500.08±0.65

Each value represents the mean±SD.* Total carbohydrates were calculated by differences.

DP: Date Powder, **Control:** 100% sugar. **F1:** 10% DP. **F2:** 20% DP, **F3:** 30%, **F 4:** 40% DP**, F 5:** 50%.

Physical properties of oatmeal cookies supplemented with date powder

The results of weight (g), thickness (mm), diameter (mm), spread ratio (D/T), and hardness (N) of oatmeal cookies mixed with DP could be seen in Table 4. Results showed that the weight (g) of cookies increased significantly with increasing the levels of DP from 18.74±0.24 to 19.25±0.18 compared with the control of 18.72±0.11. It may be due to the fact that DP has a high fiber content, which increased the crude fiber content in cookies. This increase in fiber content may contribute to improved texture and a greater sense of satiety in the cookies. Additionally, the incorporation of DP might enhance the nutritional profile of the cookies, making them a more healthful option for consumers. The diameter (mm) of oatmeal cookies enhanced with DP was shown to decrease significantly from 64.40±1.30 to 58.20±1.13 as the amount of DP increased, compared to the control, which had a diameter of 67.20±0.83. While the thickness (mm) values of oatmeal cookies mixed with different ratios of DP were gradually increased after the substitution, going from 5.39±0.35 to 6.52±0.31, as compared to the control (5.14±0.26). By logic, when the diameter of cookies reduces, the thickness will increase **(Shabnam *et al.* 2020).**

On the other hand, the spread ratio in all samples of oatmeal cookies was lower than the control cookies; the increased solubility of sucrose sugar may be the cause of the larger spread ratio value observed among the control cookies. Similar results were reported by **Amin *et al.* (2019),** who reported that adding date powder, which is less soluble in biscuit dough, decreases the dough's diameter and, consequently, the spread ratio.

The results of the texture profile analysis for hardness indicate a significant difference ($p \leq 0.05$) between the control cookies and the oatmeal cookie samples mixed with varying ratios of DP. The hardness values for the control cookies (17.80±1.92) were higher than those of all other formulations, which recorded values of 17.18±1.45, 16.14±1.12, 15.39±1.47, 13.94±1.27, and 12.17±1.0, respectively. **Majzoobi *et al.* (2016)** reported that the hardness of the cookies can be

influenced by the quantity and type of sucrose sugar in the biscuit making. The less sucrose sugar used in the biscuit making, the less the hardness of the cookies. In addition, the rate of sucrose crystallization during cooling of cookies is higher compared with fructose and glucose found in the samples with DP, which also results in the control biscuit becoming harder in nature.

Table (4). Physical properties of oatmeal cookies supplemented with date powder

Parameters	Control cookies (100% sugar)	Formulas cookies with DP (%)				
		F1	F2	F3	F4	F5
Weight (g)	18.72±0.11^{b}	18.74±0.24^{b}	18.83±٠.29^{b}	18.96±٠.20^{ab}	19.08±٠.06^{a}	19.25±٠.18^{a}
Diameter (mm)	67.20±0.83^{a}	64.40±1.30^{b}	62.20±1.77^{b}	59.60±1.30^{c}	58.41±1.27^{cd}	58.20±1.13^{d}
Thickness (mm)	5.14±٠.26^{d}	5.39±٠.35^{d}	5.53±0.24^{cd}	5.9٦±٠.38^{bc}	6.33±٠.21^{a} ^{b}	6.52±٠.31^{a}
Spread ratio (D/T)	13.10±٠.82^{a}	11.99±1.02^{ab}	11.27±0.81^{b}	10.02±٠.42^{c}	9.23±0.11^{c} ^{d}	8.62±0.23^{d}
Hardness (N)	17.80±1.92^{a}	17.18±1.45^{a}	16.14±1.12^{ab}	15.39±1.10^{b}	13.9٤±0.45^{c}	12.17±1.02^{d}

Mean values in the same row which are not followed by the same letter are significantly different (p≤0.05).

DP: Date Powder, **Control:** 100% sugar. **F1:** 10% DP. **F2:** 20% DP, **F3:** 30%, **F 4:** 40% DP, **F 5:** 50%.

Color plays an important role in consumers' acceptability of the product. Values for each L*, a*, and b* refer to the measurement of brightness, redness, and yellowing color for oat cookies supplemented with date powder. The cookies containing DP had significantly (p≤0.05) lower L* values (57.34-53.71) than the control (58.49). The lowest L* value was observed in 50% DP cookies. Cookies mixed with DP are clearly darker in color than control cookies, as indicated by the low value of L*. This decrease is due to the Maillard reaction: dates have a high sugar content and will interact with heat during baking; in so doing, they produce brownish cookies that are liked by many people compared to pale-like cookies; the sensory evaluation results confirm this. The value of a*, which indicated the redness color, also showed a significant difference (p ≤ 0.05) between control cookies and other samples. The mean values of a* for them ranged between 4.35±0.15 and 5.62±0.14, which is higher compared to control cookies (4.08±0.12). The lower L* values and higher a* values seen in cookies mixed with different ratios of DP are due to the presence of dates, which have a dark reddish-brown color, particularly when the amount added is greater. The (b*) color value indicates yellow or blue colors (a positive value indicates yellow, and a negative value indicates blue). The data indicated that the substitution of sugar for DP by more than 30% resulted in significantly lowered b* values (17.73±0.47 to 16.70±0.58) from the control (19.67±0.26); this result may be due to date powder containing a lot of polyphenols.

Regarding the previous results, it could be observed that the brightness (L*) and yellowness values (b*) in cookies had gradually declined with the increasing levels of DP, whereas the redness (a*) value had increased, which means that the DP resulted in darker cookies when the addition was higher.

Table (5). Color attributes of oatmeal cookies supplemented with date powder

Color Analysis	Control cookies (100% sugar)	Formulas cookies with DP				
		F1	F2	F3	F4	F5
L*	٥٨.49^{a} ±0.24	٥٧.٣4^{b} ±0.14	56.52^{c} ±0.18	55.65^{d} ±0.31	54.75^{e} ±0.25	53.71^{f} ±0.12
a*	4.08^{f} ±0.12	4.35^{e} ±0.15	4.82^{d} ±0.70	5.11^{c} ±0.51	5.25^{b} ±0.14	5.62^{a} ±0.14
b*	19.67^{a} ± 0.26	18.71^{a} ±0.35	18.10^{a} ±0.43	17.73^{ab} ±0.47	17.64^{b} ±0.28	16.70^{b} ±0.58

Mean values in the same row which are not followed by the same letter are significantly different ($p \leq 0.05$).

DP: Date Powder, **Control:** 100% sugar. **F1:** 10% DP. **F2:** 20% DP, **F3:** 30%, **F 4:** 40% DP, **F 5:** 50%.

Sensory characteristics of oatmeal cookies with date powder

Table (6) presented the sensory characteristics of prepared oatmeal cookies with date powder. The data showed that most formulations were acceptable in all sensory evaluation attributes (color, taste, flavor, texture, and overall palatability). Also, the data showed that there were no significant variations ($P \leq 0.05$) between the formula oatmeal cookies supplemented with up to 30% date powder and the control. Whereas replacing sucrose with 40% and 50% of date powder caused a significant difference ($P \leq 0.05$) in the same sensory evaluation attributes as compared to the control. Also, the result revealed that color in all supplemented oatmeal cookies with different levels of date powder decreased significantly ($p \leq 0.5$) in scores of colors as compared with the control because the oatmeal cookie samples became darker. Also, texture decreased with an increase in date powder level, and the hardness of cookies decreased with an increase in date powder. The hardening of cookies might be due to the crystallization of sugars during cooking. However, the results of the acceptance test showed that consumers like most of the formulas, which was confirmed by the total score, which recorded over 75% in all formulas. The results of this study are in contrast with **Ikechukwu *et al.* (2017)** whereby biscuits mixed with 50% DP obtained the highest mean score for color attribute. Additionally, the findings from **Alsenaien *et al.* (2015)** showed that biscuits with 50% or more added ingredients were preferred by the taste testers, and adding up to 50% of DP to the biscuit mix did not harm the biscuit's taste and quality. On the other hand, **Kenawi *et al.* (2016)** studied the differences in substitution of powdered dates from El Sakkoti and Tamr El Wadi types, each at substitution rates of 10%, 20%, 30%, 40% and 50% from sugar that was used in the biscuit formulation. They found that the panel lists selected biscuits with 30% substitution.

Table (6): Sensory characteristics of oatmeal cookies with DP

Sensory Characteristics	Control oatmeal cookies	Oatmeal cookies with DP				
		F1	F2	F3	F4	F5
Color (20)	19.35^{a} ±0.58	19.10^{a} ±0.57	19.00^{ab} ±0.32	18.91^{abc} ±0.62	18.50^{bc} ±0.71	17.81^{c} ±0.65
Taste (20)	18.85^{a} ±1.00	18.85^{a} ±0.91	18.85^{a} ±0.32	18.12^{ab} ±0.74	17.95^{b} ±0.98	17.55^{c} ±0.69
Flavor (20)	19.00^{a} ±1.15	18.90^{a} ±0.57	18.85^{a} ±0.58	18.32^{ab} ±0.46	18.35^{ab} ±0.32	18.00^{c} ±0.24
Texture (20)	19.30^{a} ±0.82	19.00^{a} ±0.67	18.70^{a} ±0.71	18.19^{ab} ±0.81	17.90^{b} ±0.51	17.60^{c} ±0.15
Overall Palatability (20)	19.10^{a} ±0.70	19.25^{a} ±0.59	18.90^{a} ±0.66	18.56^{ab} ±0.75	17.95^{b} ±0.36	17.40^{c} ±0.14
Total Score (100)	95.60^{a} ±0.85	95.10^{a} ±0.66	94.3^{ab} ±0.51	92.10^{b} ±0.64	90.65^{bc} ±0.83	88.36^{c} ±0.92

Values in each column which have different litters are significant different ($p \leq 0.05$).
DP: Date Powder, **Control:** 100% sugar. **F1:** 10% DP. **F2:** 20% DP, **F3:** 30%, **F 4:** 40% DP, **F 5:** 50%.

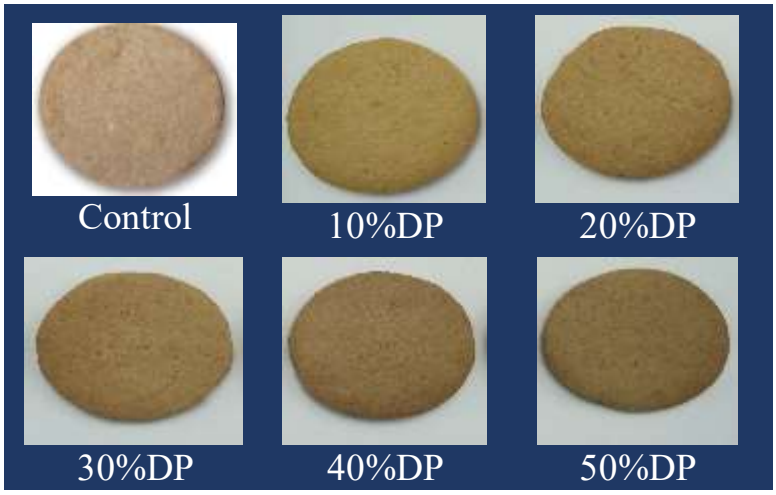


Photo (1): Oatmeal cookies with date powder

Conclusion

Date powder's potential applications as a sugar or carbohydrate source that can be used by both healthy and sick people highlight opportunities for innovation in the food industry, particularly in snack food, beverages, confectionery, bakeries, and other natural, health-conscious food sectors. Therefore, the current study confirms the possibility of replacing sucrose sugar with date powder as a natural alternative up to 50% to produce oatmeal cookies. This strategy might be preserving and enhancing the sensorial and physicochemical quality of these products.

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