

PHYSICOCHEMICAL, SENSORY AND FUNCTIONAL PROPERTIES OF WHEAT-DOUM FRUIT FLOUR COMPOSITE CAKES

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Four cake recipes were prepared; using 0, 10, 20 and 30% replacement levels of wheat flour by doum fruit flour (DFF). The chemical, physical, organoleptic characteristics and biological quality of the prepared cakes were studied. Results indicated that there was a gradual enhancement in water absorption and mixing tolerance index with increasing DFF in the cakes. The flavour and general acceptability of cake containing 10 and 20% DFF were significantly higher. The cakes were fed to rats alone or plus cholesterol powder and cholic acid for 42 days, growth and plasma total lipids were evaluated. The data showed higher food intake and lower gain in body weight in rats fed on the cake supplemented with DFF than for the hypercholesterolemic (HC) group. The plasma total cholesterol and non-HDL-cholesterol levels for animal groups which were fed on cakes with DFF (10-30%) was significantly lower than the in the hypercholesterolemic (HC) group ($p < 0.05$). The highest plasma HDL was found in rats consuming diets based on cake containing 30% DFF. The atherosclerotic index showed progressive decrease with the increase of DFF level in the cakes. It can be concluded that DFF could be useful for preparation of cakes for those suffering from hypocholesterolemia.

INTRODUCTION

Doum (*Hyphaene thebaica*) is a desert palm native to Egypt, sub-Saharan Africa and West India and is listed as one of the useful plants of the world [Fletcher, 1997]. It is known in Egypt as doum or gingerbread palm which grows up to 6-9 m high. The tree usually has forked stems with fan shaped leaves, with a flat surface of approximately 66 cm long.

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 [Doren, 1997]. The rind from the kernel is used to make molasses and ground kernels are used to dress wounds [Cunningham, 1990; Hadiwigeno & Harcharik, 1995]. To the peoples of the desert where doum palms are found, it is life-sustaining and is listed as a famine food. During the drought years from 1992 to 1994, the communities in the Turkana region of Kenya were completely dependent on wild doum [USAID, 1995]. For centuries, a traditional drink has been prepared from the fruit by infusing the dried ground fruit pulp in hot water. This drink is widely consumed as a health tonic and has been valued in the region, for its many anecdotal medicinal properties [Martin, 1999].

The chemical composition of the fruit pulp was reported by Cook *et al.* [2000], showing that the fruits are relatively rich in proteins, essential fatty acids (linoleic acid) and in selected trace elements. Research on the fruit pulp have shown that it contains 4.91% proteins, 5.26% fat, 4.5% ash and 85.33% total carbohydrate fatty acids, in particular the nutritionally

essential linoleic acid [Eissa *et al.*, 2008]. 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]. Scientific evidences are provided that the consumption of fruit and vegetable can exert positive effects upon human health and the aging process. Evidence points to those foodstuffs as being rich in antioxidant phytochemicals, in particular, the flavonoids, coumarins, hydroxycinnamates and lignin components which act to prevent or reduce oxidative stress by scavenging free radicals [Bravo, 1998; Shariff, 2001, Sohal *et al.*, 2002; Kamis *et al.*, 2003; Eldahshan *et al.*, 2008; Jeong, 2009]. Flavonoids and hydroxy cinnamates are known to exhibit various beneficial pharmacological properties, such as vasoprotective, anti-carcinogenic, anti-viral, anti-ischemic, anti-inflammatory and anti-proliferative activity in cell studies [Middleton *et al.*, 2000; Exarchou *et al.*, 2002; Soong & Barlow, 2004; Dosumu *et al.*, 2006; Swedell *et al.*, 2008; Nwosu *et al.*, 2008; Eldahshan *et al.*, 2009; Mohamed, 2009].

The objectives of this study were to test the effect of incorporation of different levels of DFF in wheat flour to produce low calorie dietetic cakes. The biological value of the prepared cakes, its influence on the lipid profile was also assessed in rat feeding experiments.

MATERIALS AND METHODS

Preparation of DFF samples

Dry doum fruits were obtained from local herbal shop (Dokki, Egypt) in a form of small pieces. The raw materi-

al was washed with tap water at room temperature (21°C) containing sodium dodecyl sulphate (Sigma Chemical Co., USA) (17 mg dry detergent per 38 L water), followed by rinsing three times with fresh water, and finally the rinsed doum was dried at 85°C for 24 h in a thermostatically-controlled oven with air fan (Shel Lab1370 FX, USA). The dry flakes were ground electrically in a mill (Wiley, model4, England) to pass through 80 mesh sieve to obtain DFF. These flours were packed in airtight polyethylene bags from the Technopack Co., Cairo, Egypt, and the bags were stored in a refrigerator (4°C) until used. Also soft wheat flour (72%) used in this study was obtained from the North Cairo Flour Mills Co., Egypt.

Preparation of low sugar and low fat bakeries (cakes)

Cakes were prepared from blends containing 0%, 10%, 20% and 30% of DFF. The formula included 1000 g flour blend, 850 g sugar, 400 g whole egg, 250 g shortening, 40 g baking powder, 16 g salt; 900 g skimmed milk and 17 g vanilla (purchased from the local market, Cairo, Egypt). Also, 75 mL tap water (21°C) were added with increasing of DFF concentration. Cake batter was prepared using a mixer (Moulinex, France) with a rotary speed of 220 r.p.m. The shortening was creamed for 15 s, after which the flour, shortening, salt and baking powder were creamed together to get a fluffy cream and added along with the milk solution (milk, vanilla and extra water, when appropriate). Mixing was continued for 15 s at a speed setting of 52 r.p.m. and then for 45 s at a speed of 184 r.p.m. The eggs and sugar were whipped together until semi-firm foam resulted and mixed with the creamed flour and shortening. Cake batter (400 g) was poured into an aluminum cake pan and baked at 177°C for 35 min in a thermostatically-controlled oven with air fan (Shel Lab1370 FX, USA). Upon cooling, the weight of each cake was recorded and the cake was wrapped tightly in a plastic food wrap and stored at room temperature for testing.

Water holding capacity (WHC) of DFF

Nineteen (DFF) samples were tested for the water holding capacity (WHC) for prolonged period of time of 30, 90 and 150 mins at different temperatures (10°C, 38°C and 66°C) according to the method of De Fouw *et al.* [1982].

Oil holding capacity (OHC) of DFF

One g of DFF was stirred mechanically in 10 mL of refined corn oil (from Misr Gulf Oil Processing Company, Egypt). Following centrifugation (Hermle Z 323K, Germany) at 3000 rpm for 30 min, the volume of the supernatant was recorded and the oil-holding capacity was expressed as the quantity of oil (grams) held by one g of DFF.

Rheological characteristics

Doum fruit flour blends at 0%, 10%, 20% and 30% levels were prepared by replacing wheat flour (72% extraction). The effect of DFF on the mixing profile of the dough was studied using a farinograph (Brabender, Duisburg, Germany) according to the standard AACC methods [1988].

Physical and sensory evaluation of cakes

The cake volume and shrinkage were measured using template according to the Official AACC Method [AACC, 1988]. The percentages of weight losses associated with baking of the cake were calculated. Color, texture, tenderness, moistness, flavor and general acceptability were judged according to Hegazy & Faheid [1990] by 10 staff members of the Food Science Dept., National Research Center, Dokki, Cairo, Egypt.

Chemical composition

The wheat flour (WF) (72% extraction), doum fruit flour (DFF) and WF-DFF composite cakes were analysed for moisture (925.10), crude protein (920.87), ether extract (920.85), ash (923.03), crude fibers (920.86) and total soluble sugars (939.03) were determined according to AOAC [1990]. Total carbohydrates were calculated by difference according to the following equation: Total carbohydrates = 100 - (% crude fat + % crude protein + % ash + % crude fiber) on dry weight basis.

Feeding experiments

Feeding experiments were done in the animal house, Department of Nutrition, NRC. Male Sprague Dawley rats with average body weight of 176 g were distributed into five groups of eight rats per group. The diets were based solely on the baked cakes (Table 3). Group 1 was based on a standard cake recipe without (DFF) and served as a control group. Four high cholesterol diets were prepared, to which cholesterol (2%) obtained from the Panreac, Quimica, Spain and sodium cholate (0.125%) obtained from Merck Co., Darmstadt, Germany, were incorporated. One of the 4 groups was served as a positive control group. Diets 2, 3, 4 and 5 contained 0, 10, 20 and 30% DFF, respectively.

Foods and water were served *ad-libitum* and the feeding experiment lasted for six weeks. Body weights and feed intake were measured weekly. At the termination of the 6 week feeding, the rats were fasted over night and blood samples were collected with heparin under slight ether anesthesia by open heart puncture. The plasma was separated in the cold and saved at -20°C for subsequent biochemical analysis.

Feed efficiency ratio (FER) of the different diets was calculated as the gain in body weight (g)/ feed intake (g) [Smith & Circle, 1971].

Analytical methods

The plasma total cholesterol [Richmond, 1973], HDL-cholesterol [Lopes-Virella *et al.*, 1997], triglycerides [Fossati & Prinicip, 1982] were assayed according to standard methods. The VLDL+ LDL was calculated as follows: LDL+ VLDL cholesterol = total cholesterol - HDL cholesterol.

Statistical analysis

Data were analysed statistically using the statistical software program SPSS, ver. 7.5. (1997). The results were presented as the arithmetic mean \pm standard deviation. The analysis of variance was performed according to Snedecor & Cochran [1980]. Differences between means were determined using the Duncan Multiple Range Tests for all variables [Duncan, 1955].

RESULTS AND DISCUSSION

Chemical composition of wheat flour (WF), doum fruit flour (DFF) and WF-DFF composite cakes

Data presented in Table 1 show the proximate composition of wheat flour 72%, DFF and the prepared fresh cakes. The data revealed a low content of fat (0.9%) with high levels of crude fiber and ash contents of DFF. Moisture, crude fiber, ash and total soluble sugars increased in prepared cakes with increasing the DFF level, whereas protein and total carbohydrates contents decreased in cakes fortified with DFF compared to the control. The increase in moisture, fat, ash, total soluble sugars and fibers of DFF supplemented cakes can be attributed to the high content of those ingredients in DFF. This clearly indicates that DFF can be an alternative source of dietary fiber in cakes making.

Physical characteristics

Water and oil holding capacity

The water holding capacity (WHC) fluctuated between 2.6 and 3.2 g water per g DFF and the highest gains in water were obtained following three hours soaking of the DFF at 66°C (Figure 1). Duration and temperature of the soaking period affected the water holding capacity; yet none of the mean differences reached a significant level ($p>0.05$). The oil holding capacity fluctuated within narrow range between 2 and 2.3 g oil/g DFF. None of the differences reached a significant level ($p>0.05$). The oil holding capacity (OHC) is important since oil acts as flavour retainer and increases the palatability of foods [Kinsella, 1976]. Also high OHC means that various kinds of mutagens and cholesterol can be adsorbed effectively, because most of these components are lipophilic [Lund, 1984].

Farinograph characteristics of wheat flour-DFF dough

Data presented in Figure 2 show the effect of adding DFF at three levels on the rheological properties of dough as evaluated by a farinograph. As shown in Figure 3a, water absorption increased as DFF level increased. This increase is due to the high fiber content of DFF. Fiber is characterised by its high water holding capacity as reported by Holloway & Grieg [1984]. The same trend was also observed in the arrival time and dough development time (Figure

2b). General incorporation of high fiber materials in dough altered dough development, consequently dough development time increased as DFF level increased. Similar findings were reported by Chen *et al.* [1988a] and Laurikainen *et al.* [1998]. Also, Sudha *et al.* [2007] pointed out that water absorption and arrival time increased as dried apple pomace level increased in dough. Dough stability (Figure 2b) decreased from 4.0 to 2.5 min as DFF level increased, while weakening increased from 80 to 140 BU and mixing tolerance index (MTI) increased from 30 to 100 BU (Figure 2a), which is due to dilution of gluten protein from wheat flour with the increase fiber content from DFF. This may also be due to the interaction between fibrous materials and gluten, which affects the dough mixing properties as reported by Shouk & Ramadan [2007].

Sensory evaluation of prepared cakes

Figure 3 presents the scores of the four prepared cakes for flavour, color, texture and tenderness. The sensory characteristics of cakes prepared with 10 or 20% DFF were closer to these of the control ones (Figure 4). However, the scores of cake containing 30% (DFF) were less favorable compared

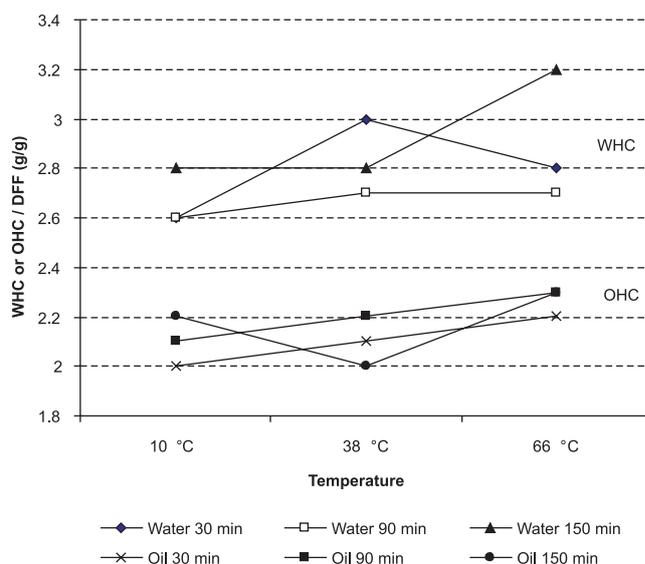


FIGURE 1. Water holding capacity (top panel) and oil holding capacity (bottom panel) of doum fruit flour as a function of time and temperature of soaking.

TABLE 1. Proximate composition of wheat flour (WF), doum fruit flour (DFF) and WF-DFF composite cakes^a.

Constituents (%)	WF	DFF	Cakes			
			0% DFF	10% DFF	20% DFF	30% DFF
Moisture	11.12±0.73	11.5±0.22	23.3±0.03	24.95±0.14	27.03±0.16	29.61±0.14
Protein	9.80±0.02	6.41±0.23	8.61±0.03	8.44±0.02	8.40±0.04	8.37±0.19
Ether extract	1.13 ±0.43	0.9±0.19	23.56±0.01	23.89±0.02	24.67±0.05	25.17±0.01
Crude fiber	0.51±0.01	12.24±0.35	0.94±0.03	1.96±0.01	3.01±0.03	4.23±0.05
Total Ash	0.45±0.00	6.42±0.08	1.74±0.01	2.22±0.02	2.96±0.06	3.44±0.03
Total carbohydrates	74.77±0.96	48.66±0.30	36.83±0.12	32.12±0.01	26.43±0.05	20.72±0.02
Total soluble sugars	2.22±0.02	13.87±0.30	5.02±0.06	6.42±0.03	7.50±0.04	8.46±0.02

^a Values are means ± standard deviations (n = 3).

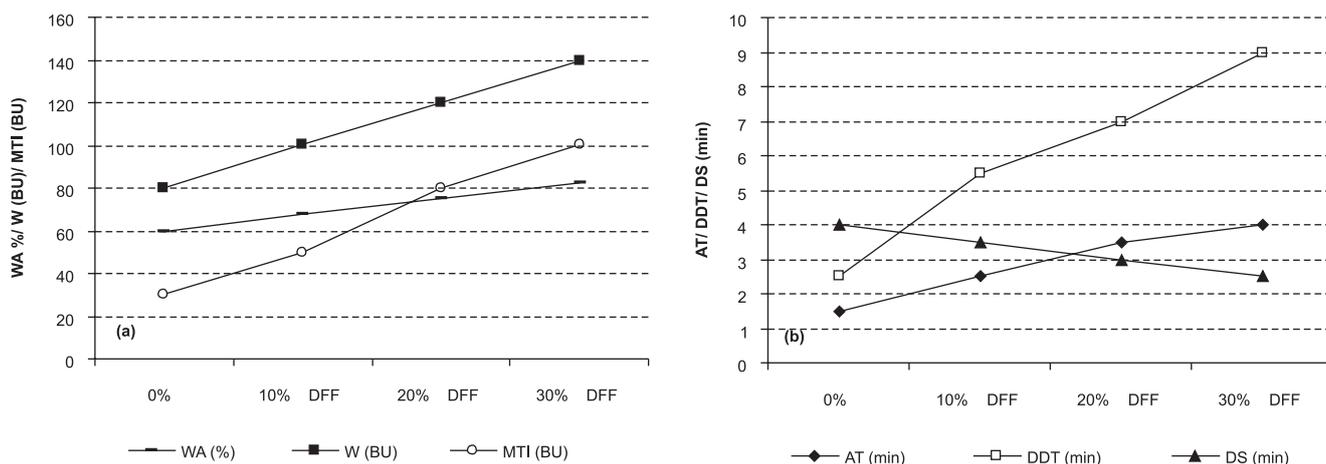


FIGURE 2. Effect of DFF on the farinograph characteristics: (a) WB: water absorption (%), W: weakening (BU), MTI: mixing tolerance index (BU); (b) AT: arrival time (min), DDT: dough development time (min) and DS: dough stability (min).

to all other cakes. There are no published taste panel data available on the sensory evaluation of DFF.

The physical properties of cakes are presented in Figure 4. As the concentration of DFF increased from 0% to 30%,

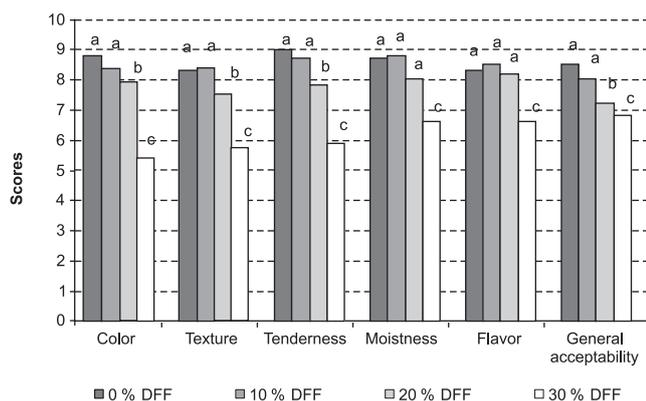


FIGURE 3. Effect of DFF replacement on sensory evaluation of prepared cakes (values were with different superscripts are significantly different at $p < 0.05$).

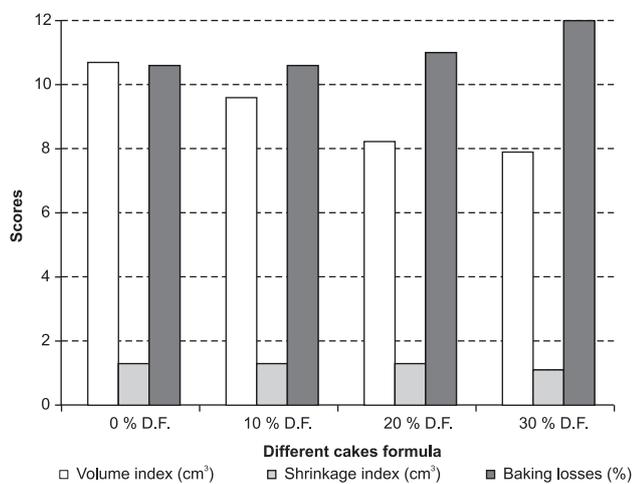


FIGURE 4. Effect of DFF replacement on physical characteristics of prepared cake.

the volume of the cakes decreased from 10.7 to 7.9 cm³ and the shrinkage index decreased from 1.3 to 1.1 cm³, while moisture content increased from 23.3 to 29.61% (Table 1). The same results were confirmed by Chen *et al.* [1988b] and Sudha *et al.* [2007] who reported that the volume and moisture content of the cakes increased due to the strong water binding properties of apple and apple pomace fiber.

Rat feeding experiments and lipids profile

Table 2 presents the mean changes in body weight, feed intake and feed efficiency ratio (FER). Significantly higher ($p < 0.05$) mean food intake was obtained among animal groups consuming the DFF-containing cake (10%, 20% and 30%) compared to the respective mean value obtained with the control cake containing 0% DFF and 2% cholesterol (positive control). This finding suggests that DFF cake was more palatable to the rats than the control one.

The mean gain in body weight per six weeks averaged 105.9, 101.5, 94.8 and 85.4 g upon the consumption of cakes containing 0%, 10%, 20% and 30% DFF, respectively. The lowest mean value was found among animal groups consuming diets containing 20 and 30% DFF ($p < 0.05$). This decrease in the body weight gain could be attributable to a reduced metabolizable energy of the diets containing DFF, due to its high fiber content (12.42 g/100 g DFF) resulting in lower mean values of FER [Lechel & Hermann, 1978]. Also, the water holding capacity (WHC) of dietary fiber is thought to be an important determinant of faecal bulking and intestinal transit times with influence on gastrointestinal disease [Holloway & Grieg, 1984].

As presented in Table 3, the plasma total cholesterol showed progressive decrease with increasing DFF proportion in the cake. The highest plasma HDL was obtained among rats consuming diet based on cake containing 30% DFF. The mean VLDL+ LDL / HDL ratio, an index of atherosclerosis, decreased gradually with the increase of DFF in the cakes (Table 3). The mechanism by which diet containing DFF lowers the plasma cholesterol and the LDL needs further investigations.

A phytochemical study identified five flavone glycosides in the ethanolic extract of doum fruit [Hashem, 1994].

TABLE 2. Experimental food intake, body weight gain and food efficiency ratio (FER) of rats on experimental diets for six weeks^a.

Parameter	Group 1 (Control)	Group 2 0% DFF	Group 3 10% DFF	Group 4 20% DFF	Group 5 30% DFF
Food intake (g)	524.6 ± 58.0 ^a	504.9 ± 36.8 ^b	541.9 ± 60.5 ^a	550.4 ± 32.5 ^a	570.9 ± 42.6 ^a
Body weight gain (g)	119.4 ± 5.36 ^a	105.9 ± 10.7 ^b	101.5 ± 12.18 ^b	94.8 ± 9.69 ^{bc}	85.4 ± 10.7 ^c
FER	0.228 ± 0.026 ^a	0.209 ± 0.013 ^b	0.188 ± 0.02 ^c	0.172 ± 0.018 ^c	0.149 ± 0.011 ^d

^a Food intake and body weight gain values are presented as means ± standard deviations of the means (n = 8). Values with different superscripts are significantly different (p < 0.05).

TABLE 3. Concentration of plasma lipid fractions of rats fed the experimental diets over six weeks^a.

Groups	Dietary cholesterol (%)	Lipid profile (mmol/L)				Atherosclerotic index ^c
		Triglycerides	Total cholesterol	HDL cholesterol	VLDL + LDL cholesterol ^b	
Group 1 – standard cake (control)	0	0.91 ± 0.190 ^a	2.21 ± 0.227 ^a	0.93 ± 0.095 ^d	1.28 ± 0.156 ^a	1.38 ± 0.131 ^a
Group 2 – standard cake (positive control)	2	1.17 ± 0.226 ^b	2.88 ± 0.351 ^c	0.65 ± 0.102 ^a	2.23 ± 0.264 ^d	3.47 ± 0.389 ^d
Group 3 – doum cake (10% DFF)	2	1.12 ± 0.138 ^b	2.59 ± 0.347 ^b	0.71 ± 0.088 ^{ab}	1.88 ± 0.273 ^c	2.67 ± 0.214 ^c
Group 4 – doum cake (20% DFF)	2	1.08 ± 0.118 ^{ab}	2.52 ± 0.173 ^b	0.77 ± 0.125 ^b	1.75 ± 0.072 ^{bc}	2.31 ± 0.310 ^b
Group 5 – doum cake (30% DFF)	2	1.05 ± 0.085 ^{ab}	2.48 ± 0.185 ^{ab}	0.82 ± 0.140 ^{cd}	1.65 ± 0.133 ^b	2.04 ± 0.389 ^b

^a Data are presented as means ± standard deviations of the means (n = 8). Values within a column with different superscripts are significantly different (p < 0.05). ^b LDL: low-density lipoprotein; VLDL: very low-density lipoprotein; VLDL + LDL -cholesterol = Total cholesterol - HDL -cholesterol; ^c Atherosclerotic index = (VLDL + LDL -cholesterol) / (HDL -cholesterol).

Cook *et al.* [1998] reported that total antioxidant capacity of the aqueous extract of doum fruit was highly possible due to substantial amount of water-soluble flavonoid glycosides. TLC analysis of hot water extract of doum fruit showed the presence of saponins, coumarins, hydroxycinnamates, essential oils and flavonoids [Betty *et al.*, 2006], which act to prevent or reduce oxidative stress by scavenging free radicals [Bravo, 1998; Sohal *et al.*, 2002; Eldahshan *et al.*, 2008; Jeong, 2009]. Vassalle *et al.* [2004] indicated an association between increased oxidative stress and atherosclerosis.

The water holding capacity (WHC) of dietary fiber is thought to be an important determinant of faecal bulking and intestinal transit times with influence on gastrointestinal disease [Holloway & Grieg, 1984].

CONCLUSION

This study revealed that flavour and general acceptability of cakes prepared with 10 and 20% DFF were more acceptable and had no adverse effect on quality compared to the control cakes. It is evident that DFF could be useful for preparation of functional food of potential application for those suffering from hyperlipidemia. The findings of this trial highlight the beneficial effect of doum fruit on human health.

REFERENCES

1. A.A.C.C., Approved methods of the AACC. 8th ed., American Association of Cereal Chemists, INC. St., Paul, 1988. Minnesota, USA.
2. A.O.A.C., Official Methods of Analysis of the Association of Official Analytical Chemists, 15th ed., Association of Official Analytical Chemists, 1990, Arlington, Virginia, USA.
3. Betty Hsu, Coupar M.I., Ken Ng., Antioxidant activity of hot water extract from the fruit of the Doum palm "*Hyphaene thebaica*". Food Chem., 2006, 98, 317–328.
4. Bravo L., Polyphenols: chemistry, dietary sources, metabolism, and nutritional significance. Nutr. Rev., 1998, 56, 317–333.
5. Chen H., Rubenthaler G.L., Schanus, E.G., Effect of apple fibre and cellulose on the physical properties of wheat flour. J. Food Sci., 1988a, 53, 304–305.
6. Chen H., Rubenthaler G.L., Leung H.K., Baranowski J.D., Chemical, physical and baking properties of apple fibre compared with wheat and oat bran. Cereal Chem., 1988b, 65, 244–247.
7. Cook J.A., VanderJagt, D.J., Dasgupta A., Mounkaila G., Glew R.S., Glew R.H., The use of the TROLOX assay to estimate the antioxidant content of 17 edible wild plants of Niger. Life Sci., 1998, 63, 105–110.
8. Cook J.A., VanderJagt D.J., Pastuszyn A., Mounkaila G., Glew R.S., Millison M., Glew H.R., Nutritional and chemical composition of 13 wild plant foods of Niger. J. Food Comp. Anal., 2000, 13, 83–92.
9. Cunningham A.B., The regional distribution, marketing and economic value of the palm wine trade in the Ingwavuma District, Natal, South Africa. South Afr. J. Botany, 1990, 56, 191–198.
10. De Fouw C., Zabik M.E., Uebersax M.A., Aguilera J.M., Lusas E., Use of unheated and heat-treated navy bean hulls as a source of dietary fiber in spice flavored layer cakes. Cereal Chem., 1982, 59, 229–230.

11. Doren, E.T., Vegetable ivory and other palm nuts/seeds as an art/craft medium. *J. Int. Palm Soc.*, 1997 (renamed as Palms since 1999), 41, 18–25.
12. Dosumu O.O., Nwosu F.O., Nwogu C.D., Phytochemical screening and anti-microbial studies of extracts of *Hyphaene thebaica* linn (Mart) Palmae. *Int. J. Trop. Med.*, 2006, 1, 186–189.
13. Duncan D.B., Multiple range and multiple F test. *Biometrics*, 1995, 11, 1–42.
14. Eissa H.A., Ramadan M.T., Ali H.S., Effect of natural extracts from the fruits of doum palm, carob and licorice on the quality and safety of apple slices. *J. Agric. Sci. Mansoura Univ.*, 2008, 33, 6609–6623.
15. Eldahshan O.A., Ayoub N.A., Singab A.B., Al-Azizi M.M., Potential superoxide anion radical scavenging activity of doum palm (*Hyphaene thebaica* L.) leaves extract. *Rec. Nat. Prod.*, 2008, 2, 83–93.
16. Eldahshan O.A., Ayoub N.A., Singab A.B., Al-Azizi M.M., Potential antioxidant phenolic metabolites from doum palm leaves. *Afr. J. Pharm. Pharmacol.*, 2009, 3, 158–164.
17. Exarchou V., Nenadis N., Tsimidou M., Gerathanassis I.P., Troganis, A., Boskou D., Antioxidant activities and phenolic composition of extracts from Greek oregano, Greek sage and summer savory. *J. Agric. Food Chem.*, 2002, 50, 5294–5299.
18. Fletcher R., Listing of useful plants of the world. Australian New Crops, 1997, [<http://www.newcrops.uq.edu.au/listing/hyphaenethebaica.Htm>].
19. Fossati P., Prinicip L., Serum triglycerides determined colorimetrically with an enzyme that produces hydrogen peroxide. *Clin. Chem.*, 1982, 28, 2077–2080.
20. Hadiwigeno S., Harcharik O.A., Tropical palms African and the western Indian Ocean region in [<http://www.fao.org/docrep/x045/E/x045/e09.htm>] published by the United Nations Food and Agriculture Organization, 1995.
21. Hashem A.N., Phytochemical investigation of the fruit of *Hyphaene thebaica* (L) Mart. growing in Egypt family palmae. 1994, MSc. Thesis, Faculty of Pharmacy, Cairo University, Egypt, pp. 72–88.
22. Hegazy N.A., Faheid S.M., Rheological and sensory characteristics of doughs and cookies based on wheat, soybean, chickpea and lupine flour. *Die Nahrung*, 1990, 34, 835–841.
23. Holloway W.D., Grieg R., Water holding capacity of hemicelluloses from fruits, vegetables and wheat bran. *Food Sci.*, 1984, 49, 1632–1633.
24. Jeong J.B., Ju S.Y., Park J.H., Lee J.R., Yun K.W., Kwon S.T., Lim J.H., Chung G.Y., Jeong H.J., Antioxidant activity in essential oils of *Cnidium officinale makino* and *Ligusticum chuanxiong hort* and their inhibitory effects on DNA damage and apoptosis induced by ultraviolet B in mammalian cell. *Cancer Epidem.*, 2009, 33, 41–46.
25. Kamis A.B., Modu S., Zanna H., Oniyangi T.A., Preliminary biochemical and haematological effects of aqueous suspension of pulp of *Hyphaene thebaica* (L) mart in rats. *Biochemistry*, 2003, 13, 1–7.
26. Kinsella J.E., Functional properties of protein food. *Crit. Rev. Food Sci.*, 1976, 1, 219–229.
27. Laurikainen T., Harkonen H., Autio K., Poutanen K., Effects of enzymes in fiber-enriched baking. *J. Sci. Food Agric.*, 1998, 76, 239–249.
28. Lechel K., Hermann K., Calorie-reduced or low calorie foods in the diet. *Ernahrungs-Umschau*, 1978, 25, 16–21.
29. Lopes-Virella M.F., Stone P., Ellis S., Colwell J.A., Cholesterol determination in high-density lipoproteins separated by three different methods. *Clin. Chem.*, 1997, 23, 882–884.
30. Lund E.D., Cholesterol binding capacity of fiber from tropical fruits and vegetables. *Lipids*, 1984, 19, 85–90.
31. Martin F.W., Palm for stable foods. 1999, *in: Multipurpose Palms You Can Grow. Metabolism and Nutritional Significance* (ed. C. Elevitch). *Nutr. Rev.*, 56, 317–333.
32. Middleton E. Jr, Kandaswami C., Theoharides T.C., The effects of plant flavonoids on mammalian cells: implications for inflammation, heart disease, and cancer. *Pharmacol. Rev.*, 2000, 52, 673–751.
33. Mohamed Amal A., Khalil A.A., El-Beltagi H.E.S., Chemical compositions and antioxidant/antimicrobial activities of kaff maryam (*Anastatica hierochuntica*) and doum palm (*Hyphaene thebaica*) cultivated in Egypt. *Biyoloji Bilimleri Araştırma Dergisi*, 2009, 2, 71–79.
34. Nwosu F.O., Dosumu O.O., Okocha J.O.C., The potential of *Terminalia catappa* (Almond) and *Hyphaene thebaica* (Dum palm) fruits as raw materials for livestock feed. *Afr. J. Biotechnol.*, 2008, 7, 4576–4580.
35. Richmond W., Preparation and properties of a cholesterol oxidase from *Nocardia* sp. and its application to the enzymatic assay of total cholesterol in serum. *Clin. Chem.*, 1973, 19, 1350–6.
36. Sharaf A., Sour A., Gamaa N., Youssef M., Some pharmacological studies on *Hyphaene thebaica*. *Qualities Planetarium Matriae Vegetable*, 1972, 22, 83–90.
37. Shariff Z.U., Modern Herbal Therapy for Common Ailments. Nature Pharmacy Series, 2001, 1, Spectrum Books Ltd., Ibadan, Nigeria in Association with Safari Books (Export) Ltd. UK, pp. 9–84.
38. Shouk A.A., Ramadan M.T., Effect of defatted rice bran addition on the quality of pan bread and biscuit. *Minufiya J. Agric. Res.*, 2007, 32, 1019–1036.
39. Smith A.K., Circle S.J., Proteins. 1971, *in: Soybeans: Chemistry and Technology*, vol. I, AVI Publishing Company, INC., Wesport, Connecticut, USA, pp. 213–216.
40. Sohal R.S., Mockett R.J., Orr W.C., Mechanisms of aging: an appraisal of the oxidative stress hypothesis. *Free Rad. Bio. Med.*, 2002, 33, 575–586.
41. Soong Y.Y., Barlow P.J., Antioxidant activity and phenolic of selected fruit seeds. *Food Chem.*, 2004, 88, 411–417.
42. Sudha M.L., Baskaran V., Leelavathi K., Apple pomace as a source of dietary fiber and polyphenols and its effect on the rheological characteristics and cake making. *Food Chem.*, 2007, 104, 686–692.
43. Swedell L., Hailemeskel G., Schreier A., Composition and seasonality of diet in wild Hamadryas Baboons: Preliminary findings from Filoha. *Folia Primatol.*, 2008, 79, 476–490.
44. USAID FEWS Bulletin, East Africa and the Horn. 1995, *in: [http://www.FEWS.ORG/Fb951223/hrbx9512]*, published by the United States Agency for International Development (USAID).
45. Vassalle C., Petrozzi L., Bollo N., Andressi M.G., Zucchelli G.C., Oxidative stress and its association with coronary artery disease and different atherogenic risk factors. *J. Int. Med.*, 2004, 256, 308–15.

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