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Physiochemical, Nutritional and Functional Properties of Doum (*Hyphene thebaica*) Powder and Its Application in Some Processed Food Products

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Abstract

The nutritive value of the products mentioned above is not high. Therefore, there is a need to increase it by adding something like Doum fruit powder. This study was carried out to investigate the possibility of utilization Doum fruit powder through determination of proximate analysis as well as the functional characteristics so that to optimize the ratio of addition and then to assess it as a supplementary in some food products including cake and Tahina as source nutrients and mineral as well as increase the acceptability for the consumer. The standard methods were used to determine the proximate analysis, minerals, functional properties and sensory evaluation. The proximate composition of Doum powder was determined. Protein, fat, fiber and total carbohydrates were 6.40, 0.91, 12.30, 6.45 and 62.45%, respectively. Among the functional properties, water, and oil absorption capacities and bulk density were 3.20g/g, 2.31g oil/g, 0.95g/mL, while the least gelation capacity was 26.0% at the highest concentration (10%). The cake was made of different concentrations of Doum powder 5, 10 and 15%, while Tahina was made of 15, 25 and 35%. The nutritional value of the processed cake and Tahina (crude protein, crude oil, fiber and ash) was found to be increased with the increase of Doum flower addition except for the total carbohydrates compared with the control sample (without addition of Doum powder). The same trend was investigated in minerals content (Ca, K and Na). The viscosity and density of processed Tahina were found at the highest addition (35%) were 45.50 cp and 1.089g/mL, respectively. The sensory evaluation results illustrated the presence of significant differences ($p<0.005$) among the samples which increased in the acceptability by increasing the Doum powder substitution comparing with the control sample. Tahina and cake samples with highest Doum powder addition had the highest overall consumer acceptability score. The results have demonstrated that the Doum powder possesses good nutritional and functional properties and can be used for various important applications in food industry. It can be recommended that further study on the purification and identification of the bioactive compounds that can be found in Doum flour and assess it as an in vivo antioxidant activity by using the animals test.

Keywords: Physiochemical properties; Nutritional value; Functional characteristics; Doum powder; Food products

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Introduction

Doum palm (*Hyphaene thebaica*) is a desert palm native to Egypt, sub-Saharan Africa and West India. It is known in Sudan as the Doum or gingerbread palm which grows to a height of 6 or 9 and usually has forked stems with fan shaped leaves, 65 to 75 cm long. It is listed as one of the useful plants of the world [1]. The trunk of the palm is used for construction, as well as for manufacture of various domestic utensils and the leaves used to make mats, bind parcels and writing paper. The oblong, yellow-orange apple sized fruit has a red outer skin, a thick, spongy and rather sweet, fibrous fruit pulp that tastes like gingerbread and a large kernel. The covering of the fruit is edible and can either be pounded to form a powder or cut off in slices; the powder is often dried then added to food as a flavoring agent [2]. The fruit pulp is used in cooking, in various ways, and the different varieties differ in their edibility. While the unripe kernel is edible, the ripe kernel is hard and used only as a vegetable ivory [3]. Previous studies on Doum had focused on the fruit because, besides its nutritional value, the fruit drink brewed from a hot water infusion of the dried fruit pulp is widely consumed as a health tonic and has been valued in the region for its many anecdotal medicinal properties. Research on the fruit pulp of *H. thebaica* showed that it contains nutritional trace minerals, proteins and fatty acids, in particular the nutritionally essential linoleic acid [4]. Also, the aqueous extract of Doum fruits showed an antioxidant and anticancer activities; this is due to the substantial amount of their water-soluble phenolic contents [5]. The Doum palm is among the more important plant families that supplies human with dietary fibers, carbohydrates and anti-hypertension substances. The phytochemical, called lignans, having apparent anti-carcinogenic action as mentioned by Carter [6]. The aqueous extract of the Doum fruits revealed an antifungal activity against a wide range of fungal isolates. Also, prominent antibacterial activities of Doum fruits was reported against gram positive and gram-negative bacteria [7]. Essential minerals are sometimes divided up into major minerals (macro-minerals) and trace minerals (micro-minerals). These two groups of minerals are equally important, but trace minerals are needed in smaller amounts than major minerals. The amounts needed in the body are not an indication of their importance. The biochemical functions of trace elements appear to be as components of prosthetic groups or as cofactors for enzymes. Deficiency syndromes for several of the essential trace elements was not recognized until recently because of their exceedingly small requirements and because of the ubiquitous nature of these elements in foodstuffs [8]. Vitamins are organic substances present in minute amounts in foodstuffs and necessary for metabolism. They are grouped together not because they are chemically related or have similar physiological functions, but because, as their name implies, they are vital factors in the diet and because they were all discovered in connection with the diseases resulting from their deficiency [9]. The simplest carbohydrates are the monosaccharide, or simple sugars. These sugars can pass through the wall of the alimentary tract without being changed by the digestive enzymes [9]. The color of dried products is an important quality factor which reflects the sensory attractiveness and the quality of the powder. Though a functional food could provide several health benefits to consumers, without visual attraction to the consumers it cannot be marketable Bakery products constitute one of the most consumed foods in the world. Among them, cakes are popular and are associated in the consumer's mind with a delicious sponge product with desired organoleptic characteristics. The result indicated that the Doum could be an important dietary source of phenolic compounds with high antioxidant and anticancer activities. Bakery products constitute one of the most consumed foods in the world. Among them, cakes are popular and are associated in the consumer's mind with a delicious sponge product with desired organoleptic characteristics [8]. Doum is an important fruit contained essential nutrients and functional properties which will be exploited for various useful applications. The flesh of the Doum fruit is a good source of glucose, fructose and is a rich source of fibers and antioxidants, also other valuable substances such as carbohydrates and minerals especially potassium (K for people suffering from blood pressure problems), this investigation was carried out to study the possibility of utilization Doum fruit powder in cake and Tahina production. The objective of this study was to investigate physiochemical, nutritional and functional properties of Doum powder and it is assessment in some processed food products.

Materials and Methods

Materials

Standard laboratory materials including sample preparation ingredients, reagents, apparatus, equipment and tools as specified in the standard methods was used in carrying out the analyzed of samples. These materials are specified within the description of methods respectively Doum fruit, wheat flour, Sugar, corn oil, eggs, skim milk and vanilla were collected from a local market in Wad Medani, Gezira State, Sudan and then it will be transported to the laboratory of food analysis, Department of Food Engineering and Technology, Faculty of Engineering and Technology, University of Gezira, Sudan.

Methods

Preparation of doum powder: Dry Doum fruit flakes was ground electrically in laboratory mill.

Cake preparation: A cake was prepared from substitution blends containing 0%, 5%, 10% and 15% of Doum powder (DP). Table 1, shows the formula prepared with DP, included 100g wheat flour, ingredients, corn oil and half milk will be mixed at low speed for 30sec with a wire whip in a 4 - 7 l bowl of an electric mixer. After the bowl was scraped, mixing was continued half remain milk was added, and the batter was mixed 30sec on low speed. The remaining milk was added, the butter was mixed for 20sec on low speed, the bowl will be scraped, and mixing will be continued for 30 seconds on low speed.

The cake batter was immediately deposited into round cake pans. For each cake was poured into a cake pan and baked at 180˚C for 25min in preheated electric oven. The cakes were allowed to cool for 1h and were then removed from the pans. The cooled cakes were sensory evaluate and packed in a polyethylene bags at room temperature before analysis [8].

Tahina preparation: Tahina was prepared by milling of dehulled roasted white sesame seeds as described by Abd-elrashid [10]. The Doum powder was use to replace sesame seeds by different level (0, 15, 25, 35%) and homogenized for 5min. Tahina samples was package in glasses, and stored at room temperature for further analysis and sensory evolution.

Proximate analysis

Moisture content: The moisture content of the different samples was determined according to AOAC [11]. Six porcelain dishes were taken, washed and dried for one hour at 100^{o}C by the oven, then cooled down to room temperature in a desiccator for 30min. and weighed; 5g of cakes and Tahina samples were taken and placed in porcelain dishes. The dish with sample was then dried for two hours at 105^{o}C and cooled down in desiccators and weighed. The moisture content was calculated according to following formula.

$$\text{Moisture\%} = \frac{W_1 - W_2}{W_1} \times 100$$

where: W_1 = weight of the sample before drying, W_2 = weight of the sample after drying.

Protein content: Protein content was achieved follows: Digestion 1gm of each sample wheat flour and sorghum flour was transferred to Kjeldal flask (500mL) with 20ml concentrated sulphuric acid, 25ml H_2SO_4 and 1gm copper sulphate. The mixture was heated gently, so the initial has ceased to a loose pear-shaped stopper in the top of the flask and then heated more strongly, so that the liquid boil at moderate, the flask was shake from time to time and the heating was continued for 3 hours. In 350^{o}C until the liquid had become clear. Distillation twenty ml of the digest were transferred to the distillation flask, followed by 50mL of 40% sodium hydroxide. So, the dilute digest was mixed up. The distillation apparatus was connected with the delivery tube dipping in 25ml of 2% boric acids placed into the receiving flask. Ammonia liberated was distilled into the boric acid solution, after reaching 75mL, it was opened and the condenser washed down into delivery tube and into the received. Titration the distillate was titrated with 0.02N hydrochloric acid. The blank should not exceed 0.5mL. The nitrogen in the sample was calculated (1mL 0.02N hydrochloric acid = 1.4008N). The percentage of crude protein content was calculated using the following formula:

$$\text{Nitrogen (\%)} = \frac{\text{titer } 0.02 \times 14.008 \times \text{dilution factor}}{1000 \times \text{sample weight} \times 100\text{-sample moisture}} \times 100$$

Titer = sample titer – blank titer, protein% = Nitrogen% × 6.25.

Fiber content: Transfer the remaining sample from the fat extract to a 600mL cassette and add 200mL H_2SO_4 1.25%, then put in the extraction device, leave to boil for half an hour while stirring during boiling, then use the Buechner funnel and wash the leach ate, then transfer to cup and add 200mL NaOH 1.25% The contents were prepared for half an hour, then the contents were filtered using Buchner funnel and the leach ate was washed with warm water. The spoon was then used to transfer the sample to the crucible and then dried and took the dish and its contents into the oven for 110°C hours. And then to a temperature oven 550°C for 5 hours then the dish was moved and weighed again [12].

$$\text{Total fiber \%} = \frac{W_2}{W_1} \times 100$$

W_2= weight loss, W_1= the weight of the sample

Ash content: The ash content was determined according to the AOAC method, [13] using five grams of defatted sample was ignited at 500°C in a muffle furnace for 2 hours until a black color appeared. After cooling in desiccators, they were weighed. The difference in weight before and after burning process give the percent ash content obtained using standard formula:

$$\text{Total ash (\%)} = \frac{\text{Ash weight}}{\text{Sample weight}} \times 100$$

Determination of minerals

Determination of Sodium (Na^+), calcium (Ca^+) and potassium(K^+) concentrations were accomplished by a flame photometer (model corning, 400) according to AOAC Official Method, [14], as follows:

Sodium stock solution: About 2.54g of NaCl were dissolved in distilled water and diluted to 1 liter "1000ppm Na/mL, and then 10ml of solution were taken and diluted by distilled water to give 100ppm Na/mL.

Potassium stock solution: About 1.91g of KCl were dissolved in distilled water and diluted to 1 liter "1000ppm K/mL, and then 10ml of solution were taken and diluted by distilled water to give 100ppm K/mL.

Calcium stock solution: About 1.91g of $CaCl_2$ were dissolved in distilled water and diluted to 1 liter "1000ppm Ca/mL, and then 10ml of solution were taken and diluted by distilled water to give 100ppm Ca/mL.

Procedure

Different concentrations (20, 40, 60, 80 and 100 ppm) were prepared from stock solution of Na, Ca and K. Then by using the flame photometer the reading taken and a graph was made. The sample was prepared by weighing 5gm of ash then the sample dissolved in distilled water and 0.1N HCl was added to make 1000mL. About 10mL were then taken and diluted to 100mL, and then 5mL were taken and diluted to 100mL to give 100ppm.

Fat content determination

The fat content was determined by Gerber method according to AOAC [12] as follows: 10g of cheese sample was taken, 10mL sulfuric acid and 1mL of amyl alcohol was added to it and close with rubber cork, and centrifuged at 1100 revaluations per minute (rpm) for 15 minutes and the tubes were then transferred to a bath at 65°C for 5 minutes. The fat percent was then read out directly from the fat column.

Total carbohydrate content

The total carbohydrate content was determined according to AOAC [11]. The total carbohydrates were calculated by difference according to the following equation: Total carbohydrates = 100 – (% Moisture + % crude fat + % crude protein +% ash + % crude fiber) on dry weight basis.

Functional properties

The water absorption capacity (WAC) and fat absorption capacity (FAC) of were determined according to the method reported by Sathe et al. [15]. WAC was determined by dissolving 0.5g of the samples with 10mL of distilled water, the samples were then vortexed for 30s. The dispersions were allowed to stand at room temperature (22°C) for 30min then centrifuged at 1000rpm for 20min. The supernatant was filtered and the volume retrieved was accurately measured. The difference between initial volumes of distilled water added to the protein samples and the volume retrieved was recorded as the volume (mL) of water absorbed per g of protein sample. FAC was determined by using 2g of protein stirred with 20mL of sunflower oil for 30min and centrifuged at 13,600g for 15min. The volume of supernatant was measured. The FAC was expressed as the volume (mL) of oil retained by 100g of proteins [16]. The least gelation capacity was determined by using the method of Ogunsua and Oke [17]; briefly, Triplicate suspensions of 6, 8 and 10% Doum powder (dry w/v, at 1% increments) were prepared in 10mL of distilled water and mixed thoroughly without pH adjustment. The slurries were heated in 125×20 mm screw capped test tubes in a water bath at 95°C with intermittent stirring. After 1h of heating, tubes were immediately cooled in tap water for 30s and then in ice water for 5min to accelerate gel formation. All tubes were then held at 4°C for 3h. Least gelation capacity (percent) was determined as the concentration above which the sample remained in the bottom of the inverted tube. Bulk density of Doum powder was determined according to Aboshora et al. [18]. A calibrated plastic centrifuge tubes was weighed, protein samples were filled to 25mL and the tubes were tapped to eliminate the spaces between the particles, the final volume was taken as the volume of the sample. The tube was weighed again. The bulk density of the Doum powder was calculated from the difference in weight and expressed as (g/mL).

Physicochemical properties

The viscosity, density was determined by using AACC template method 10-91 [19].

Sensory evaluation

Cakes and Tahina samples was subjected to sensory evaluation using 10 panelists, the panelists were asked to assess each sample for color, appearance, flavor, texture and overall acceptability a 9-point hedonic scale with 1 as the extremely bad and 9 the excellent. All

Table 1: Cakes formula prepared with Doum fruit powder at different levels of substitutions.

Ingredients	Level (g)
Wheat flour	100
Sugar	75
Doum powder (DP)	5 –15%
Corn oil	20
Whole eggs	60
Half milk	30
Baking powder	3
Vanilla	0.3
Salt	0.2

*30g solved in 45mL water.

Table 2: Proximate composition of Doum fruit powder.

Constituent	%
Moisture	11.49±0.12
Protein	6.40±0.01
Crude fat	0.91±0.13
Crude fiber	12.30±0.16
Ash	6.45±0.01
Total carbohydrates	62.45±0.19

Table 3: Functional properties of Doum fruit powder.

Parameter	Value
Water absorption capacity	3.20±0.09g/g
oil absorption capacity	2.31±0.09 g oil/g
Bulk density	0.95±0.09 g/mL
Least gelation concentration (LGC)	
Concentration (%)	**LGC (%)**
6	10.60±0.09
8	17.50±0.71
10	26.00±0.03

analysis took place in a room free from disturbing noises, and in which fresh air were circulation conditions were equalized for all the tests. The order of presentation for samples was randomized and the samples were given codes before being tested.

Statistical analysis

Statistical analysis was done using Statistical Package for Social Studies Software SPSS, 2016, Complete Randomized Design was used to estimate chemical, physiochemical proprieties and sensory characteristics of cakes and Tahina product.

Results and Discussion

Proximate composition of Doum fruit powder

Results for the proximate composition of the Doum fruit are presented in Table 2. Moisture content of Doum fruit flour was 11.49%, the oil content of the fruit was found to be 0.91%. The results on the crude oil content of the flesh sample are in agreement with the result 0.95% of Doum pulp (*Hyphaene thebaica*) reported by Nwosu [20] and 0.8% of African Doum palm fruit mesocarp, (*Hyphaene compressa*) reported by Hoebeke [21]. The protein content of the powder was 6.40%, and was found to be more than the value 0.01% obtained in Doum pulp (*Hyphaene thebaica*) as reported by Nwosu [20]. Other researchers for example Bonde et al. [22] found higher protein content 9.26%, 3.8% for *Hyphaene dichotoma* (young fruit) and *(Hyphaene compressa*), respectively [21]. These differences might be attributed to the species diversity, regional climate differences and postharvest treatments. Ash content of sample was registered as the highest 6.45% that is less than the result 8.1% reported by Nwosu [20]. Fiber content of Doum fruits powder was found to be 12.30% (Table 2), the high fiber content of Doum fruit is suggesting as a potential to be used in the formulation of bakery products to enrich their texture, flavor and nutritional value, beside its great contribution to the health and wellbeing of humankind by preventing the gastrointestinal problems such as constipation and therefore it is regarded as a natural anti colon cancer [21]. The total carbohydrate content in the Doum fruit powder was 73.94% (Table 2), this high carbohydrate content in Doum fruit powder can be very helpful to many low-income communities especially in developing countries as it can be used as a substitute for other high cost carbohydrate sources.

Functional properties of Doum fruits powder

The results of water absorption capacity (WAC), oil absorption capacity (OAC), bulk density (BD) as well as least gelation concentration for the Doum fruit powder sample are presented in Table 3. The results showed that the WAC was 3.20g/g. Water absorption characteristics represent the ability of a product to associate with water under conditions where water is limiting [23]. The high WAC of flesh could be attributed to the presence of higher amount of carbohydrates in this sample. The OAC of Doum fruit powder was found to be 2.31g oil/g. OAC is of great importance from an industrial viewpoint, since it reflects emulsifying capacity. The ability of flours to absorb and retain water and/or oil may help to improve binding of the structure, enhance flavor retention and improve the mouth feel [24]. The critical factor influencing gel formation is the protein concentration. Below a minimum concentration, aggregation and increased viscosity of Doum fruit powder suspensions were observed, but gelation did not occur. At least 10.60% was required for gel formation. A least gelation capacity at difference concentrations (6, 8 and 10%) was found to be 10.60, 17.50 and 26%, respectively. Gelation takes place more readily at higher protein concentration because of the greater intermolecular contacts during heating. High protein solubility is not always necessary for gelation, as observed in this study. Heat treatment increased the least gelation capacity of cowpea flours. At least 15% (dry w/v) heated (S/B) flour was required compared to 10% control flour for gel formation. Because cowpeas contain high protein and starch content, the least gelation capacity of flours is influenced by a physical competition for water between protein gelation and starch gelatinization. The major difference between flours made from control and soaked seeds and flours made from S/B seeds is the functional qualities of protein and starch [25]. The lower amounts of flours from control and soaked seeds required for gel formation are therefore due to synergistic effects of protein and starch. The ability of Doum fruits powder to absorb/retain water and oil and to form a gel is desirable for the preparation of various comminuted cake and bread products [26].

Chemical composition of processed cakes by addition of DP

As shown in Table 4, the proximate composition of processed cake was determined. The value of moisture content in control was 24.0%, which was found to be lower than other (5, 10 and 15%) DP cake with which were 24.4, 25.2 and 26.8%, respectively. Statistically, no significant differences ($p<0.005$) in moisture content of different

Table 4: Chemical composition (%) of processed cake with different additions of DP (on dry weight basis).

Samples	Moisture	Protein	Total fats%	Crude fiber	Ash	CHO
Control	24±0.12^{c}	13.50±0.20^{ab}	17.17±0.10^{c}	0.98 ±0.05^{c}	0.50± 0.03^{c}	43.85±0.18^{a}
5% DP	24.4±0.15^{b}	13.79±0.20^{a}	17.6 6±0.20^{b}	1.49±0.04^{bc}	0.87± 0.05^{b}	41.79±0.44^{ab}
10% DP	25.2±0.09^{ab}	13.81±0.10^{b}	17.95±0.10^{ab}	1.90 ±0.05^{b}	1.26±0.01^{ab}	40.26±0.36^{b}
15% DP	26.8±0.13^{a}	13.82±0.90^{c}	18.01± 0.30^{a}	3.52 ±0.10^{a}	1.97± 0.05^{a}	36.48±0.65^{c}

Mean values ± standard deviation having different superscript letter(s) in each column differs significantly (P<0.005), DP: Doum Powder; CHO: Total Carbohydrates.

Table 5: Minerals content (mg/100g) of processed cake with different additions of DP.

Samples	Na	Ca	K
Control cake	526.24±0.04^{d}	14.85±0.22^{d}	512.09±1.73^{d}
5% DP	562.95±0.22^{c}	15.96 ±0.12^{c}	563.63±011^{c}
10% DP	612.25±0.11^{b}	17.50±0.11^{b}	622.52±0.09^{b}
15% DP	625.50±0.11^{a}	19.56±0.12^{a}	696.44±0.14^{a}

Mean values ± standard deviation having different superscript letter(s) in each column differs significantly (P<0.005), DP: Doum Powder.

concentrations of DP in cake samples. These results were higher than that reported by Aboshora et al. [27]. Protein content of control cakes which was 13.50, which was found to be lower when compared to Seleem [28], and higher than reported by Akubor [29], which were reported as 13.97 and 11.0%, respectively. The protein content of processed cakes with different concentrations of DP (5, 10 and 15%) was 13.79, 13.43, and 13.22%, respectively. The crude fats content of control sample was 17.17%; this value is lower than other cakes samples with (5, 10 and 15%) DP which were found to be 17.66, 17.95 and 18.01%, respectively. This value is higher compared to that results reported by Seleem [28], who found it as 16.41%, and Samiha [30], who reported the value as 14.0%. Fiber content in control sample was 0.98% is lower than other cakes sample by addition DP (1.49, 1.90, and 3.25%, respectively), which was found to be increased with increase of DP. These results are higher than found by Seleem [28], he reported it 0.75%, and also higher than reported by Samiha [30], which was found the fiber content 0.79%. As shown Table 4, also, the ash content of control sample was 0.50%, this value was lower when compared with those found in cakes with 5, 10 and15% DP which were 0.87, 1.26 and 1.97%, respectively. These results were found in agreement with those results found by Seleem [28], which was 0.85%, and in line with that reported by Aboshora et al. [27], they reported was 0.55%, and higher than that reported by Samiha [30]. Total carbohydrates of substituted cake with DP decreased significantly 41.79, 40.26, 36.48% in 5, 10 and 15%, respectively, compared with control cake which was 43.85%. These results are in agreement with those obtained by Samiha [30], who found it 43.27%, statistically, there are significant differences in total carbohydrates content between Doum cake at 10% and 15% levels.

Minerals content of processed cakes by addition of DP

Cakes made with DP were analyzed for, calcium, potassium, sodium, as presented in Table 5. The results showed the minerals content of Doum fruit powder. Sodium (Na) in control sample was 479.80mg/100g, this result increased with increase of DP addition (5, 10 and 15%), which were found to be 555.02, 589.70, 619.50% mg/100g, respectively. In a study was conducted by Seleem [28], reported that the highest content of sodium was recorded in 15%, which was 619.50mg/100g, while the lowest one in control sample 479.80mg/100g. These results are similar to those found by Akubor [29], which was found sodium content as 526.24mg/100g. Statistically, there are significant different (p<0.005) between cakes sample in concentration sodium. The data presented in Table 5, also showed that the concentration of potassium (K) in control sample which was found to be 509.9mg/100g which is considered lower than that found in the samples of cake with addition of DP (5, 10 and 15%) which were 528.20, 596.17, 612.25 mg/100g, respectively. These results are in agreement with those reported by Seleem, (2015) who recorded it as 512.09mg/100g, and lower than reported by Samiha [28], which was found to be 521.00mg/100g. Statistically, there are significant differences were found (p<0.005) between cakes samples in the potassium concentration. The concentration calcium (Ca) content slightly increased compared with control sample which was 13.30mg/100g compared with those cakes made by addition of DP (5, 10, 15%) were 15.09, 16.47, 18.52 mg/100g, respectively.

These results are in agreement with those found by Seleem [28], which was found 14.85mg/100g, and lower than reported by Samiha [30], which was recorded it as 15.2mg/100g. Statistically, there are significant differences were found (p<0.005) between cakes samples in concentration of calcium. The processed cakes have a good amount of K, so they are considered an advantage for people suffering from blood pressure problems.

Chemical composition of processed Tahina by addition of DP

Chemical composition of the Tahina by the DP replacement 15, 25 and 35% is showed in Table 6. The moisture content in the control sample was 44.0%, this value lower than other found in Tahina made with different concentrations of DP (15, 25 and 35 %), which were found to be 45.30, 45.90 and 56.0%, respectively. Statistically, there are significant differences (p<0.005) between the sample made of 25 and 35% DP, while there are no significant differences between that made of 15 and 25% DP. The moisture content of different concentrations of DP in Tahina samples were found similar to those results were found lower than that reported by Khalil [31], which was 55.14%, and that reported by Abd-elrashid [10], which was 50.60%.

Table 6: Chemical composition (%) of Tahina samples by addition of DP.

Samples	Moisture	Protein	Crude fats	Crude fiber	Ash	CHO
Control	44.0±0.07^{cb}	2.39±0.09^{b}	0.19±0.52^{c}	13.89±0.11^{d}	5.87±0.14^{c}	33.66±0.10^{a}
15% DP	45.3±0.12^{b}	2.50±0.12^{a}	1.20±0.12^{ab}	14.75±0.09^{c}	6.01±0.08^{b}	30.24±0.90^{b}
25% DP	45.9±0.10^{b}	2.41±0.15^{ab}	1.98±0.43^{b}	15.08±0.09^{b}	6.81±0.09^{ab}	27.88±80.11^{ab}
35% DP	56.0±0.14^{a}	2.49±0.09^{c}	2.31±0.45^{a}	16.32±0.08^{a}	7.0±0.08^{a}	16.25±0.11^{c}

Mean values ± standard deviation having different superscript letter(s) in each column differs significantly (P<0.005), DP: Doum Powder; CHO: Total Carbohydrates.

Table 7: Minerals content (mg/100g) of Tahina samples made of addition of DP.

Samples	Na	Ca	K
0% DP	182.13±0.04^{b}	345.09±0.33^{a}	167.85±1.73^{a}
15% DP	186.80±0.12^{c}	345.96±0.34^{d}	189.45±0.23^{c}
25% DP	212.6±0.33^{b}	348.0±0.44^{b}	199.09±0.32^{b}
35% DP	229.29±0.23^{a}	350.07±0.34^{c}	216.02±0.45^{b}

Mean values ± standard deviation having different superscript letter(s) in each column differs significantly (P<0.005).

Table 8: Viscosity and density of Tahina samples.

Samples	Viscosity (cp)	Density (g/mL)
Control	30.5	0.93
15% DP	33.5	0.99
25% DP	42	0.9902
35% DP	45.5	1.089

Table 9: Effect of Doum powder on consumer acceptability (Means ± SD) of cake samples (n = 10).

Samples	Color	Texture	Flavor	Aroma	Taste	Overall
Control	7.40^{a}	7.40^{c}	7.30^{c}	7.20^{ab}	7.50^{ab}	7.00^{ab}
5% DP	7.50^{ab}	8.00^{b}	7.60^{b}	7.40^{b}	7.90^{b}	7.80^{b}
10% DP	7.70^{b}	8.10^{ab}	7.70^{ab}	7.40^{b}	6.80^{c}	6.70^{c}
15% DP	8.10^{c}	8.30^{a}	8.00^{a}	7.90^{a}	8.30^{a}	8.30^{a}

n = Total number of panelists; DP: Doum Powder.

As shown in Table 6, also, the protein content of the control sample of Tahina (2.39%) was found to be lower when compared with Abd-elrashid [10] and Tefaruk [32], whom reported that 2.90% and 3.0%, respectively. Among Tahina made of different concentrations of DP (15, 25 and 35%), which were 2.50, 2.35, and 2.12%, respectively. Statistically, there are significant differences (p<0.005) in protein content. The value of crude fats content in control was 0.19%, this value is lower than other found in Tahina with different addition (15, 25, 35%) of DP, which were found to be 1.20, 1.98 and 2.31%, respectively.

Minerals content of processed Tahina by addition of DP

Tahina replacement with Doum fruit powders (15, 25, and 35%) were determined for calcium, potassium, sodium, as presented in Table 7. Sodium (Na) in control sample was 182.09mg/100g, this result is lower than that sample by addition of DP, which were found to be 186.80, 212.6, and 229.29 mg/100, in the samples made of addition of different concentrations (15, 25, 35% respectively), while found to be lower than that reported by Abd-elrashid [10], who found it 175.0mg/100g and also lower than that result reported by Abdallah [33], which was 180.02mg/100g. Statistically, there are significant differences (p<0.005) between Tahina sample in concentration of sodium. The data presented in Table 7 also showed that the concentration of potassium (K) in control sample was 167.85 mg/100g lower than found in sample of Tahina with addition of DP (15, 25 and 35%) which were 189.45, 199.09 and 216.02 mg/100g, respectively, these results are in line with those found by Abd-elrashid [10], which was 166.0mg/100g, and this result is lower when compared by Abdallah [33] results, which was169mg/100g. Statistically, there are significant differences (p<0.005) between the samples in concentration of potassium. The potassium content of samples indicates that Tahina product can be used as a natural source of potassium supplementation for pregnant and lactating women, as well as for children and the elderly [33]. Calcium content of the control sample was 345.09mg/100g and in the sample made of DP (15, 25 and 35%) were 345.96, 348.0 and 350.07 mg/100g, respectively, these results are in agreement of those results found by Abd-elrashid [10], which was found the value is 343.0mg/100g, and this value is higher compared by Abdallah [33], and Tefaruk [32], whom were found the value are 341.89, 339.12 mg/100g, respectively and statistically there are significant differences (p<0.005) among the samples in concentration of calcium.

Table 10: Effect of Doum powder on consumer acceptability (Means ± SD) of Tahina samples.

Samples	Color	Texture	Flavor	Aroma	Taste	Overall
Control	7.70^{a}	6.10^{c}	5.90^{c}	4.20^{c}	4.50^{c}	5.70^{c}
15% DP	6.30^{b}	5.40^{b}	5.20^{b}	5.40^{b}	5.60^{b}	5.80^{b}
25% DP	5.10^{c}	6.20^{ab}	6.10^{ab}	5.90^{ab}	6.00^{ab}	6. 00^{ab}
35% DP	4.90^{d}	7.30^{a}	6.30^{a}	6.20^{a}	6.20^{a}	6.30^{a}

n = Total number of panelists; DP: Doum Powder.

Viscosity and density of processed Tahina samples

Tahina samples were confirmed when apparent viscosity (cp) is figured against share rate (S-1) for both control and the samples prepared by replacement with different levels of DP obtained values of viscosity indicated the presence in Table 8. Viscosity of control sample was found to be 30.500 cp, and all the other Tahina samples prepared with different levels of DP replacement with 15, 25 and 35% had higher apparent viscosity than the control sample which were 33.500, 42.000 and, 45.500 cp, respectively, this value was the lower compared with that result reported by Bonde et al. [22], which was found to be 36.500 cp, while in a study conducted by Abd-elrashid [10], who found the highest viscosity is 27.500 cp. Thus, the increase of the apparent viscosity could attribute to the fiber content in Doum which caused higher molecular mass than control sample. On the other hand, density of Tahina samples also is shown in Table 8. The results showed that, the density of Tahina replacement of DP in 15, 25 and 35% were 0.99, 0.9902, and 1.089 g/mL respectively. These results were found to be higher than the control sample which was 0.93g/mL. This value was lower than that reported by Beretta [34] and Phillips, which was 1.02 and 0.1, respectively. The increase of the density could attribute to the fiber content in Doum which caused higher molecular mass than control sample.

Sensory evaluation of cake samples produced by addition of DP

Sensory evaluation of the samples was affected by the type and level of spice powder are presented in Table 9, comments given by the panelists showed preference for a product which has good on the color, flavor, taste, texture, aroma and overall acceptability were significantly different (p<0.005) among cake samples. The highest color score in control sample while the lowest one was recorded in cake sample with 15% Doum powder. The addition of different level of Doum powder affected the flavor of samples. The highest flavor scores were obtained in cake sample with 15% DP and the lowest one with control, with significant differences (p≥0.005). Taste of cake samples, the highest score was obtained in 15% DP, while the lowest one in 10% Doum powder, with significant differences (p≥0.005). The effect of DP on the texture of cake samples found to be the highest texture score of cake samples was recorded in 15% DP, while the lowest one in control samples, with significant differences (p≥0.005). The highest aroma score in 15% DP, while the lowest one was recorded in control samples, with significant differences (P≥0.005). The consumer acceptability means values ranged from 7.0 - 8.30 (Table 9); cake samples with 15% DP, had the highest overall consumer acceptability score and the lowest one in cake samples with 10% DP.

Sensory evaluation of Tahina samples processed by addition of DP

Sensory evaluation of the samples is presented in Table 10. Comments given by the panelists showed preference for a product which has good on the color, flavor, taste, texture, aroma and overall acceptability were significantly different ($p<0.005$) among of Tahina samples. The highest color score in control sample while the lowest one was recorded in Tahina sample with 35% DP. The replacement of different level Doum powder affected the flavor of samples. The highest flavor scores were obtained in Tahina sample with 35% Doum powder and the lowest one with control, with significant differences ($p\geq0.005$). Taste of Tahina samples, the highest score was obtained in 35% Doum powder while the lowest one in control, with significant differences ($p\geq0.005$). The effect of DP on the texture of Tahina samples was found to be the highest texture score of Tahina samples was recorded in 35% DP, while the lowest one in control samples, with significant differences ($p\geq0.005$). The highest aroma score in 35% Doum powder while the lowest one was recorded in control samples, with significant differences ($p\geq0.005$). The consumer acceptability means values showed in Table 10, Tahina samples with 35% DP had the highest overall consumer acceptability score and the lowest one in Tahina samples with control samples.

Conclusion

The findings of this study show that physicochemical, nutritional and functional properties differ significantly in the cakes and Tahina sample of Doum fruit (*Hyphaene thebaica*). The results show that Doum fruit is a good source of essential minerals such as potassium, sodium, calcium, Furthermore, Doum fruit has shown to provide essential vitamins, carbohydrate and fibers essential for good nutrition. The results have also demonstrated that the Doum fruit possesses good functional properties, which can be used for various important applications in food industry. It can therefore be concluded that the Doum fruit provides essential nutrients and possesses important functional properties which if well exploited can help to address many food related problems like diabetic and hypertensive patients.

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