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EFFECT OF THE ADDITION OF DEFATTED DATE SEEDS ON WHEAT DOUGH PERFORMANCE AND BREAD QUALITY

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ABSTRACT

Defatted palm date seeds (date seed fiber concentrate: DSFC) of two varieties, Allig and Deglet Nour, were milled into two fractions: fine (particle size ≤ 280 μm) and coarse (280 μm $<$ particle size ≤ 600 μm). DSFC was used to replace wheat flour in bread at 1 and 3% replacement levels. Dough and bread evaluation revealed that the addition of DSFC with fine size caused the decrease of bread volume, the change of crumb color and slightly increase bread crumb firmness. On the other hand, the addition of DSFC with a coarse size affected the mixing characteristics, decreased significantly the specific volume exceptionally at 3% and the bread crumb firmness ($P < 0.05$). An enrichment of bread with DSFC at 1 or 3% increased the dietary fiber contents in bread with lightly adverse effects on bread quality.

PARACTICAL APPLICATION

Tunisia is considered to be one of the dates-producing countries. The mean annual yield of date fruits is about 125,000 tons. From this, around 12,500 tons of date seeds could be collected. This by-product of date processing industries could be regarded as an excellent source of dietary fiber with interesting technological functionality and many beneficial effects on human health.

Then, date seeds could present a value addition by extraction and use of date seed fiber concentrate in bread formulation.

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KEYWORDS

Bread, date seeds, dough, texture

INTRODUCTION

The importance of dietary fiber (DF) has been demonstrated in many studies. The current recommendations for the daily intake of fiber range from 25 to 30 g (Asp 2004). The development of DF enriched is one of the efficient ways to increase the DF intake (Wang *et al*. 2002; Sangnark and Noomhorm 2004; Goesaert *et al*. 2005). The most common source of fibrous materials, which can be incorporated into bakery products, is cereal bran, particularly wheat bran. However, additions of cereal bran affected negatively the final bread quality (Lai *et al*. 1989; Ranhotra *et al*. 1990; Sidhu *et al*. 1999). Bran supplementation usually modifies the structure and baking quality of wheat dough, decreases bread volume (Salmenkallio-Marttila *et al*. 2001) and enhances firmness of crumb bread (Laurikainen *et al*. 1998). The deleterious effects of fiber addition on dough structure was explained by the dilution of gluten network (Pomeranz *et al*. 1977) and presence of bran particles forcing gas cells to expand in a particular dimension (Gan *et al*. 1992). So, investigations need to be directed toward other possible sources, including defatted palm date seeds.

Date seeds (*Phoenix dactylifera* L.) are by-products, which could be easily recovered, in the technological or biological dates-processing industries (Al-Obaidi and Berry 1982). Date seed represents nearly 10–15% of the total weight of the fruit (Almana and Mahmoud 1994). Chemical composition of date pits showed high amounts of fiber (75–80%), fat (10–12%) and proteins (5–6%) (El-Shurafa *et al*. 1982; Devshony *et al*. 1992; Al-Hooti *et al*. 1998; Hamada *et al*. 2002; Besbes *et al*. 2004a, 2005b).

This by-product of date-processing industries could be regarded as an excellent source of food ingredients with interesting technological functionality that could also be used in food as an important source of DF (Hamada *et al*. 2002; Besbes *et al*. 2004a,b,c, 2005, 2009, 2005a; Bouaziz *et al*. 2008).

Few works are interested to study the supplementation of bread with a palm date seed powdered. Heated defatted Agwa and Aprimi seeds, added at levels of 1 and 3%, enhanced bread quality and re-treated staling scene (Wasif 1996). Almana and Mahmoud (1994) showed that the coarse fraction affected the mixing characteristics and extensograph parameters in a relatively similar manner to wheat bran, but the fine fraction behaved in a different manner, they caused deterioration in bread color, flavor, odor, chewing, uniformity and overall acceptability.

This paper reports on value addition to date seeds from the most produced and consumed Tunisian varieties: (Deglet Nour and Allig), through preparation of date seed fiber concentrate (DSFC). The effect of addition of DSFC on physicochemical properties of dough and bread is also investigated.

MATERIALS AND METHODS

Materials

The seeds of the two cultivars under investigation (Deglet Nour and Allig) were directly isolated from one Bach of 50 kg of date fruit from Degach region (Tunisia), collected at the "Tamr stage" (full ripeness) and kept at 10C for a week. The seeds were soaked in water, washed to get rid of any adhering date flesh and then air-dried. They were also further dried at about 50C. Date pits of each variety were separately milled in a heavy-duty grinder. The obtained powdered date pits were divided into three samples and preserved at −20C until analyses.

Lipid extraction was carried out as described by Besbes *et al*. (2004a) with a SER 148 Solvent Extractor (Velp Scientifica, Italy) equipped with six Soxhlet posts. The extraction was carried out over 30 min, with thimbles immersed in boiling petroleum ether, and 60 min of reflux washing.

Particle Size Preparation

Ground samples of defatted date seeds, each weighing approximately 30 g, were separated according to particle size using a sieve shaker (Model VE 100, Retch, Germany). Mesh size of sieves was 1,000, 600 and 280 μm. Each sample was placed in the top sieve with the largest mesh and shaken for 5 min, disassembled and stirred lightly then shaken for an additional 5 min. Two fractions were used for the substitution of the wheat flour bread: fine size DSFC (particle size < 280 μm) and coarse size DSFC (280 μm $<$ particle size < 600 μm).

Chemical Analysis of Defatted Date Seeds

All analytical values were determined using three independent determinations. Values of different parameters were expressed as the mean ± standard deviation (x ± SD).

Dry matter was determined according to the Association of Official Analytical Chemists (AOAC 1995).

Neutral detergent fiber (NDF) content, acid detergent fiber (ADF) content and acid detergent lignin (ADL) content were determined according to the procedure of Van Soest (1963).

This methods used for estimating detergent fiber and lignin fractions are based on extraction of soluble components to remove protein and other materials. Briefly, 1 g of DSFC (W0) with 100 mL of solution containing EDTA, sodium borate, sodium lauryl sulfates, 2-éthoxyethanol and disodium hydrogenophosphate (100C, 1 h). Then, the mixture was filtered and washed with warm water and acetone. The residues (W1) were dried (103C, 24 h) and incinerated in muffle furnace at 550C for 4 h (W2).

$$NDF = \frac{W1 - W2}{Wo} \times 100 \times dry\ matter$$

ADF was determined by using 1 g of DSFC (*W*0) with 100 mL of ADS reagent (1/50 w/v of cetyl-trimethyl-ammonium bromide with sulfuric acid 1N (100C, 1 h). Then, the mixture was filtered and washed with warm water and acetone. The residues (*W*1) were dried (103C, 24 h). Then, they were hydrolyzed with sulfuric acid (72%, 3 h), filtered and washed with warm water until pH 7 was obtained. These residues were dried (103C, 24 h) (*W*2) and incinerated at 550C for 4 h (w3).

$$ADF = \frac{w1 - w2}{wo} \times 100 \times dry\ matter$$

$$ADL = \frac{w2 - w3}{wo} \times 100 \times dry\ matter$$

Water- and Oil-Holding Capacity

The method of Moure *et al.* (2001) was used with some modifications. One gram of defatted date seed samples was stirred in 10 mL of distilled water or corn oil and then centrifuged at 6,000 rpm and room temperature for 20 min. The volume of the supernatant was measured. Water-holding capacity (WHC) was expressed as the number of grams of water held by 1.0 g of defatted date seed sample. Oil-holding capacity (OHC) was expressed as the number of grams of oil held by 1.0 g of defatted date seed sample.

Measurements of Color

The CIE Lab parameters *(L^*, a^*, b^*)* were directly read with a spectrophotocolorimeter MS/Y-2500 (Hunterlab, Inc., Reston, VA), calibrated with a white tile. In this coordinate system, the L^* value is a measure of lightness, ranging from 0 (black) to 100 (white); the a^* value ranges from −100 (green) to +100 (red) and the b^* value ranges from −100 (blue) to +100 (yellow).

Dough Preparation and Baking Procedure

Dough constituents were: wheat flour enriched by fine or coarse DSFC (1 and 3%) having (particle size $\leq 280\ \mu m$ and $280\ \mu m <$ particle size $\leq 600\ \mu m$, respectively), salt (2%), yeast (2.5%) and 1% of additive. 10

Breads were prepared by mixing dough constituents and water in two stages with a Kenwood robot.

(1) A low speed, during 1 min and 30 s, mixing dry the flour and the other components excepted salt. 11
(2) Addition of water and increased speed during 5 min. Salt was added at the last minute.

After mixing, dough was fermented for 45 min in the chamber of fermentation (Salva AR 2201, Germany) at 30C and 90% of relative humidity. Then, dough pieces were divided (into 500 g) and molded mechanically. Doughs were proofed in pans for 35 min at 30C and baked in a furnace (Salva EM 2004, A2, Germany) at 220C for 25 min. After 2 h of cooling, breads were packed in plastic bags and bread quality was evaluated after 24 h at room temperature.

Dough Characteristics

The effect of defatted date seeds on dough rheology during mixing was determined by a Farinograph (Brabender, Germany) (ISO 5530-1 1997). The determined parameters were:

(1) Water absorption (WA) or percentage of water required to yield dough consistency of 500 BU (Brabender Units);
(2) Dough development time (DDT): is a time (min) to reach maximum consistency;
(3) Stability: it is the time dough consistency that remains at 500 BU (min); 12
(4) Mixing tolerance index (MTI): is a consistency difference between height at peak and that 12 min later (unit Brabender). 13 14

Measurement of Loaf Volume

Loaf volume (cm^3) was determined using a loaf volumeter (Puratos, Belgium). Colza seed displacements were used.

The specific volume of bread (cm^3/g) is given by the relationship between the volume and weight of the bread.

Crumb Firmness Measurements

Crumb firmness and springiness were determined according to the standard method published by the American Association of Cereal Chemistry

(AACC 1998) using a “Hold Until Time test” performed by Texture Analyser (TA-XT2; Stable Micro systems, Survey, U.K.). After 24 h at room temperature, two slices of bread were compressed with a 3.5-cm-diameter cylindrical probe using the same speed as the firmness measurement to 50% of strain, held for 60 s, and then removed. Firmness corresponds to the maximum peak force value. The springiness values were determined as a ratio of constant force during time holding to the peak force before time holding.

Statistical Analysis

Duncan’s test, at the level of $P \leq 0.05$, was applied to data to establish significance of difference between the samples. Statistical analyses were performed on statistical analysis package STATISTICA (Release 5.0 Stat Soft Inc., Tulsa, OK).

RESULTS AND DISCUSSION

Chemical Composition

Table 1 shows the chemical composition of DSFC from Deglet Nour and Allig varieties. No statistical difference was observed between the two varieties studied concerning NDF content. NDF content is about 70.18 and 70.81% for Allig and Deglet Nour, respectively. Thanks to this high content in [15] fiber, the defatted date pits can beings considered as a fiber concentrate (FC) and beings used as ingredient in dietetic food formulations. These values were

TABLE 1.
COMPOSITION OF DSFC FROM DEGLET NOUR AND ALLIG SEED*

Component (%)	Deglet Nour	Allig
Dry matter	$90.45^{a} \pm 0.24$	$91.4^{b} \pm 0.10$
Neutral detergent fibers	$70.81^{a} \pm 0.25$	$70.18^{a} \pm 0.17$
Acids detergent fibers	$50.80^{a} \pm 0.92$	$56.78^{b} \pm 0.56$
Lignin (ADL)	$0.11^{a} \pm 0.01$	$0.14^{b} \pm 0.01$
Cellulose	$50.69^{a} \pm 0.91$	$56.64^{b} \pm 0.70$
Hemicelluloses	$20.01^{a} \pm 0.68$	$13.40^{b} \pm 0.17$

Values in lines with different letters are significantly different ($P \leq 0.05$).
* Dry matter basis.
DSFC, defatted date seed fiber concentrate; ADL, acid detergent lignin.

slightly lower than those of DSFC from Fard (74.30%) and Lulu (74.50%) varieties and similar to that of Khalas (69.40%) variety studied by Hamada *et al*. (2002).

Allig DSFC presented higher ADF content compared to Deglet Nour DSFC ($P \leq 0.05$). ADF in DSFC from Deglet Nour and Allig varieties (50% and 56%, respectively) were similar than those of DSFC from Fard (50.20%), Lulu (54.00%) and Khalas (54.40%) varieties studied by Hamada *et al*. (2002).

Allig DSFC presented a significantly higher content of celluloses (~56%) than those from Deglet Nour DSFC (~50%) ($P \leq 0.05$). However, Deglet Nour DSFC contained higher hemicelluloses content (20% against 13%). These contents are comparable with those of DSFC from Khalas (14.95%), Fard (24.10%) and Lulu (21.35%) varieties studied by Hamada *et al*. (2002).

DSFC from Deglet Nour and Allig presented low content of lignin compared with the content of celluloses and hemicelluloses.

Evaluation of the CF Color from Date Seeds

Table 2 presents the CIE Lab (L^*, a^* *and* b^*) parameters of DSFC. No significant differences were observed for a^* value of the two DSFC ($P \geq 0.05$), both having a slightly brown color. DSFC from Deglet Nour variety was characterized by slightly higher L^* and b^* values compared to the Allig DSFC. This suggests that the latter is slightly darker.

It is also important to note that fine fractions of DSFC are darker than coarse fractions (Table 2).

Indeed, e.g., a^* of Deglet Nour DSFC is 13.09 or 10.27 according to particle size as fine or coarse, respectively. A same result was observed for the CF of Allig seeds. This could be explained by a better extraction of the pigments responsible for the dark color. The CFs of date seeds are true natural 16

TABLE 2.
CIE LAB PARAMETERS (L^*, a^*, b^*) OF DSFC FROM THE TWO STUDIED VARIETIES (FINE AND COARSE FRACTION)

Parameters	DSFC			
	Deglet Nour	Allig	Deglet Nour	Allig
	Particle size ≤280 μm		280 μm < Particle size ≤600 μm	
L^*	$56.25^a \pm 0.58$	$51.28^b \pm 0.45$	$55.88^a \pm 0.02$	$51.41^b \pm 0.35$
a^*	$13.09^a \pm 0.23$	$12.58^a \pm 0.56$	$10.27^b \pm 0.24$	$10.54^b \pm 0.11$
b^*	$20.55^a \pm 0.15$	$17.42^b \pm 0.22$	$17.64^b \pm 0.02$	$17.49^b \pm 0.13$

Values in lines with different letters are significantly different ($P \leq 0.05$).
DSFC, defatted date seed fiber concentrate

dyes, and by consequence, their incorporation in the foodstuffs has an effect on the color of the finished product (Hamada *et al.* 2002).

WHC of DSFC

Table 3 presents the WHC of DSFC of the two studied varieties. DSFC showed a WHC significantly similar for the two studied particle sizes ($P \leq 0.05$) (3.88, 3.73 g water/g of DSFC from Allig and 3.52, 3.50 g water/g of DSFC from Deglet Nour). These values were lower than those reported in [17] other fruit FCs, such as in date fruit (15.45–15.90) (Elleuch *et al.* (2008), peach and orange (7.30–12.10 g water/g sample) (Grigelmo-Miguel and Martin-Belloso 1999b). This could probably be explained by the harder texture [18] of date seeds. The high percentages of fiber, especially polysaccharides, are the origin of high WHC of DSFC (Macconnell *et al.* 1974; Fleury and Lahaye 1991). This relatively high WHC allows the use of DSFC as an ingredient for improvement as sensory proprieties of formulated product. Addition of DSFC [19] could be also effective to reduce water activity of food and then to improve [20] their stability during storage (Mansour and Khalil 1997; Grigelmo-Miguel and Martin-Belloso 1999b). WHC could be affected by size, shape, hydrophilic and hydrophobic interactions and the presence of lipids, carbohydrates and amino acid residues on the surface (Damodaran and Paraf 1997; Moure *et al.* [21] 2001).

OHC of DSFC

Table 3 shows OHC of DSFC that no statistical difference was observed between DSFC from the two studied date varieties whatever the particle size (fine and coarse fractions) ($P > 0.05$). DSFC was characterized by a lower OHC (1 g oil/1 g of FC) compared to other DF such as sugarcane bagasse fiber (3.26 g oil/g fiber) (Sangnark and Noomhorm 2003) and that of defatted rice [22] bran fiber (4.54 g oil/g fiber) (Abdul-Hamid and Siew Luan 2000). However, [23] [24]

TABLE 3.
WATER-HOLDING AND OIL-HOLDING CAPACITIES OF DSFC

Proprieties		Particle size ≤280 μm	280 μm < Particle size ≤600 μm
WHC (g water/g DSFC)	DSFC Deglet Nour	$3.52^{a} \pm 0.60$	$3.50^{a} \pm 0.70$
	DSFC Allig	$3.88^{a} \pm 0.20$	$3.73^{a} \pm 0.30$
OHC (g oil/g DSFC)	DSFC Deglet Nour	$1.05^{b} \pm 0.30$	$1.06^{b} \pm 0.20$
	DSFC Allig	$1.09^{b} \pm 0.25$	$1.08^{b} \pm 0.30$

Values in lines and rows with different letters are significantly different ($P \leq 0.05$).
WHC, water-holding capacity; OHC: oil-holding capacity; DSFC, defatted date seed fiber concentrate.

OHC of DSFC is similar to that of peach fiber (1.09 g oil/g fiber) (Grigelmo-Miguel and Martin-Belloso 1999a) and to that of orange fiber (1.27 g oil/g fiber) (Grigelmo-Miguel and Martin-Belloso 1999b). This low OHC could be explained by composition and structure of absorbent components from DSFC (celluloses and hemicelluloses) and their surface properties (Caprez *et al.* 1986; Fleury and Lahaye 1991).

DSFC could thus be used as an ingredient to stabilize food products slightly rich in oil.

Influence of Fibers on Dough Properties

The addition of DSFC could promote differences on the dough mixing behavior measured by the farinograph (dough at 1 and 3% of DSFC with fine and coarse fractions). Table 4 shows the main parameters registered in the farinogram. Significant variations were observed between control and dough enriched by DSFC ($P \leq 0.05$). The WA and DDT were not affected by DSFC variety and particle size. However, Addition of DSFC increased slightly the WA. This could be related to the structure and composition of the added fiber. Similar results were observed in dough fortified with pea, lentils and chickpea hulls (Dalgetty and Baik 2006), pea fiber, carob fiber (Wang *et al.* 2002), wheat bran (Pomeranz *et al.* 1977), rye bran (Laurikainen *et al.* 1998) and rice bran (Barber *et al.* 1981). The increase of WA could be explained by the important number of hydroxyl groups existing in the fiber structure which allow more water interactions through hydrogen bonding (Wang *et al.* 2002). These results explained an improvement of the dough output and thereafter a reduction in the mass of finished product (Table 4).

DDT of dough supplemented by DSFC was 3.1–3.3 min, whatever the rate substitution, the finest and the coarsest particles used. This DDT was slightly higher than those of dough control (2.8 min). These results were in agreement with those found by Laurikainen *et al.* (1998) which substituted the corn flour by the rye fiber. However, our results are in opposition to those of Wang *et al.* (2002) who found that the addition of the carob, inulin and pea fiber does not modify the DDT.

Stability of dough enriched by fine particles size DSFC (13.50–16.00 min) was higher than those of dough enriched by coarse particles size DSFC (11.80–12.40 min).

The use of DSFC increased significantly the stability of dough compared to the control (10.90 min) ($P \leq 0.05$). This could be explained by higher interactions between DSFC, water and flour proteins (gluten). In fact, although the WHC of DSFC is high, the same water quantity was added for dough preparation. Then, the obtained dough presented higher firmness and stability during mixing. However, this higher firmness will cause lower extensibility in oven and then lower bread's volume (Table 5). 25

TABLE 4.
FARINOGRAPH ANALYSIS OF WHEAT DOUGH CONTAINING DSFC

Parameters	Control	DSFC-DN				DSFC-AL			
		Particle size ≤280 μm		280 μm < Particle size ≤600 μm		Particle size ≤280 μm		280 μm < Particle size ≤600 μm	
DSFC Level	0%	1%	3%	1%	3%	1%	3%	1%	3%
WA (%)	$56.30^{a} \pm 0.10$	$59.65^{b} \pm 0.15$	$59.85^{b} \pm 0.15$	$59.55^{b} \pm 0.05$	$59.60^{b} \pm 0.10$	$59.60^{b} \pm 0.10$	$59.80^{b} \pm 0.10$	$59,50^{b} \pm 0,10$	$59,75^{b} \pm 0,25$
DDT (min)	$2.80^{a} \pm 0.20$	$3.10^{b} \pm 0.10$	$3.20^{b} \pm 0.20$	$3.20^{b} \pm 0.20$	$3.20^{b} \pm 0.20$	$3.20^{b} \pm 0.20$	$3.30^{b} \pm 0.10$	$3.20^{b} \pm 0.20$	$3.30^{b} \pm 0.10$
Stability (min)	$10.90^{a} \pm 0.30$	$14.00^{b} \pm 0.30$	$16.00^{c} \pm 0.20$	$12.00^{d} \pm 0.10$	$12.20^{d} \pm 0.30$	$13.50^{b} \pm 0.50$	$15.50^{c} \pm 0.40$	$11.80^{d} \pm 0.20$	$12.40^{d} \pm 0.20$
MTI (UB)	$60.50^{a} \pm 3$	$60.00^{a} \pm 3$	$42.00^{b} \pm 4$	$59.00^{a} \pm 2$	$57.00^{a} \pm 3$	$58.00^{a} \pm 1$	$41.00^{b} \pm 2$	$59.00^{a} \pm 2$	$57.50^{a} \pm 3$

Values in lines with different letters are significantly different ($P \leq 0.05$).
WA, water absorption; DDT, dough development time; MTI, mixing time index; UB, unit Brabender; DSFC, defatted date seed fiber concentrate; DSFC-DN, dough enriched with DSFC from Deglet Nour seed; DSFC-AL, dough enriched with DSFC from Allig seed.

TABLE 5.
VOLUME, WEIGHT AND SPECIFIC VOLUME OF BREAD ENRICHED DSFC

Parameters	Control bread	DSFC- DN bread				DSFC-AL bread			
		Particle size ≤280 μm		280 μm < Particle size ≤600 μm		Particle size ≤280 μm		280 μm < Particle size ≤600 μm	
DSFC Level	0%	1%	3%	1%	3%	1%	3%	1%	3%
Volume (cm^3)	$3687.95^a \pm 1.20$	$2599.60^b \pm 1.85$	$2610.96^c \pm 1.15$	$3581.57^d \pm 2.52$	$2449.45^e \pm 2.82$	$2515.45^f \pm 1.10$	$2495.24^f \pm 2.50$	$3491.47^g \pm 1.03$	$2161.70^h \pm 2.73$
Weight (g)	$446.01^a \pm 0.18$	$437.78^{bd} \pm 2.4$	$438.78^b \pm 1.23$	$434.86^{bcd} \pm 1.66$	$434.45^{bcd} \pm 1.96$	$432.83^{cd} \pm 2.37$	$434.63^{bcd} \pm 2.19$	$431.9^c \pm 0.40$	$431.24^c \pm 1.57$
Specific volume (cm^3/g)	$8.26^a \pm 0.00$	$5.93^b \pm 0.02$	$5.95^b \pm 0.01$	$8.23^a \pm 0.02$	$5.63^c \pm 0.01$	$5.81^d \pm 0.02$	$5.74^e \pm 0.02$	$8.08^a \pm 0.00$	$5.01^g \pm 0.01$

Values in lines with different letters are significantly different ($P \leq 0.05$).
DSFC, defatted date seed fiber concentrate; DSFC-DN bread, bread enriched with DSFC from Deglet Nour seed; DSFC-AL bread, bread enriched with DSFC from Allig seed.

No statistical difference was observed between control and dough supplemented with DSFC concerning MTI, except the dough enriched with 3% of fine fraction which presented a lower MTI. These results could be explained by the interactions between fiber and gluten, as suggested by Chen *et al.* (1988). The farinogram result shows that the addition of the defatted date seeds confers two different mixing properties of dough probably due to the variation of the origin of fiber, their compositions, extraction methods and supplementation rate.

Influence of DSFC Addition on Bread Quality Evaluation

Volume and Weight of Bread. The effects of DSFC addition of date seeds on the bread volumes and weights are seen in Table 5. The loaf volume of fortified breads with DSFC was lower than the bread control, whatever the addition level and particle size ($P < 0.05$). These results were similar to those reported by Dalgetty and Baik (2006), Wang *et al.* (2002) and Pomeranz *et al.* (1977), who proved that the addition of fiber in bread formulation reduces volume. The highest volume of bread enriched by date seeds is obtained starting from flour with 1% of DSFC from Deglet Nour with a coarse fraction. The smaller is obtained starting from flour with 3% of DSFC from Allig with a coarse fraction. 26

In terms of specific bread volume, DSFC promoted a significant decrease ($P < 0.05$) except for DSFC coarse fraction at 1% of supplementation. The reductions obtained were comparable to those previously reported for the addition of fiber of pea, lentils and chickpea hulls (Dalgetty and Baik 2006), carob (Wang *et al.* 2002), wheat bran (Pomeranz *et al.* 1977), rye bran (Laurikainen *et al.* 1998) and rice bran (Barber *et al.* 1981). 27

The breads baked from dough containing 1–3% DSFC (fine and coarse fractions) exhibited lower weights than the control. This is probably due to the lowest water retention during baking, the hardness of date seeds, the particles size and substitution levels. Similar results were observed by Dalgetty and Baik (2006) when loaf weights of breads containing soluble fiber showed a decreasing trend when increasing the level of substitution 1–3% but increasing with 3–5% soluble fiber. In fact, breads supplemented by Deglet Nour DSFC have higher weights than those supplemented by Allig DSFC (Table 5).

External Appearance of Breads. Figure 1 shows the aspect of the crust of the different breads obtained by DSFC addition. The color of the crust of DSFC-enriched bread is similar with that of the control.

Breads enriched by 1 and 3% by a coarse DSFC from Allig or Deglet Nour seeds have a uniform and acceptable aspect, with a brown gilded color of the crust. In opposition, breads enriched by 1–3% of the fine DSFC from Allig

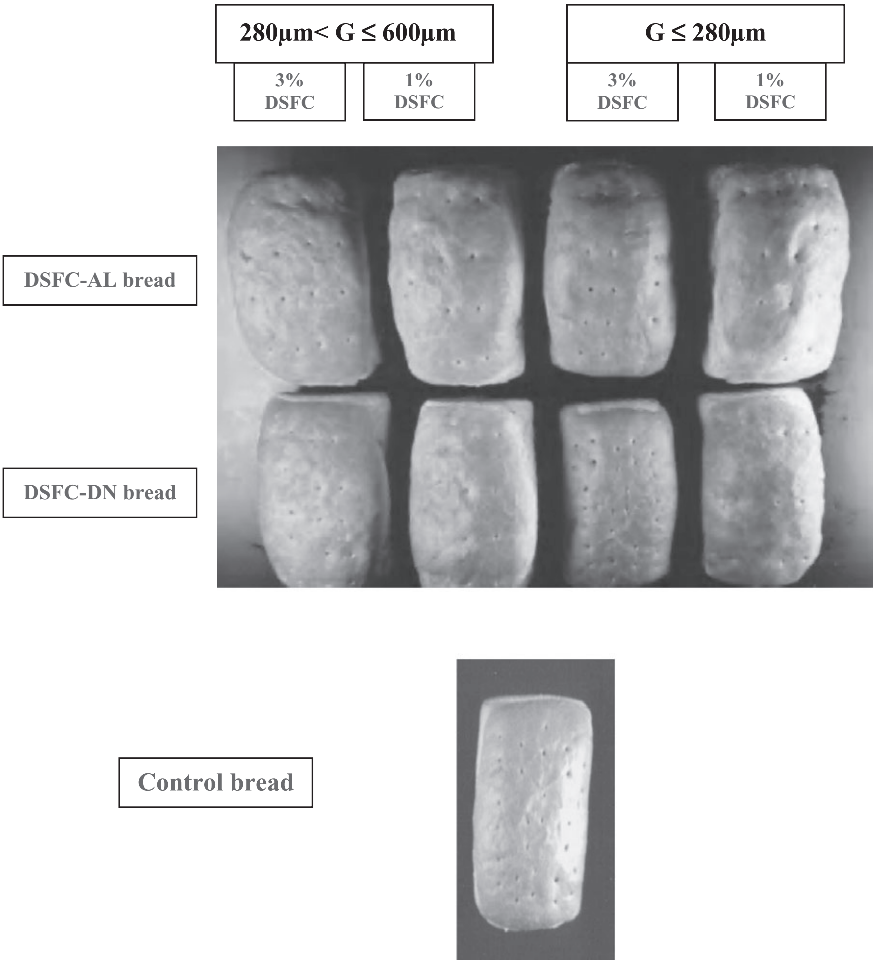

FIG. 1. EXTERNAL APPEARANCE OF BREADS ENRICHED WITH DSFC FROM THE TWO STUDIED VARIETIES 44
DSFC, defatted date seed fiber concentrate; DSFC-DN bread, bread enriched with DSFC from Deglet Nour seed; DSFC-AL bread, bread enriched with DSFC from Allig seed.

or Deglet Nour have a thicker, irregular and darker crust. Residual protein and short-chain carbohydrates in the DSFC probably contributed to the darker crust color through the development of Maillard reaction pigments. Similar results were observed by Dalgetty and Baik (2006) when the crust of breads containing soluble fiber was much darker than other breads enriched by hull fiber and insoluble fiber. In fact, it is important to note that the obtaining an 28 excellent appearance of bread, coarse fraction (280 μm < particle size $\leq$ 600 μm) could be used whatever the substitution rate (1 or 3%) of DSFC. These results were comparable to those previously reported by Almana and Mahmoud (1994).

Crumb Structure and Color. The crumbs of control bread are characterized by regular cell distribution, predominant round cells and some lengthened cells (Fig. 2). Enriched DSFC bread exhibited a less uniform crumb structure when compared with the control. For breads supplemented with 3% of fine DSFC, crumb cells seemed to be smaller and more condensed. This observation correlated well with the high density of these breads (lower specific volume).

Table 6 reproduces the values of CIE Lab parameters (L^*, a^* and b^*) of the bread crumbs supplemented by 1 and 3% DSFC from Deglet Nour and Allig. Indeed, the control bread showed white crumbs ($L^* = 81.24$). The bread crumbs with DSFC were darker and more red and less yellow colored (i.e., L^* and b^* decreased an a^* increased) compared to the control bread crumbs (Fig. 2).

The crumb color of bread supplemented by the fine DSFC (particle size <280 μm) tended to be gray pinkish. In opposition, those enriched with coarse particle changed slightly compared to the control bread. In general, the color of the bread crumbs was not dramatically affected by the substitution of coarse fraction (280 μm < particle size $\leq$ 600 μm).

Crumb Texture

Table 7 presents textural parameters of breads supplemented by DSFC determined 24 h after cooking.

Elasticity was not significantly different for DSFC-supplemented breads and control. It was almost identical than the control bread whatever particle size (fine or coarse fraction) and the incorporation rate (1–3%).

There was no statistical difference between DSFC-supplemented bread crumb firmness and the control. Indeed, at 1–3% fine fraction DSFC, firmness was slightly higher than the control bread crumbs. For example, firmness of fine DSFC-enriched bread crumbs are 7.6–7.9 N against 7.0 N for the control. However, for coarse fraction DSFC, firmness was slightly lower (6.6 N) than the control (7.0 N).

On the other hand, firmness is a function of the particle size (fine and coarse fractions). There was a significant difference between coarse fraction DSFC-supplemented bread and fine fraction-supplemented bread ($P \leq 0.05$). Whatever the substitution rate (1–3%), the firmness of coarse fraction DSFC-supplemented bread is lower (5.2–6.6 N) than that of fine fraction DSFC-

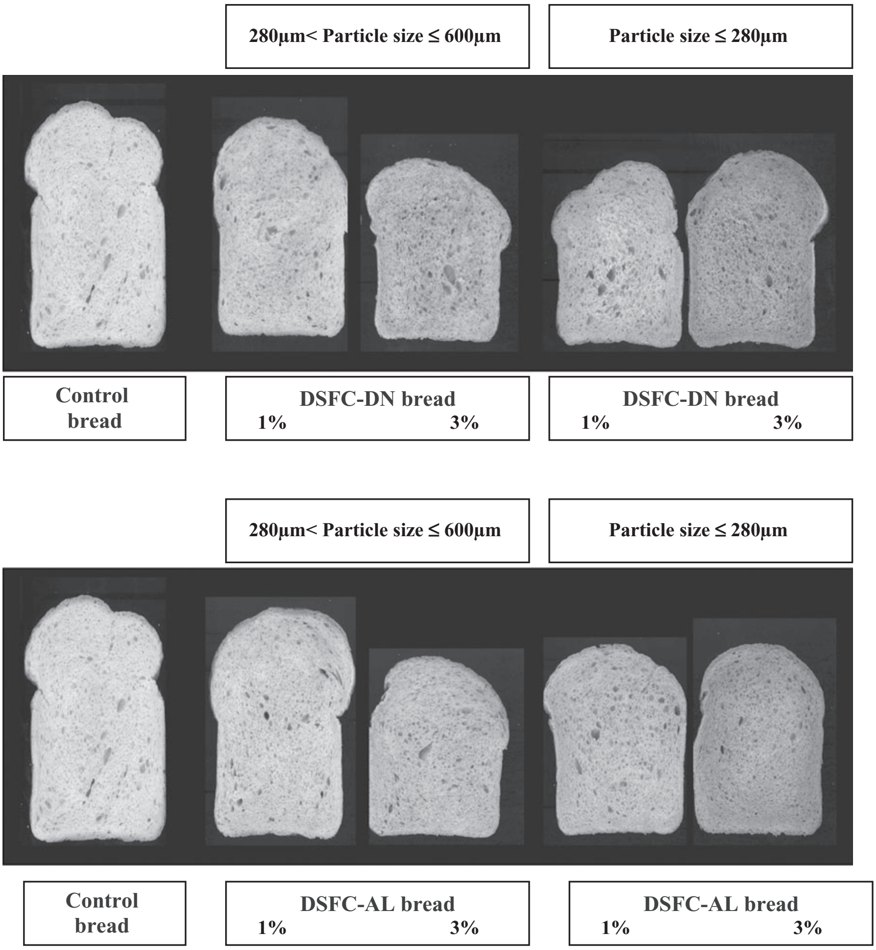

FIG. 2. EFFECT OF PARTICLE SIZE AND DSFC LEVEL ON BREAD CRUMB QUALITY (STRUCTURE AND COLOR)
DSFC-DN bread, bread enriched with DSFC from Deglet Nour seed; DSFC-AL bread, bread enriched with DSFC from Allig seed.

enriched bread (7.70–7.92 N). These results were supported by Almana and [32] Mahmoud (1994), which showed that the addition of the coarse fraction of the DSFC allowed better quality of bread or almost is identical to the control. In opposition, bread quality increased with particle size reduction of DF from sugarcane bagasse studied by Sangnark and Noomhorm (2004). [33]

DSFC does not have an influence on the elasticity of the breads. Thus, it [34] appears that DSFC may be successfully incorporated into bread without nega-

TABLE 6.
EFFECT OF DSFC SUPPLEMENTATION ON THE BREAD CRUMB COLOR

Parameters	Control bread	DSFC-DN bread				DSFC-AL bread			
		Particle size $\leq$280 μm		280 μm < Particle size $\leq$600 μm		Particle size $\leq$280 μm		280 μm < Particle size $\leq$600 μm	
DSFC Level	0%	1%	3%	1%	3%	1%	3%	1%	3%
L^*	$81.24^{a} \pm 0.15$	$70.30^{b} \pm 0.65$	$59.70^{c} \pm 0.02$	$77.70^{d} \pm 0.10$	$69.70^{b} \pm 0.4$	$70.20^{b} \pm 0.20$	$59.90^{c} \pm 0.92$	$74.95^{e} \pm 1.87$	$68.97^{b} \pm 0.61$
a^*	$1.77^{a} \pm 0.08$	$3.60^{b} \pm 0.15$	$7.07^{c} \pm 0.03$	$2.00^{d} \pm 0.08$	$3.18^{e} \pm 0.04$	$3.95^{f} \pm 0.12$	$7.40^{g} \pm 0.20$	$2.30^{h} \pm 0.20$	$3.460^{b} \pm 0.04$
b^*	$22.36^{a} \pm 0.03$	$16.20^{b} \pm 0.22$	$16.44^{b} \pm 0.05$	$18.60^{c} \pm 0.20$	$17.00^{b} \pm 0.20$	$15.92^{b} \pm 0.06$	$14.70^{d} \pm 0.30$	$18.72^{c} \pm 0.90$	$16.80^{b} \pm 0.50$

Values in lines with different letters are significantly different ($P \leq 0.05$).
DSFC, defatted date seed fiber concentrate; DSFC-DN bread, bread enriched with DSFC from Deglet Nour seed; DSFC-AL bread, bread enriched with DSFC from Allig seed.

TABLE 7.
EFFECT OF THE DSFC ON THE WHEAT BREAD TEXTURE PROPERTIES

Parameters DSFC Level	Control bread 0%	DSFC- DN bread				DSFC- AL bread			
		Particle size ≤280 μm		280 μm < Particle size ≤600 μm		Particle size ≤280 μm		280 μm < Particle size ≤600 μm	
		1%	3%	1%	3%	1%	3%	1%	3%
Elasticity	$0.48^a \pm 0.02$	$0.48^a \pm 0.02$	$0.47^a \pm 0.02$	$0.47^a \pm 0.08$	$0.48^a \pm 0.03$	$0.47^a \pm 0.01$	$0.46^a \pm 0.01$	$0.48^a \pm 0.01$	$0.47^a \pm 0.03$
Firmness (N)	$7.00^{ab} \pm 0.20$	$7.92^a \pm 0.3$	$7.7^a \pm 0.24$	$5.28^b \pm 0.95$	$5.71^b \pm 0.4$	$7.84^a \pm 0.14$	$7.6^a \pm 0.78$	$5.39^b \pm 0.86$	$6.6^{ab} \pm 0.81$

Values in lines with different letters are significantly different ($P \leq 0.05$).DSFC: Defatted date seed fiber concentrate.
DSFC-DN bread, bread enriched with DSFC from Deglet Nour seed; DSFC-AL bread, bread enriched with DSFC from Allig seed.

tively impacting texture and overall acceptability, if we added the coarser particles (280 μm < particle size $\leq$ 600 μm).

CONCLUSION

The addition of DSFC in dough increased stability and decreased MTI compared to the control. Coarse DSFC affected slightly the bread color and crumb texture compared to fine DSFC that was darker and redder colored mainly when increasing substitution rate.

Date seeds are by-products that could be an excellent source of fiber. Extraction and addition of coarse DSFC fraction (280 μm < particle size $\leq$ 600 μm) in bread formulation could give an important value addition to date seeds.

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