Original Article
Food Science and Technology

ISSN 0101-2061 (Print)
ISSN 1678-457X (Online)

DOI: https://doi.org/10.1590/fst.95222

Organoleptic, antioxidant activity and microbial aspects of functional biscuit formulated with date fruit fibers grown in Qassim Region

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Abstract

Al-Qassim is superabundant date fruits production in kingdom of Saudi Arabia (KSA); considers the plentiful region for producing date syrup resulting in massive amounts of crude date fibers (DFs). Current study aimed to valorizes powdered DFs usage by formulating biscuits with different DFs levels (5, 10 & 15%). Chemical compositions, antioxidant activity and total phenolic levels as well as physical and microbiological properties for dough and DFs were evaluated. The quality attributes (physical, texture, microbiological and sensory traits) of formulated biscuits were evaluated. The magnesium was the highest element in DFs powder (124.40 mg/100g) followed by potassium (30.39 mg/100g). Biscuits formulated with 5% DFs had the lowest water activity a_w (0.354*; P ≤ 0.05*) that was increased with 15% DFs. Increasing the DFs substitution level increased the darkness of biscuit crust color. Biscuits with 5% DFs addition showed the lowest total phenolic, scavenging activity (7.82 mg GAE/g & 9.59% respectively) and hardness (17.28). Date fruits had the lowest total viable count (TVC; 4.6 log cfu/g) while *Salmonella* and *E.coli* were totally absent. In conclusion, the powdered DFs significantly improved overall acceptability of formulated biscuits at levels up-to 10% and could be recommended for marketplace.

Keywords: date powder; fiber; microbiology criteria and sensory evaluation.

Practical Application: Producing new formulated biscuits supplemented by DFs that could improve their health benefits with saving massive amounts of crude date fibers (DFs).

1 Introduction

People in Arabic countries; mainly Egypt and KSA are the most top 10 countries date-production. Saudi Arabia was the second largest date producer from 2018–2019, with a total production of 1,483,631 ton (Alharbi et al., 2021). It has their own especial dietary habits that is concentrated mainly on date fruit consumptions that remains to be an important part/component of the consumed daily diet. It is also consider as super-food for all healthy people to be included in their diets; about 3-5 dates daily perfect to break their fast and also to be consumed early morning. E.g. Al-Qassim region is one of the most date producers in KSA as it contains about 8 million of date tree that producing about 205 thousand ton of date fruits yearly with a serious governmental plan to duplicate the produced quantity by 2030 (Mirghani, 2021). Date fruits have many health benefits as they are good source for phytochemicals and very low fat levels that can decrease cholesterol, risk of heart disease and cancer that mainly depending on their nutritional value especially with their dietary fiber levels. The dietary fiber presented in different fruit shown many beneficial physiological effects especially stomach function improvements with total cholesterol reduction (Lou et al., 2022). Additionally, different minerals presented in date fruits show to have beneficial effects regarding glycemic control within diabetic patients especially its big amount of selenium which protects the body from oxidative stress and then prevent the diabetic complications; e.g. atherosclerosis and neurodegenerative diseases (Juhaimi et al., 2012; Mirghani, 2021). Date syrup (Debis; prepared from tamer stage fruits) is useful product that could be obtained either by used pectinase and cellulase enzymes or with the conventional hot water and autoclaving extraction methods. Such collected debis is used in a many different dietary products such as cakes, carbonated beverages, soft frozen yogurt and milk-based drinks (Sidhu, 2012). Al-Qassim reign produce date syrup so considering as the abundant region for producing large amounts of crude date fibers (DFs) extraction and that could lead to ecological problems consider as dietary waste. A number of studies have been dedicated to the composition additionally to the functional characteristics of dates and their derived by products (Al-Farsi et al., 2007; Biglari et al., 2008). There are three mainly major by-products resulting from date-fruit processing plants; waste date pulp, low-grade rejected date fruits, and date seeds (both pits & stones) (Sidhu, 2012). However, fibers either soluble or insoluble are at very high concentrations in dates boosting the immune responses and gut health as they are non-digestible oligosaccharides (used as a fermentation substrate known previously as prebiotics; (Bensaci et al., 2021). Additionally,

Received 26 Sept., 2022
Accepted 15 Nov., 2022

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it is important for obtaining the human gut health therefore; it should be consumed daily for achieving and maintaining the best human health states. Indeed, many utilization techniques have been developed recently to solve such problem successfully and valorize the economic value. However, no food producer or researcher thought of using such date fruit fibers (DFs) that could be considered as an interesting addition to diet, food bakery products, food supplements, or herbal medicines. E.g. food bakery products such as biscuits have many advantages to be used because of their relatively long shelf life additionally to their affordable cost and high nutritional value that in total help as ready-to-eat nature and sweet taste foods (Weng et al., 2021). Recently, innovative functional food is an interesting research area in processed food industry for long run. According to the world market analysis for functional foods the demand for functional food in 2020 reached about 188,56 billion U.S. dollar and expected to promote to 275,77 billion U.S. dollar by 2025 (Functional Food Market, 2019). So increasing the consumptions of such DFs could be in help for modulating many healthy problems. E.g. reduce obesity rate which means changing healthy related disorders between not only the Saudi Arabian communities but also for most of the obese subjects worldwide. To the best to our knowledge, there is no report available on utilizing of date fiber flour in the development of any bakery or biscuit products that can be recommended or used for modifying and controlling any healthy problem. Indeed, biscuits have been used widely as popular dietary bake product loved between all human ages e.g. children, adults and the elderly (Weng et al., 2021).

However, the problem is real and finding best strategies are important. Therefore, current study carried out to valorize the DFs that have been converted to powder to increase its functionality; applicability and incorporated in different levels (5%, 10%, and 15%) in biscuit formula. Additionally the chemical composition, mineral contents, antioxidant activity, total phenolic compounds, microbiological criteria and sensory attributes of the formulated biscuits were evaluated; new accepted and approved DFs functional biscuits were recommended.

2 Materials and methods

2.1 Materials

Date fruit (*Phoenix dactylifera L* . Known as SUKARY or Sugary), soft wheat flour (70% extraction), shortening, salt, sugar and skimmed milk powder used in the current study were purchased from the local market, Qassim, KSA. Food grade dextrose, sodium bicarbonate and ammonium bicarbonate were used in biscuit preparing. Sodium carbonate, methanol, 1,1-diphenyl-2-picrylhydrazyl radical (DPPH) and Folin-Ciocalteus phenol reagent were purchased from Sigma–Aldrich Inc. (St Louis, MO, USA). Also, the used media for microbiological analysis (Nutrient agar; NA, Potato Dextrose agar; PDA, Salmonella Shigella agar; SSA and Eosin Methylene Blue; EMB) were obtained from Sigma.

2.2 Methods

Sukary date fruits were subjected to fiber extraction then the collected fibers were dried and milled to powder which used for further analysis in two main phases as shown in following sections.

Dates fruit fiber powder and new biscuit samples preparation

Sukary date fruits were subjected to fiber extraction by separation the syrup using the aqueous extraction method as described by Thanigaivelan et al. (2022). The collected fibers were dried in an air draught oven at (50 ± 2 °C) and milled to powder which have been used for further analysis.

Biscuit preparation

Biscuit samples were prepared by replacing 5, 10 and 15% of wheat flour with date fruit fiber powder (DFs) according to the method described by Leelavathi & Haridas Rao (1993) with slight modification. The used standard recipe for semi-sweet biscuit dough was carried out and also the used amount of water has been added after being adjusted to the water absorption capacity. The formula used was as follows: 200 g wheat flour, 60 g sugar, 50 g shortening, 2 g salt, 0.8 g sodium bicarbonate, 3 g ammonium bicarbonate, 4 g dextrose, 4 g skimmed milk powder and 40 - 42 ml water. The shortening and sugar were creamed in a Hobart mixer (N-50) with a flat beater for 3 min at 61 rpm (speed 1). Sodium bicarbonate, salt and ammonium bicarbonate were dissolved in water and added. Skimmed milk powder was made into suspension with water and transferred to the cream. The contents were mixed for 6 min at 125 rpm (speed 2) to obtain a homogenized and creamy texture. Sieved flour (or flour substituted with 5, 10 and 15% DFS) was added to the cream and mixed for 2 min at 61 rpm (speed 1). The dough pieces were sheeted to a thickness of 3.5 mm, cut using a circular mould (50 mm diameter) and baked at 180 °C for 10-15 min. After baking, biscuits were left to cool at room temperature and wrapped tightly with polypropylene pouches and kept for further analysis.

Chemical composition and minerals determination of date fruit fibers

Date fruit fiber powder was analyzed for their moisture content, ash, crude protein, lipids and crude fiber according to the methods described in AOAC (Association of Official Analytical Chemists, 2007). The moisture content was determined by an electric air draught oven (VEB MLW Medizinische, Gerete, Berlin, Germany). Nitrogen free extract (NFE; carbohydrates) were calculated by the difference. Regarding the mineral contents of the date fruit fiber powders, including potassium (K), sodium (Na), calcium (Ca), ferrous (Fe), Magnesium (Mg), and zinc (Zn) elements were determined using an Atomic Absorption Flame Emission Spectrophotometer (Perkin-Elmer Model AA-6200 from Shimadzu 7000, Japan) as reported by AOAC (Association of Official Analytical Chemists, 2000).

Water activity of crude DFs and biscuit samples

Water activity (a_w) of dates fruit fiber powder and biscuit samples was determined using AQUA LAB (model series 3), USA by methods described by Landrock & Proctor (1951).

Samples (in small plastic cups) were equilibrated against the saturated salt solution at 20 °C.

Physical properties of biscuits samples

Diameter (W) of biscuits was measured by laying six biscuits edge-to-edge with the help of a scale. The same set of biscuits was rotated 90° and the diameter was premeasured. Average values of biscuits were reported in millimeter (Srivastava et al., 2010). Thickness (T) of biscuits was measured by stacking six biscuits on top of one another and taking the average in millimeter. The spread ratio was calculated by dividing diameter (W) by thickness (T).

Instrumental crust color parameters of crude DFs and formulated biscuits

Color of biscuit surface samples formulated with different DFs levels were measured by Hunter Lab Color QUEST II Minolta CR-400 (Konica Minolta Inc., Osaka, Japan) according to the method described in Francis (1983) that has been modified according to recent published similar samples (Bölek, 2022). The measurements were expressed in L*, a*, and b* values which represents light–dark spectrum with a range from 0 (black) to 100 (white), the green–red spectrum with a range from -60 (green) to +60 (red), and the blue–yellow spectrum with a range from -60 (blue) to +60 (yellow) dimensions, respectively.

Determination of total phenolic and radical scavenging activity (DPPH) of biscuits

Total phenolic content was measured by the Folin–Ciocalteu assay along with spectrometer as described by Singleton et al. (1999). Aliquots of 0.5 ml of each extracts were added to 0.5 mL of Folin-Ciocalteu reagent, followed by addition of 0.5 ml of an aqueous 20% solution of sodium carbonate. The mixture was stirred and allowed to stand for 30 min. The absorbance at 765 nm was measured using a model UV/VIS 1201 spectrophotometer (Shimadzu, Kyoto, Japan). A blank sample consisting of water and reagents was used as a reference. Gallic acid was applied as a standard, and the results were expressed as mg gallic acid equivalent (Bölek, 2022). The ability of the extracts to scavenge DPPH free radicals was determined by the method described by Valko et al. (2007). Aliquots (100 µl) of each extracts were mixed with 2.9 ml of 0.1 mM DPPH in methanol. The control samples contained all the reagents except the extract. The absorbance at 517 nm was measured after 30 min of incubation at room temperature. The remaining DPPH free radical was determined by absorbance measurement against methanol blanks. The percentage scavenging effect was calculated from the reduction of absorbance against control (DPPH radical solution in methanol without sample) using the following equation: Scavenging activity % = $[(Abs_{control} - Abs_{sample})/Abs_{control}] \times 100$.

Determination of biscuit texture

Texture (Hardness (n) and Factorability (mm)) of biscuit samples formulated with different DFs levels was measured using Texture Analyzer (QTS 25, Brookfield AMETEK, Massachusetts, and USA).

Microbiological analysis of original prepared DFs powder and biscuits

Media used were Nutrient agar (NA), Potato Dextrose agar (PDA), Salmonella Shigella agar (SSA) and Eosin Methylene Blue (EMB). All the media were prepared according to manufacturer's instructions dissolving with distilled water in conical flask that was covered with non-absorbent cotton wool plug wrapped with aluminum foil and warmed on a heating mantle for the mixture to homogenize. Thereafter, the content of the flask was sterilized in an autoclave at 121 °C for 15 min. The microorganisms were isolated using the pour plate method with different serial dilution. About 1 g of each sample was added into test tubes containing 10 mL sterile peptone water and these served as stock solutions to make 10-1-10-4 dilution. The NA, SSA and EMB plates (for bacterial culture) were incubated at 37 °C for 24 hrs. while the PDA plates (for fungal culture) were incubated at 25 °C for 72 hr. Thereafter, the number of colonies found on each media after incubation were counted.

Sensory evaluation of biscuits

Biscuits formulated with different levels of DFs were coded with different numbers and submitted to sensory evaluation by twenty-member semi trained panels at food science and human nutrition department, Qassim University. The panelists were asked to rate each sensory attribute using the control biscuit as the basic for evaluation. The used questionnaire was prepared according to the study of Ivanišová et al. (2020) after being modified. Biscuits were evaluated for appearance, surface color, interior color, texture, aroma, taste and overall acceptability on a 9-point hedonic scale as it was ranging from 9 (like extremely) to 1 (dislike extremely) for each characteristic (Hooda & Jood, 2005).

Statistical analysis

Statistical analysis was conducted with SAS program (SAS Institute Inc., 1996). Data were represented as means ± standard errors. Statistical analysis was performed using one-way analysis of variance (ANOVA) followed by Duncan's Multiple Range Test with $P \leq 0.05$ being considered statistically significant (Snedecor & Cochran, 1980).

3 Results and discussions

3.1 Proximate composition and minerals content of crude DFs powder

Chemical composition of date fibers powder was measured (moisture, ash, crude protein, lipids, crude fiber) in addition to nitrogen free extract and minerals. Collected data are presented in Table 1.

It can be seen that the chemical composition of DFs was very high content of crude fiber level; reached about 88%. Indeed regulating date fruits intake such as fruit and vegetable have low levels of calories and fats while have high levels in fibers and vitamins (Bensaci et al., 2021). Form such point of view high levels of dietary fibers and antioxidant activity are increased

Table 1. Chemical composition and minerals contents of crude DFs powder.

	Chemical composition (%)					
	Moisture	Ash	Crude fat	Crude protein	Crude fiber	Nitrogen free extract (NFE)
DFs	4.48 ± 0.03	2.34 ± 0.05	0.70 ± 0.42	3.31 ± 0.52	87.26 ± 0.56	1.91 ± 0.46
	Mean of minerals (mg / 100 g powder)					
	K	Ca	Na	Mg	Fe	Zn
DFs	30.39 ± 1.8	10.89 ± 0.28	8.84 ± 0.57	124.40 ± 6.36	10.83 ± 0.82	0.34 ± 0.02

Date presented as Mean ± SE, n = 3.

Table 2. Water activity ($a_{w)}$ & Physical properties of biscuits with different DFs levels.

Treatments	Water activity		Physical properties		
	a_w	Temp. °C	Diameter W (mm)	Thickness T (mm)	Spread ratio W/T
Control biscuits	0.169 ± 0.003	21.95	51.67 ± 0.33^a	7.89 ± 0.06^a	6.55 ± 0.09^b
Biscuits with DFs 5%	0.316 ± 0.007^c	21.80	51.33 ± 0.34^a	7.72 ± 0.53^a	6.65 ± 0.02^b
Biscuits with DFs 10%	0.354 ± 0.001^b	21.93	50.67 ± 0.67^a	7.67 ± 0.09^a	6.61 ± 0.05^b
Biscuits with DFs 15%	0.367 ± 0.006^{ab}	22.23	50.00 ± 0.58^a	7.11 ± 0.06^b	7.03 ± 0.04^a

Data presented as Mean ± SE, n = 3. Letters in the same column referred to statistical differences among samples *($P \leq 0.05$)*.

worldwide among all age groups as functional foods with health oriented bakery products. Indeed, such components contributed to improve immune system functions, digestive, lowering cholesterol levels coroner health diseases and type-2 diabete so using dates fruit fibers (DFs) as many plant dietary fibers may have many beneficial properties (Bölek, 2022). Therefore, consuming such DFs could be used as protective factor against degenerative disorders especially obesity with its consequences (diabetes mellitus, cardiovascular diseases, constipation, and colon cancer). Meanwhile, the DFs had 4.48% moisture, 3.31% crude protein, 2.34% ash, NFE 1.91% and 0.70% crude fat. The main values of minerals contents as mg/100 g DFs powder again were illustrated in Table 1. It can be noticed that the highest levels of measured minerals was seen with magnesium (Mg) that was the first abundant mineral (124.40 mg/100 g DFs powder) followed by potassium (31 mg/100 g DFs powder) while, calcium (Ca) and iron (Fe) where similarly presented at levels of 10.89 and 10.83 mg/100g DFs powder, respectively. Finally, zinc (Zn) and sodium (Na) showed the lowest minerals content (0.34 and 8.84 mg/100 g DFs powder, respectively). Previous data is about to agree within similar results presented herein indeed by such beneficial nutrients as they all recommended high levels of different minerals. E.g. magnesium, potassium, iron, and calcium were at high levels with research published by Megdoud et al. (2022). Additionally, they have been shown date fruits have low levels of sodium that in turn can help to reduce the hypertension effects and that low sodium to high potassium ration shown again preferable choice for hypertension patients thus such measured minerals in total are important for human health.

3.2 Water activity and physical properties of crude DFs and biscuit formulated with different DFs levels

Table 2 illustrates the water activity ($a_{w)}$ of prepared DFs powders and biscuit samples formulated with different DFs supplemented powders in three different levels (5, 10 and 15%). All measured samples were at temperature of about 22 ± 2 °C. The measured a_w used as an indicator of water availability as it is an important parameter for measuring the suitability of foods for storage. Such activity has been linked to water through sorption isotherms that well known in food sciences and technology. It is being used as a tool for calculating moisture changes affecting the design and optimization of drying equipment in addition to the predictions of quality and stability resulting in their appropriate shelf-life during the storage period (Megdoud et al., 2022). Prepared DFs powder alone show water activity by 0.169 a_w while the control biscuit sample with no additions revealed 0.316 a_w water activity. The latest was in significant differences between all samples *($P \leq 0.05$)*. Additionally prepared biscuits supplemented with all the DFs powders especially at 5% shows the lowest water activity level; 0.354 a_w and such samples were again significantly differences *($P \leq 0.05$)* from the only biscuit samples with DFs supplementation at 15%. Such evaluated activity was increased with increasing the supplemented DFs powder additions to prepared biscuits. It reached 0.373 a_w as the highest water activity levels by 15% supplemented DFs (Table 2). So the best activity was at 5% supplemented DFs powder; was the closest to the control biscuit samples (0.316 a_w). So, the biscuit samples shown the best a_w activities are within the samples supplemented by 5% DFs powders that in turn will result in predictions of quality and stability giving long shelf-life and storage period comparing to all the other biscuit samples.

Regarding the physical properties (diameters, thickness and spread ratio) of biscuit samples formulated with different DFs levels (5, 10 and 15%) were presented in Table 2.

Generally, no significant differences ($P > 0.05$) in thickness were observed among biscuit samples formulated with different DFs levels up to 10%. However, formulation of biscuit with 15% DFs significantly *($P \leq 0.05$)* decreased the thickness compared with the control samples and the other formulas. On the other hand, the highest *(P ≤ 0.05)* measured spread ratio was detected in biscuits formulated with 15% DFs (7.03 ± 0.04 W/T) comparing to the control samples (6.55 W/T). But, no significant differences (*P > 0.05)* were noticed in speared ratio among the control samples and the samples formulated with up to 10% DFs. To sum up, measured physical properties (diameter, thickness & spread ration) of biscuits were very close to the control samples especially at the DFs supplementations of 5% and 10% levels; was the best at the diameter level between all the formulated biscuit samples (about 51 *vs.* 51.33 and 50.67 mm respectively).

3.3 Crust color parameters of crude DFs and biscuits samples

Measured crust color parameters, Lightness (L*), Redness (a*) and Yellowness (b*) parameters surface of DFs, control biscuit and biscuits formulated with different levels of DFs (5, 10 and 15%) have been illustrated in Table 3.

It can be understood that the lightness levels as a part of the measured color parameters were about similar levels between DFs powder and the control biscuit samples; 66.43 and 68.00 respectively. Generally, increasing the DFs supplemented levels in biscuit increased significantly (*P ≤ 0.05)* the darkness of the samples. The biscuit formulated with 15% DFs showed the darkness darkening biscuit color (48.34) while the control sample showed the lightness (*P ≤ 0.05)* biscuit sample (68.00 ± 0.53) followed by that formulated with 5% with a value of 66.43 ± 2.45 (Table 4). Regarding the redness, it could be concluded that the biscuit formulated with 5% DFs had the lowest (*P ≤ 0.05)* redness value 2.13 ± 0.14. It increased to 8.24 ± 0.13when the formulation level reached to 15%. Such obtained color might be resulted from Maillard/browning reactions due to enzymatic and non-enzymatic activities as it has been explained previously and known as a phenomenon that being one of the main causes of alteration of date fruit color (Megdoud et al., 2022). Maillard reactions are depending on the water activities of the current samples (a_w has explained early), indeed presented highly with high a_w levels. Thus, increasing a_w activity within the prepared biscuit samples supplemented with high DFs levels shown the darkness presented color as the Maillard reaction also increased and again should be increased by increasing the DFs supplemented levels as it increases consequently by their sugars levels; the substrates for non-enzymatic reactions. Previous similar studies that increased different dietary fibers in various biscuit products such as mango peel, apple pomace and orange psyllium have indeed increased consequently colour, flavour and taste of such new developed biscuits products (Weng et al., 2021). Finally, the measured yellowness was the clear achieved levels at the original DFs powder samples; reached 25.78 ± 0.42 while it was 20.95 ± 0.08 at the 5% DFs supplementations that was the nearest value (25.00 ± 0.19) among all formulated biscuit samples to the control ones with significant differences (*P ≤ 0.05)*. However, yellowness color property was very low (*P ≤ 0.05)* at 15% (18.43 ± 0.04; Table 4) so in conclusion the best effective supplemented percentage of the measured crust color was seen with 5% addition between all the three DFs supplementations. Previous such effects of added DFs on prepared new supplemented DFs biscuit samples; a_w, physical properties and color parameters are clear and well presented with the following photo of the prepared biscuit samples in Figure 1.

Table 3. Crust color parameters of DFs and biscuit formulated with different DFs levels.

Treatments	Color parameters		
	Lightness (L*)	Redness (a*)	Yellowness (b*)
DFs sample	66.43 ± 2.45	3.73 ± 0.38	25.78 ± 0.42
Control biscuits	68.00 ± 0.53^{a}	2.13 ± 0.14^{d}	25.00 ± 0.19^{a}
Biscuits + DFs 5%	59.34 ± 0.59^{b}	5.07 ± 0.13^{c}	20.95 ± 0.08^{b}
Biscuits + DFs 10%	54.93 ± 0.32^{c}	6.37 ± 0.11^{b}	19.37 ± 0.05^{c}
Biscuits + DFs 15%	48.34 ± 0.26^{d}	8.24 ± 0.13^{a}	18.43 ± 0.04^{d}

Data presented as Mean ± SE, n = 3. Letters in the same column referred to statistical differences among groups (*P ≤ 0.05)*.

3.4 Total phenolic and DPPH scavenging activity additionally to the texture of biscuits samples formulated with different DFs levels

Radical scavenging activity (DPPH) is well known as a stable radical that is used to estimate samples' ability of providing protons; DPPH radical was scavenged when the solution purple color turned into light yellow. It has been evaluated as well as total phenolic in all formulated biscuits with different DFs levels comparing to the control biscuit samples (Table 4).

It can be noticed that, total phenolic and scavenging activity were 7.82 mg GAE/g and 9.59%, respectively of biscuits formulated with 5% DFs. Both results were the lowest (*P ≤ 0.05)* among all the supplemented DFs samples (10 and 15%) which were the nearest to the both measured parameters of control sample (2.47 mg GAE/g and 4.31%, respectively). However, both 10 and 15% DFs additions showed high levels (*P ≤ 0.05)* of the phenolic and DPPH scavenging activity in dose dependent

Table 4. Total phenolic & DPPH scavenging activity additionally to the texture of different biscuit of DFs levels.

Treatments	Total phenolic (mg GAE/g)	DPPH Scavenging activity (%)	Texture	
			Hardness (n)	Factorability (mm)
Control biscuit	2.47 ± 0.04^{d}	4.31 ± 0.12^{d}	14.38 ± 0.74^{c}	2.36 ± 0.19^{b}
Biscuits + DFs 5%	7.82 ± 0.05^{c}	9.59 ± 0.45^{c}	17.28 ± 0.99^{bc}	6.14 ± 0.82^{a}
Biscuits + DFs 10%	9.36 ± 0.32^{b}	26.72 ± 0.46^{b}	19.72 ± 1.60^{ab}	6.01 ± 0.29^{a}
Biscuits + DFs 15%	13.48 ± 0.66^{a}	34.95 ± 0.65^{a}	22.59 ± 0.64^{a}	6.72 ± 0.30^{a}

Date presented as Mean ± SE, n = 3. Letters in the same column referred to statistical differences among groups *(P ≤ 0.05)*.

manner (increasing the supplemented DFs levels have raised the measured activities). Previous study proves positive correlation between the antioxidant capacity and total phenol concentration in dates as presented recently by Belfar et al. (2022). Therefore, having dates means having good phytochemicals that are very useful for the human health; decreasing levels of cholesterol, risk of heart disease and cancer (Abdalla et al., 2012). Indeed, previous data with dietary polyphenols obtained from grape that mainly contain anthocyanins with flavonols in addition to flavanols and phenolic acids shown different biological activities such as antioxidant and antimicrobial with anti-inflammatory properties (Lou et al., 2022). Such data agree of high antioxidant-rich foods intake reducing the incidence of human disease: mainly the polyphenols. Again, the antioxidant activity improved by the increasing the DFs supplementation levels in correlation to the color associated with Maillard reaction (Alptekin & Bolek, 2021). So all the prepared biscuit samples represented good phenolic and DPPH scavenging activity within the current study comparing to the control samples. Additionally Table 4 demonstrates the texture levels of biscuit formulated with and/or without different DFs supplemented levels. Evaluated hardness levels were 17.28 n at 5% DFs additions and that is the lowest (*P ≤ 0.05)* levels among all prepared biscuit samples. Such effected supplementation is the closest effect to the control biscuits samples (14.38 n). However, the 15% addition showed the highest (*P ≤ 0.05)* hardness compared to other prepared biscuit samples. Factorability levels were at the lowest with 10% DFs supplementations (6.01 mm) while 5% edition show good relative measured factorability level comparing to the highest supplemented DFs levels at 15% (6.14 and 6.72 mm) and that in fact correlated well again with all the measured parameters within all the study in comparison to the results obtained from control biscuit samples. So it could be concluded that the new supplemented products; biscuits with DFs could be the best after 5% and 10% DFs additions. Indeed, pervious enriched biscuits with different dietary powders such as dried pomegranate peel powder and olive stone powder changed the hardness levels and factorability due to the water content decreased (Bölek, 2022)

3.5 Microbiological analysis of prepared DFs powder and biscuits samples

Microbiological results within the date fruit, paste and DFs powder and prepared supplemented DFs biscuits at different levels (5, 10 and 15%) were presented with Table 5.

The collected data of *E.coli* and *salmonella* haven't been detected at any levels of all the measured samples so there is no single growth for both *Salmonella and/or E.coli* in any produced sample with all the experimental. However, yeast and molds we are presented a different amount between all the measured samples. Also, the original date fruits had the lowest level of total bacterial numbers (Total Viable count; TVC) between all the samples (4.6 log cfu/g). However, it was very close to the levels with prepared DFs powder samples and that was followed by numbers with the formulated control biscuits samples (4.7 and 4.8 log cfu/g respectively). Additionally, formulated biscuit samples supplemented by DFs at 5 and 15% shown the same TVC numbers and (4.9 and 4.9 log cfu/g respectively). However, Samples supplemented by 10% DFs was the highest TVC levels (5.3 log cfu/g) after the dough samples (5.9 log cfu/g). Regarding the yeasts and molds numbers that were countered within all the samples, Table 5 again show that the fruit dates were the lowest numbers (3.8 log cfu/g) and that was nearly the counted numbers

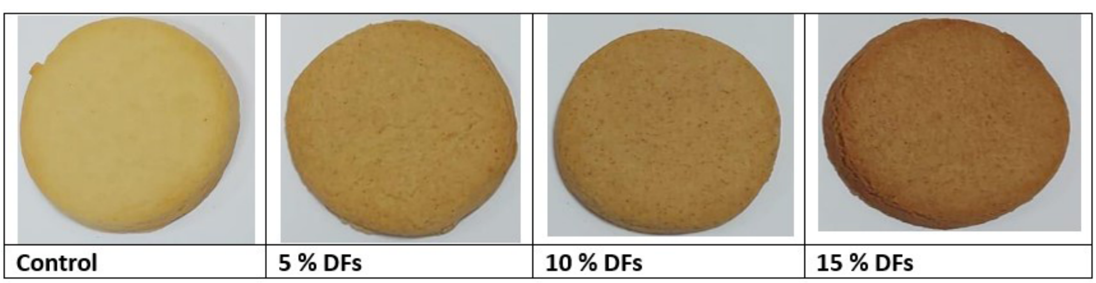

Figure 1. Crust color parameters of biscuit samples formulated with different DFs levels.

Table 5. Microbiological analysis of original prepared DFs powder and different formulated biscuits with DFs additions (log cfu/g).

	Microbiological levels counted as log cfu/g			
Samples	Total Viable count (TVC)	Yeast & Molds	*E. coli*	*Salmonella*
Date fruit	4.6 ± 0.06^{c}	3.8 ± 0.58^{b}	Nil	Nil
Date paste	5.9 ± 0.05^{a}	6.0 ± 0.06^{a}	Nil	Nil
Date powder (DFs)	4.7 ± 0.04^{c}	5.8 ± 0.09^{a}	Nil	Nil
Control biscuit	4.8 ± 0.13^{c}	3.7 ± 0.07^{c}	Nil	Nil
Biscuit + DFs 5%	4.9 ± 0.04^{c}	3.9 ± 0.08^{b}	Nil	Nil
Biscuit + DFs 10%	5.3 ± 0.02^{b}	4.1 ± 0.06^{b}	Nil	Nil
Biscuit + DFs 15%	4.9 ± 0.08^{c}	3.9 ± 0.04^{b}	Nil	Nil

Data presented as Mean ± SE, n = 3. Letters in the same column referred to statistical differences among groups *(P ≤ 0.05)*.

Table 6. sensory evaluations of biscuits formulated with different DFs levels.

Samples	Appearance	Surface color	Interior color	Texture	Aroma	Taste	Overall acceptability
Control biscuit	8.4 ± 0.16[ab]	8.4 ± 0.17[ab]	8.4 ± 0.22[b]	8.2 ± 0.20[b]	8.5 ± 0.17[a]	8.3 ± 0.21[bc]	8.4 ± 0.16[b]
Biscuit +DFs 5%	8.0 ± 0.15[b]	8.0 ± 0.16[b]	7.9 ± 0.11[c]	8.0 ± 0.15[b]	8.0 ± 0.14[b]	8.7 ± 0.23[ab]	7.9 ± 0.10[c]
Biscuit +DFs 10%	7.8 ± 0.29[b]	8.8 ± 0.13[a]	8.9 ± 0.10[a]	8.7 ± 0.15[a]	8.7 ± 0.15[a]	8.2 ± 0.13[c]	8.8 ± 0.14[a]
Biscuit +DFs 15%	8.8 ± 0.20[a]	8.8 ± 0.23[a]	7.0 ± 015[d]	7.0 ± 0.27[c]	7.0 ± 0.38[c]	9.0 ± 0.24[a]	7.0 ± 0.16[d]

Data presented as Mean ±S E, n = 10. Letters in the same column referred to statistical differences among groups *($P \leq 0.05$)*.

with control biscuit samples (3.7 log cfu/g). Again biscuit samples with 5 and 15% DFs additions were about the same exact levels (3.9 and 3.9 log cfu/g respectively). However, powder and dough samples represented the big yeast and molds numbers (5.8 and 6.0 log cfu/g respectively). To conclude up, the species with the public health concern *E. coli* and *Salmonella* were totally unpresented between all samples and 5% DFs supplementations to the formulated new biscuits show the best product sample with low contamination levels between all samples.

3.6 Sensory evaluations of biscuits formulated with different DFs levels

Sensory analysis of new formulated biscuits is important as any food sensory characteristic can affect significantly the choice of consumers in order to be recommended for the marketplace due to its nutritional values and its overall acceptability (Bolek & Ozdemir, 2017; Bölek, 2022). So the acceptable DFs added amounts should be identified; may alter the consumers' attitude to products with the best sensory evaluation. The data presented in Table 6 shown the sensory measurements of biscuits formulated with different DFs levels (5, 10 and 15%). All the sensory parameters (appearance, surface, and interior colors, texture, aroma, and taste with their overall acceptability) had been evaluated. The collected data revealed that, all the measured parameter were the best with the biscuit samples supplemented by 10% DFs. All of them were very close to the control formulated samples as appearance, surface and interior colors in additions to their texture, aroma and taste were at levels of 8.0, 8.7, 8.9, 8.0, 8.5, 8.7 and 8.6 *vs.* the controls at 8.4, 8.7, 8.9, 8.2, 8.5, 8.9 and 8.7 respectively. However, all the measured parameters decreased within increasing the DFs supplemented levels.

Added DFs at 10% was at low levels comparing to the 5% and again 15% addition was the lowest within all the measurements (7.5, 7.5, 7.0, 7.1, 7.0, 7.6 and 7.1 for appearance, surface colors, interior colors, texture, aroma and taste, respectively. The low sensory scores of textures between prepared biscuits could be attributed to the gluten dilution resulted from wheat flour replacement by DFs and also that can result in low aroma and over all acceptability as well as shown with new different biscuits formulated with different fiber sources additions (Yağcı, 2019). All the measured sensory characteristics appearance, surface and interior color in addition to the texture, aroma, taste, and overall acceptability of biscuits showed no strong differences especially samples supplemented 5% and 10% DFs. Only the aftertaste characteristics mainly for interior color, texture, taste and overall acceptability varied significantly for the biscuits supplemented 15% DFs; such samples took higher scores than control biscuits by the panelist ($P \leq 0.05$). Generally and to conclude up, all prepared biscuit samples took high score by the panelists with a higher overall acceptability ($P \leq 0.05$) for samples formulated with 10% DFs. Thus, the best scored biscuits by the panelists sensory supplemented with DFs powder are important advantage for biscuit producers and consumers.

4 Conclusion

To conclude up, the current study revealed that DFs powder added to different new formulated biscuits enhanced the nutritional value especially by the crude fiber content. Adding 5, 10 and 15% DFs helped the new biscuits physical characteristics mainly with 5% and 10% DFs supplementations. Also, date fibers addition improved the sensory characteristics of the new products with the best overall acceptability in biscuits with 10% DFs content. Therefore, powdered date fibers application in biscuits production can be recommended for targeting of nutritional and sensorial properties of this bakery product. Such results recommend that the powdered date fiber has significant health benefits to the human health states and could serve as a source of antioxidants with potential applications so new applicable model within health issue is recommended.

Ethical approval

The authors declare that the current study sensory evaluations were carried out by twenty-member semi trained panels at food science and human nutrition department, Qassim University. Again, all participants gave informed consent via the statement "I am aware that my responses are confidential, and I agree to participate in this study with felling free to withdraw at any time without giving a reason. The study been conducted at Department of Food Science and Human Nutrition, College of Agriculture and Veterinary Medicine, Qassim University, Buraidah, Saudi Arabia after being approved from the academic professional committee under the safety and well-being conditions. Also all data collection was performed in accordance with relevant guidelines and regulations after being reviewed and approved from the committee. We confirm that the appropriate protocols for protecting all participants' rights and privacy were utilized during the execution of the research and full disclosure of study requirements. No risks were expected and all the products tested were safe for consumption, then we explained there is no release of participant data without their knowledge and permission.

Conflicts of interest

The authors declare that there is no conflict of interests to influence the work reported in this paper.

Data available statement

All relevant used data to support the finding of the current research are included within the article. Also, the raw data are available at the Department of Food Science and Human Nutrition, College of Agriculture and Veterinary Medicine (project funded by the deanship of Scientific Research -grant numbers; 10272-Cavm-2020-1-3-1), Qassim University, Buraidah, Saudi Arabia.

Funding

The authors confirm that this work was funded by Qassim University, Deanship of Scientific Research, project (10272-CAVM-2020-1-3-1), the academic year 1441 AH/2020 AD].

Acknowledgements

The authors gratefully acknowledge Qassim University, represented by the Deanship of Scientific Research, for the financial support for this research under the number (10272-Cavm-2020-1-3-1) during the academic year 1441AH/2020AD". The financial support also including for article processing charges.

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