Physicohemical Properties of Doum (*Hyphaene thebaica*) Fruits and Utilization of its Flour in Formulating Some Functional Foods

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ABSTRACT

Doum (*Hyphaene thebaica*) fruit, and doum-fruit flour (DFF) were studied in terms of physicohemical properties as well as technological processing to prepare biscuits, crackers and pudding containing DFF. Chemical composition showed that DFF possessed low contents of crude protein and crude ether extract being, 2.87 and 0.76%, respectively. Non reducing sugars represented about (91.94 %) of the total sugars (43.70%). The DFF could be considered as a good source of minerals (K, Ca, Na, and Mg). The results also indicated that DFF had very good values in terms of dietary fiber, total phenolic content, flavonoid content and antioxidant activity in addition to some vitamins such as B_3, B_6 and B_1. The edible portion of doum fruits (DFF) was used to formulate some functional foods. The organoleptic properties of biscuits and crackers containing DFF up to 20% and budding up to 50% showed that generally all the treatments were well accepted by the panelists.

Key words: Doum fruit, Hyphaene thebaica, chemical composition, functional properties, antioxidant, phenolic, flavonoid, sensory, technological utilization.

INTRODUCTION

Doum (*Hyphaene thebaica*) is a desert palm native to Nile valley (Egypt, sub-Saharan Africa) and West India and is listed as one of the useful plants of the world. The trunk of this small palm commonly branches into two like Y and often each branch divides again in a Y form, giving the tree a very distinctive appearance; it is dichotomous and arborescent in nature. (Fletcher, 1997). It is known in Egypt as doum or gingerbread, belongs to *Palmae* family which is made up of over 217 genus and 2500 species that grown up to 6-9 m high. The tree usually has forked stems with fan shaped leaves, 65-75 cm long (Lokuruka, 2008, Nwosu, *et al.*,2008). The trunk of the palm is used for construction, as well as for manufacture of various domestic utensils and the leaves are 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 has a large kernel. The covering of the fruit is edible and can either be pounded to form a powder or cut off to slices; the powder is often dried then added to foods as a flavouring agent. Roots of doum palm are used for treatment of bilharzias while the fruit is often chewed to control hypertension (Orwa *et al.*, 2009). Doum palm fruit is also a good source of potent antioxidants (Hsu *et al.*, 2006).

The fruit pulp is used for cooking, in various ways, but the different varieties differ in their edibility. While the unripe kernel is edible, the ripe kernel is hard and is used only as a vegetable ivory, and is used to treat sore eyes in livestock using charcoal from the seed kernel as well as making buttons and small carvings, and artificial pearls (Doren, 1997). The rind from the kernel is used to make molasses and the ground kernels are used to dress wounds (Cunningham, 1990, Hadiwigeno & Harcharik, 1995).

Doum was reported to lower the blood pressure, when its biological activity was evaluated in rat feeding experiments (Sharaf *et al.*, 1972, Betty *et al.*, 2006).

Despite the health benefits of this fruit, this crop in Egypt is cultivated in limited area. However, little literatures are available on the detailed characteristics of it. Therefore, this work aimed to investigate doum fruit properties, chemical chomposition, and some functional properties of it, and utilization for preparing some functional foods such as biscuits, crackers and budding.

MATERIALS AND METHODS

Materials

Doum fruits (5 kg) were purchased from the arid Aswan desert region of Southern Egypt. The general appearance of doum fruits and doum-fruit flour (DFF) are illustrated in Fig. (1). All chemicals and reagents used in the present study were of analytical grade and purchased from El-Gomhouria Co. for chemical and medical requisites, Alexandria, Egypt except chemicals used in HPLC methods were of HPLC grade and purchased from Sigma Co. Wheat flour (72% extraction), corn starch, powdered sugar, vegetable oils, baking powder, ammonium bicarbonate, sodium chloride and liquid milk mentioned in the present work were of food grade and purchased from the local market, Alexandria, Egypt.

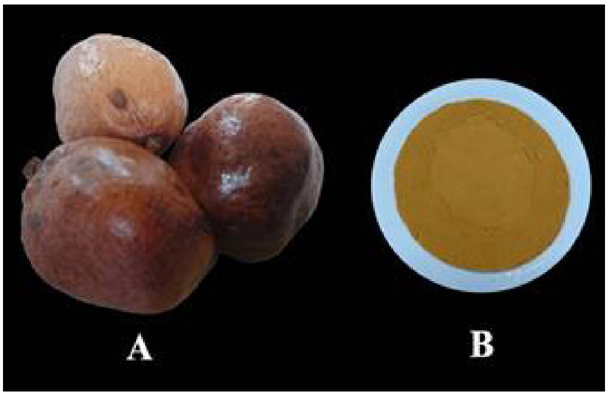

Fig. 1: General appearance of: whole doum fruits (A) and doum-fruit flour (DFF) (B).

Methods:

Preparation of doum-fruit flour (DFF)

Doum-fruit flour (DFF) was prepared as follow: Doum fruits were washed by with tap water and then drained. The epicarp (external part) and the edible portion (mesocarp) were scraped from the seed using stainless steel knife and crushed. The crushed portion was milled with a stainless steel grinder (Sf stardust, model: Cml-600 mkii, JAPAN) to pass through 100 mesh sieve and stored in glass jars at 5 ^{o}C until used (Omar *et al.*, 2002).

Fruit properties

Shape, skin colour, edible part colour and taste were visually described. Average fruit weight (g), average fruit volume (cm^3) and number of fruit per kg were determined as mentioned by Kramer & Twigg (1970). Measurements of the three major perpendicular dimensions of the fruit, namely length, width and thickness were carried out with vernier calipers (Kanon Instruments, Japan) reading to 0.01 mm.. In addition, the edible part (mesocarp), epicarp and the seed of doum fruits were weighed by a top loading balance (model: D0001-HR120, AQD company, Limited EC).

Proximate chemical composition

Proximate chemical composition including moisture, crude ether extract, crude protein (N×6.25), crude fiber and total ash were determined according to the AOAC (2003) methods unless otherwise stated. Nitrogen free extract was calculated by difference. Total, reducing and non-reducing sugars were determined using Lane- Eynon procedure as stated in the AOAC (2003). Energy value was calculated using the universally acceptable conversion factors by multiplying protein and carbohydrates by 4.00 and fat by 9.00 Kcal/g.

Determination of dietary fiber

Dietary fiber fractions including neutral detergent fiber (NDF), acid detergent fiber (ADF) and hemicellulose were analyzed using the method of Goering & Van Soest (1970).

Determination of minerals

Minerals (Ca, Mg, Fe, Zn, Mn, Cu, Ni and Co) were measured using Perkin Elmer Atomic Absorption Spectrophotometer (Model 2380, Japan), as described in the AOAC (2003). On the other hand, Na and K were determined using Flame Photometer (model PE P7, England).

Determination of total phenolics, flavonoid contents and antioxidant activity

The total phenolics content as (% tannic acid) of the doum fruit extract were determined by Folin-Denis reagent after extracting with 70% ethanol according to the method of Taga *et al.* (1984). Total flavonoid content was determined according to the method of Siddhuraju & Becker (2003). Antioxidant activity was determined by scavenging the radical 1,1-diphenyl-2-picryhydrazyl (DPPH) as described by Tadolini *et al.* (2000).

Identification of phenolic and flavonoid compounds

The HPLC system was used for analysis of the methanolic extract of doum fruits to identify the phenolic and flavonoid compounds according to the methods of Goupy *et al.* (1999) and Mattila *et al.* (2000), respectively. Ultraviolet (UV) detector at wavelength 280 nm and quaternary HP pump (series 1100) was used for phenolic compounds, while Ultraviolet (UV) detector at wavelength 330 nm and quarter HP pump (series 1050) was used for flavonoid compounds. The column (Agilent Zerbax ODS C18 column 150×4.5 mm) temperature was maintained at 35 °C. Gradient separation was carried out with methanol and acetonitrile as mobile phase at flow rate of 1 ml/min. Phenolic acids and flavonoid standards from Sigma Co. were dissolved in a mobile phase and injected into HPLC. Retention time and peak area were used to calculate the concentration of the previous compounds by the data analysis of Hewllet Packared software.

Determination of vitamin B complex

Vitamin B complex of doum fruit samples were determined by reversed-phase high-performance liquid chromatography (RP-HPLC) according to the method of Papadoyannis *et al.* (1997) with some modifications. The ground sample (0.5 g) was macerated in a glass blender containing 5 mL 30% metaphosphate. The macerate was diluted to 25 ml in a graduated flask with distilled water. The diluted solution was then filtered through a 0.45 µm filter. The filtrate was then injected directly into the HPLC with the injection volume 10 µl, column (Hypersil™ ODS C18 µm, 100 × 4.6 mm), temperature 30°C, flow rate (0.8 ml/min), detector (Ultraviolet detector, wavelength was set at 280 nm) and a mobile phase of phosphoric acid and methanol at different time intervals 0, 20 and 25 min in ratios of 90:10, 30:70 and 30:70, respectively.

Determination of ß-carotene

ß-carotene was determined using HPLC according to the method of Chinosa *et al*. (2005). Two different detectors, one UV detection (785 UV/VIS detector) and one using fluorescence detection (Perkin-Elmer Luminescence spectrometer LC 300) were used in the HPLC analysis. The data were collected and integrated with a Gynko Soft Chromatography DS Version 5.30. The mobile phase was acetonitrile - tetrahydrofuran - methanol - ammonium acetate (68,4 % (v:v) : THF 22.0 % (v:v) : 6.8 % (v:v) : 2.8 % (v:v) (1% (w:v)). Detection wavelength was set at 450 nm with flow rate at 1.5 ml/min.

Determination of water and oil holding capacities

Water holding capacity of doum powder was determined following the method described by Ang (1991). By using a glass rod, a sample of 2 g was mixed with 30 mL of distilled water in a 50-mL centrifuge tube. The slurry was allowed to stand for 10 min, and then centrifuged at 2,000 x g for 15 min. After centrifugation, the supernatant was drained and the wet sample precipitate was weighed. The result was expressed as g of water per g sample. For oil retention capacity, the same procedure was used except palm oil was used instead of water.

Technological Methods:

Preparation of biscuits

Biscuits were prepared by replacing wheat flour (72% extraction) with 5, 10, 15 and 20% DFF according to the method described by Smith (1972). The formula used for preparing biscuits is shown in Table (1).

Preparation of crackers

Crackers were prepared in a straight dough process according to Ahmed and Abozed (2015). Wheat flour was replaced with 5, 10, 15 and 20% DFF. The formula used for preparing crackers is shown in Table (1).

Preparation of budding

Budding was prepared from blends containing10%, 20%, 30, 40 and 50% DFF according to the method described by Abdel-Hady (1998). The formula used for preparing budding is shown in Table (1).

Sensory evaluation of the products

Colour, odour, taste, texture and overall acceptability of biscuits, crackers and pudding containing DFF were assessed using 10 panelists of Food Technol. Lab., Food Technol. Research Inst., Agriculture Research Center, of Sabahia, Alexandria, Egypt. In addition to the previous attributes, crispiness was assessed in crackers containing DFF. The panelists were asked to score the above attributes according to a standard hedonic rating scale from 9 (like extremely) to 1 (dislike extremely) according to Kramer & Twigg (1973).

Table 1: Ingredients used for the preparation of biscuits, crackers and budding.

Ingredients (g)	Biscuits					Crackers					Budding					
	% (DFF)*					% (DFF) *					% (DFF) *					
	Control	5	10	15	20	Control	5	10	15	20	Control	10	20	30	40	50
Wheat flour	100	95	90	85	80	100	95	90	85	80	-	-	-	-	-	-
Corn starch	-	-	-	-	-	-	-	-	-	-	25	25	25	25	25	25
DFF *	-	5	10	15	20	-	5	10	15	20	-	2.5	5	7.5	10	12.5
Sugar	60	60	60	60	60	2	2	2	2	2	35	35	35	35	35	35
Vegetable oil	40	40	40	40	40	-	-	-	-	-	-	-	-	-	-	-
Liquid milk (ml)	41	38	30	28	28	-	-	-	-	-	400	400	400	400	400	400
Baking powder	-	-	-	-	-	2	2	2	2	2	-	-	-	-	-	-
Ammonium bicarbonate	1.5	1.5	1.5	1.5	1.5	-	-	-	-	-	-	-	-	-	-	-
Sodium chloride	-	-	-	-	-	2	2	2	2	2	-	-	-	-	-	-
Water (ml)	-	-	-	-	-	65	65	65	65	65	-	-	-	-	-	-

* (DFF): Doum-fruit flour.

Statistical analysis

The data of the chemical composition, physical and the organoleptic properties of the products containing DFF were subjected to analysis of variance using (ANOVA) followed by Duncan's multiple range test with P≥0.05 being considered statistically significant using SAS program software program (SAS Institute 2004).

RESULTS AND DISCUSSION

Fruit properties

As shown in Fig. (1) and Table (2), the shape of doum fruit was asymmetric. Skin colour was light to dark brown (gingerbread brown) while the edible part had light brown (tawny brown) colour. Fruit taste was sweet. This description agreed well with that found by Abdel-Rahman *et al.* (2014) in shape and taste but disagreed with respect to skin and edible part colours. Aremu & Fadele (2011) mentioned that *H. thebaica* is a variety of doum palm which is dark to light brown in colour.

The data in Table (2) reveal that the number of fruits/Kg, average fruit weight and volume were 20.00 fruits/Kg, 50.55 g and 71.67 cm^3, respectively. The average number of fruits/Kg and weight of the fruit are far away from those reported by Abdel-Rahman *et al.* (2014) which were 8.7 fruits/kg and 116.92 g, respectively. Also, Aremu & Fadele (2011) found that the mean fruit volume (38.83 cm^3) was far away from the results obtained in the present study.

With regard to the fruit dimensions, the data declared that fruit length (6.55 cm) was longer than width (5.00 cm), while width and thickness had equal values tending to have an oblate form. These results are in agreement with those reported by Aremu & Fadele (2011), while to some extent are different from those stated by Kheiralipour *et al.* (2008) and Abdel-Rahman *et al.* (2014).

Table 2: Properties of doum fruit

Parameter	Description
Shape	Asymmetric
Skin colour	light to dark brown
Edible part colour	light brown
Taste	Sweety
	Value *
Number of fruits/ kg	20±1
Average fruit weight (g/fruit)	50.55±4.20
Average fruit volume (cm^3/fruit)	71.67±5.77
Fruit dimensions (cm)	
Length	6.55±0.44
Width	5±0.59
Thickness	5.36±0.15
Weight composition(%)	
Epicarp	12.88±1.33
Edible part (mesocarp)	24.90±4.46
Seed	61.35±5.21

* Means of three determinations ±S.D

The results in the same Table showed that the seed had the highest percentage (61.35%) of the fruit weight, followed by the edible part (mesocarp) (24.90%) and finally the peel (epicarp) (12.88%). These results are in agreement with those reported by Abdel-Rahman *et al.* (2014).

Chemical composition

The proximate chemical composition of the edible portion of doum fruits is shown in Table (3). The data revealed that DFF had (0.76%) high percentages of crude fiber (14.08%), ash (9.57%) and nitrogen free extract (72.72%) on dry weighet basis. It can be noted that the moisture content (10.15%) was very close to that found by Hussein *et al.*(2010)(11.50%) and higher than that reported by FAO (2006) (4.00%), Abdel-Rahman *et al.* (2014) (5.47%) and Aboshora *et al.* (2014a) (5.50%). The crude protein and crude ether extract contents of DFF were found to be very low, being 2.87 and 0.76%, respectively. Crude protein value was closed to that published by Aboshora *et al.* (2014 a) and Abdel-Rahman *et al.* (2014). Other researchers found a higher protein content. For example, Hoebeke (1989), Bonde *et al.* (1990) and Hussein *et al.* (2010) found that the crude protein content was 3.80, 9.26 and 6.41 %, respectively. The results of crude ether extract agreed with that reported by Hoebeke (1989), Nwosu *et al.* (2008), Hussein *et al.* (2010) and Abdel-Rahman *et al.* (2014). The value of crude fiber (14.08%) was higher than the values found by Hussein *et al.* (2010) (12.24%) and Aboshora *et al.* (2014a) (12.27%) and lower than that reported by Abdel-Rahman *et al.* (2014). The result also showed that doum fruit contained 9.57 % ash, which was higher than the results reported by Nwosu *et al.* (2008) (8.1%), Hussein *et al.* (2010)(6.42%), Aboshora *et al.* (2014 a) (6.64%) and Abdel-Rahman *et al.* (2014) (7.17%).

The results of nitrogen free extract (72.72%) was closed to that reported by Aboshora *et al.* (2014a) (72.5%) and Abdel-Rahman *et al.* (2014) (69.72%). The high NFE content in doum fruits 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. (Aboshora *et al.*, 2014a). It could be seen from the same Table that, non reducing sugars represented 91.94% out of the total sugars. The energy value was 309.18 expressed as Kcal/ 100g sample. This value was similar to that calculated by Abdel-Rahman *et al.* (2014) and less than that calculated by Aboshora *et al.* (2014a). The previous authors mentioned that consumption of doum fruits can provide relevant needed energy level and address the energy related disease disorders in humans.

Data in Table (3) also show that doum fruits had considerable amount of phenolic and flavonoid contents being 49.82 mg /100g and 6.98 mg/ 100 g, respectively. Dosumu *et al.* (2006) mentioned that doum fruits contain important substances including saponins, tannins, and flavonoids. It has been reported by Aboshora *et al.* (2014b) that doum fruit extracts contain high levels of phenols and flavonoids. Falleh *et al.* (2012) found that the total polyphenol level is significantly influenced by the nature of the extraction solvent, sonication, extraction time, as well as the interaction between these factors.

The antioxidant activity of the methanolic extract of DFF was 45.86% as shown in Table (3). Hsu *et al.* (2006) mentioned that the antioxidant activity of doum fruits was lower than that of black tea and was comparable in magnitude to a number of food sources, such as potato peels (Nandita & Rajini, 2004), honey (Aljadi & Kamarudin, 2004), quince fruits (Silva *et al.*, 2004) and mushroom (Abu-tor *et al.*, 2012) which are rich in antioxidants. Hsu *et al.* (2006) examined various reactions that might contribute to antioxidant activity present in doum fruits and which could play an important nutritional

Table 3: Proximate chemical composition of DFF (on dry weight basis)

Component	Value*
Moisture (%)	10.15±0.52
Crude protein (%)	2.87±0.37
Crude ether extract (%)	0.76±0.04
Crude fiber (%)	14.08±0.18
Ash (%)	9.57±0.39
N- free extract (NFE)**(%)	72.72±0.39
Energy value (Kcal /100g)	309.18±0.49
Total sugars (%)	43.70±1.13
Reducing sugars (%)	4.04±0.08
Non reducing sugars (%)	39.74±1.21
Total phenolic content (mg /100g)***	49.82 ±0.18
Total flavonoids (mg/ 100 g)	6.98±0.02
Antioxidant activity (%)	45.86±0.03
ß-carotene (mg / 100 g)	0.502
Dietary fiber (%)	
Neutral detergent fiber (NDF)	32.40±0.51
Acid detergent fiber (ADF)	26.10±0.46
Hemicellulose (NDF-ADF)	6.30±0.05
Vitamin B-complex (mg/100g)	
Niacin (B3)	20.08
Pyridoxine (B6)	10.07
Thiamin (B1)	5.00
Riboflavin (B2)	4.22
Folic acid (B9)	3.02

* Mean of three replicates ± SD. (on dry weight basis) except ß-carotene.
** Calculated by difference
*** Tannic acid equivalent

role in the diet of adults and children alike in some of the poorest regions of the world (Egypt, India and sub-Saharan Africa). Ksouri *et al.* (2009) stated that various factors, such as temperature, solvent extracting power, extraction time, and extraction method, significantly affect the composition of the extract. However, solvent extracting power is the most important factor affecting antioxidant capacity as found by Falleh *et al.* (2012).

The data presented in Table (3) reveal that doum fruit contains low level of ß-carotene (0.502 mg/100g). Also, Abdel-Rahman *et al.* (2014) reported that the doum fruit contains low level of ß-carotene.

The percentages of the dietary fiber fractions including neutral detergent fiber (NDF), acid detergent fiber (ADF) and hemicellulose of DFF were 32.40, 26.10 and 6.30 %, respectively as presented in Table (3).

The data in Table (3) show that vitamin B-complex in DFF can be arranged in descending order as follows: Niacin (20.08 mg/100g), pyridoxine (10.07 mg/100g), thiamin (5.00 mg/100g), riboflavin (4.22 mg/100g) and finally folic acid (3.02mg/100g). The results found by Aboshora *et al.* (2014a) were different in quantity from the results obtained in the present study except that folic acid being the lowest value. These results are somewhat different from those found in the present study. This may be due to variation in both cultivar and location.

Mineral contents

Mineral contents of DFF are given in Table (4).The following minerals: K, Ca, Na, and Mg were the major. Meanwhile, Fe, Mn, Zn, Cu, Ni and Co were found in minor amounts. Potassium (3784.83mg), calcium (326.44 mg) and sodium (198.00 mg) per 100g dry matter content were higher than the findings of Aboshora *et al.* (2014a). Also, these findings were higher than the values mentioned by Babiker & Makki (2013) except that calcium was very close and iron was very low. Na/K ratio in the present study was less than one (0.052 mg/100g). This showed that DFF could have a potential to control hypertension as reported by Aremu *et al.* (2006). It is clear from the results that DFF contains higher amounts of essential minerals which in most instances exceed the recommended dietary allowance (RDA), thus may keep the balances and ratios between those in need (Aboshora *et al.*, 2014a).

Table 4: Mineral contents of DFF (on dry weight basis)

Minerals	Value (mg/100g)
K	3784.83
Ca	326.44
Na	198.00
Mg	168.66
Fe	5.64
Mn	0.91
Zn	0.54
Cu	0.38
Ni	0.27
Co	0.10
Na/K	0.052

Identification of phenolic and flavonoid compounds by HPLC

Table (5) shows the compounds, retention time (RT), as well as concentrations of various phenolic compounds found in the methanolic extract of DFF. Nineteen separated phenolic compounds were identified. These compounds are 3-oH tyrosol, protocatechuic, chlorogenic, catechin, *p*-oH benzoic, caffeic, vanillic, ferulic, iso-ferulic, E-vanillic, resveratrol, oleuropein, ellagic, alpha-coumaric, salicylic, 3,4,5 methoxy cinnamic, coumarin, *p*-coumaric and cinnamic. The compounds with the highest concentrations were E-vanillic, oleuropein, catechin, chlo-

Table 5: Phenolic compounds of DFF by HPLC

Peaks	Compounds	RT(min)	Concentrations mg/100g
1	3- oH tyrosol	8.413	3.54
2	Protocatchoic	8.704	1.5
3	Chlorogenic	9.410	3.59
4	Catechin	9.823	5.99
5	p-oH benzoic	10.158	2.77
6	Caffeic	10.595	1.00
7	Vanillic	10.626	1.24
8	Ferulic	12.347	1.47
9	Iso-Ferulic	12.773	1.43
10	E-Vanillic	13.232	6.61
11	Resveratrol	13.327	0.62
12	Oleuropein	13.625	6.18
13	Ellagic	13.692	0.98
14	Alpha-coumaric	13.840	0.54
15	Salicylic	14.627	0.99
16	3,4,5 methoxy cinnamic	14.627	0.48
17	Coumarin	15.087	0.33
18	P-Coumaric	15.434	0.31
19	Cinnamic	15.820	0.23

rogenic, and 3- oH tyrosol being 6.61, 6.18, 5.99, 3.59, and 3.54 mg/100g, respectively ,while those low in concentrations were coumarin, *p*-coumaric and cinnamic being 0.33, 0.31 and 0.23 mg/100g, respectively. These results are in agreement with those reported by Cook *et al.* (1998) and Hsu *et al.* (2006). It has been reported that the aqueous extract of doum fruits showed an antioxidant activity; this is due to the substantial amount of their water-soluble phenolic contents (Hsu *et al.*, 2006).

Flavonoid constituents found by HPLC analysis in the DFF are presented in Table (6). The data showed the retention time and concentrations of 11 compounds *i.e.* naringin, rutin, hesperidin, rosmarinic acid, quercitrin, quercetin, naringenin, hesperetin, kaempferol, apigenin and 7-hydroxy-flavone.

The methanolic extract of DFF contain high amounts of hesperidin, naringenin and naringin compounds being 1.35, 1.18 and 1.11 mg/100g, respectively, and low amounts of 7-hydroxy-flavone, apigenin and kaempferol (0.02, 0.04 and 0.04 mg /100g), respectively. Doum-fruit flour showed antimicrobial and antihypertensive activities. These activities are attributed to the presence of flavonoids as mentioned by El-egami *et al.* (2001). Five flavone glycosides were isolated and identified from doum fruits, luteolin 7-*o*-glucuronoide, apigenin 7-*o*-glucuronoide, luteolin *o*- glycoside, luteolin 7-*o*-rutinoside and chrysoeriol 7-*o*-rutinoside (Hashim, 1994).

Water and oil holding capacities

The results of water holding capacity (WHC) and oil holding capacity (OHC) for DFF are presented in Fig. (2) The results show that WHC of DFF was 3.05 ml/g, while OHC was1.8 ml/g. This result is closed to that found by Seleem (2015)(3.32 ml/g) and higher than that reported by Aboshora *et al.* (2014a) and agreed well with that found by Hussein *et al.* (2010). Water holding characteristics represent the ability of a product to associate with water under conditions where water is limiting (Singh *et al.*, 2004). The high WHC of DFF could be attributed to the presence of high amount of carbohydrates. The oil holding capacity (OHC) is important since oil acts as flavour retainer and increases the palatability of foods (Kinsella, 1976). The ability of flour to absorb and retain water or oil may help to improve binding of the structure, enhance flavour retention and improve the mouth feel (Kaur *et al.*, 2013). The results found by Seleem (2015) indicated that doum flour absorbed more water than wheat flour. By increasing the level of DFF, the water holding capacity increased. This may be attributed to the high non reducing sugar content of this flour.

Table 6: Flavonoid compounds of DFF by HPLC

Peaks	Compounds	RT(min)	Concentrations mg/100g
1	Naringin	12.925	1.11
2	Rutin	12.925	0.96
3	Hesperidin	13.033	1.35
4	Rosmarinic acid	13.231	0.21
5	Quercitrin	13.962	0.79
6	Quercetin	15.590	0.29
7	Naringenin	15.803	1.18
8	Hesperetin	16.777	0.7
9	Kaempferol	16.790	0.04
10	Apigenin	17.283	0.04
11	7-hydroxy-flavone	18.150	0.02

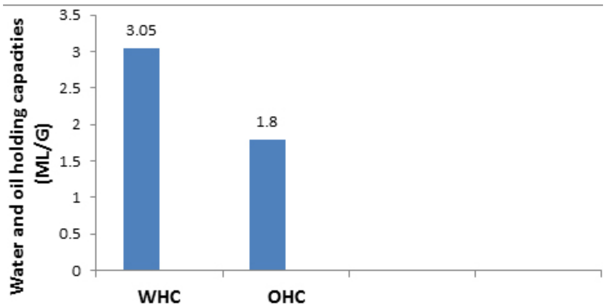

Fig. 2 : Water and oil holding capacities (mL/g) of DFF (*Hyphaene thebaica*).

Sensory evaluation of some products containing DFF

The general appearance of biscuits, crackers and pudding containing DFF are shown in Figs. (3-5).

Biscuits and crackers

The results of organoleptic properties of biscuits containing DFF (Table 7) showed that generally all the treatments were still well accepted by the panelists, being over the numerical value of (7).

There were no significant differences between all the treatments in all the attributes except colour of the control and the texture of biscuits containing 10% DFF.

In the light of results given in Table (8), except the colour and the texture of crackers containing 5% DFF, the numerical values of the organoleptic attributes decreased with increasing the amount

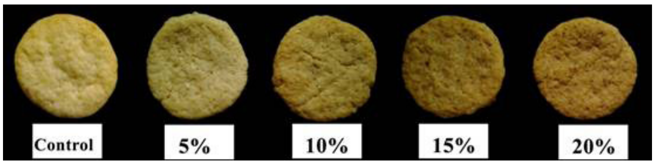

Fig. 3: Appearance of biscuits containing different percentage of DFF

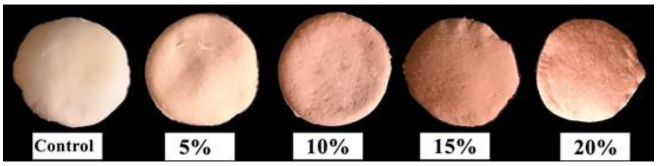

Fig. 4: Appearance of crackers containing different percentage of DFF.

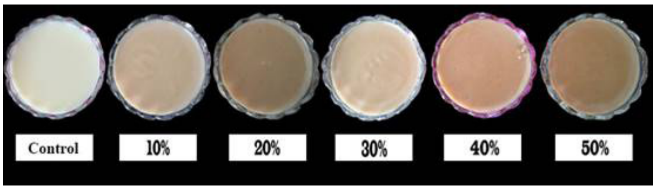

Fig. 5: Appearance of budding containing different percentage of DFF.

Table 7: Organoleptic evaluation of biscuits containing DFF*.

Treat-ments	Attributes				
	Colour	Odour	Taste	Texture	Overall acceptability
Control	7.13^{b}	7.38^{a}	7.50^{a}	7.19^{ab}	7.43^{a}
5%	8.19^{a}	8.16^{a}	7.59^{a}	8.06^{a}	8.06^{a}
10%	7.38^{ab}	7.66^{a}	7.53^{a}	7.03^{b}	7.38^{a}
15%	7.91^{ab}	8.19^{a}	7.81^{a}	8.00^{a}	8.00^{a}
20%	7.75^{ab}	7.56^{a}	8.19^{a}	7.19^{ab}	7.69^{a}
L.S.D$_{0.05}$	0.86	0.87	1.01	0.92	0.78

Means in a column not sharing the same letter are significantly different at P ≤ 0.05.
*DFF= Doum-fruit flour.

Table 8: Organoleptic evaluation of crackers containing DFF*.

Treat-ments	Attributes					
	Colour	Odour	Taste	Tex-ture	Crispiness	Overall acceptability
Control	8.25^{ab}	8.50^{a}	8.41^{a}	8.16^{a}	8.75^{a}	8.37^{a}
5%	8.58^{a}	8.33^{ab}	8.58^{a}	8.25^{a}	8.45^{a}	8.41^{a}
10%	8.16^{ab}	8.25^{ab}	8.00^{a}	7.91^{a}	7.70^{ab}	7.87^{ab}
15%	7.66^{b}	7.66^{bc}	7.83^{a}	7.50^{ab}	7.29^{b}	7.29^{bc}
20%	6.83^{c}	7.08^{c}	6.83^{b}	6.75^{b}	7.00^{b}	6.58^{c}
L.S.D$_{0.05}$	0.80	0.74	0.80	0.94	1.07	0.88

Means in a column not sharing the same letter are significantly different at P ≤ 0.05.

Table 9: Organoliptic evaluation of budding containing DFF*.

Treat-ments	Attributes				
	Colour	Odour	Taste	Texture	Overall acceptability
Control	8.27^{a}	7.82^{a}	8.18^{a}	7.90^{a}	8.10^{a}
10%	7.64^{a}	7.36^{a}	7.27^{b}	7.36^{a}	7.41^{a}
20%	8.36^{a}	8.14^{a}	8.00^{ab}	8.05^{a}	8.10^{a}
30%	7.55^{a}	7.36^{a}	7.27^{b}	7.45^{a}	7.55^{a}
40%	8.18^{a}	7.54^{a}	7.90^{ab}	7.90^{a}	7.91^{a}
50%	7.63^{a}	7.63^{a}	7.45^{ab}	7.54^{a}	7.64^{a}
L.S.D$_{0.05}$	0.84	0.81	0.88	0.84	0.84

Means in a column not sharing the same letter are significantly different at P ≤ 0.05.
*DFF= Doum-fruit flour

of DFF. In the light of the obtained data, it was obvious that panelists accepted the product containing up to 10% DFF, and the other treatments were still accepted by the panelists even those containing the higher percentages of DFF up to 20%. The data also revealed that no significant differences were noted in the organoleptic attributes between the control sample and those containing DFF up to 10% DFF.

Budding

The results of organoleptic evaluation and the appearance of budding containing DFF are given in Table (9). The colour, taste, odour, texture and overall acceptability of all the samples were over the numerical value of 7.0 (like moderately). These results indicate that all the attributes were very well accepted by the panelists. Also, the results indicated that no significant differences were noted in the organoleptic attributes between the control sample and those containing the different concentrations of DFF except the taste of budding containing 10 and 30% DFF.

CONCLUSION

It can be concluded that DFF could be used as a successful replacer source in baked products such as biscuits and crackers as well as budding, thus allowing production of potentially healthier and functional food items. Therefore, it could be quite worthwhile for commercial applications in healthy food.

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الخواص الفيزيوكيماوية لثمار الدوم
واستخدام مطحونها فى توليف بعض الاغذية الوظيفية

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تم دراسة الخصائص الفيزيوكيماوية لثمرة الدوم وناتج طحن الجزء القابل للأكل منها بالإضافة إلى عمل منتجات لها خصائص وظيفية وتشمل البسكويت ، المقرمشات والبودنج وذلك بإضافة نسب مختلفة من مطحون ثمرة الدوم . أظهرت النتائج أن ثمرة الدوم منخفضة فى محتواها من البروتين الخام والمستخلص الاثيرى الخام (٢,٨٧ و ٠,٧٦ ٪ على التوالى). تمثل السكريات غير المختزلة ٩١,٩٤ ٪ من السكريات الكلية (٤٣,٧٠ ٪). ويعتبر مطحون ثمرة الدوم مصدرا غنياً بالعناصر الغذائية (البوتاسيوم ، الكالسيوم ، الصوديوم والماغنسيوم) . أظهرت النتائج أيضا أن مطحون ثمرة الدوم غنى بالسكريات غير المختزلة ، الألياف التغذوية، المركبات الفينولية، الفلافونيدات ومضادات الأكسدة بالإضافة إلى غنى هذه الثمار ببعض الفيتامينات مثل ب٣، ب٦ وب١ ونتيجة لذلك تم استخدام مطحون ثمرة الدوم فى تحضير بعض الأغذية الوظيفية مثل البسكويت ، المقرمشات والبودنج. أظهرت الخصائص العضوية الحسية لكل من البسكويت والمقرمشات قبولا من قبل المحكمين حتى نسب استبدال ٢٠٪ كما لاقى البودنج قبولا لدى المحكمين حتى نسب إضافة ٥٠٪ .