

1 **Title: Quality Characteristics and Antioxidant Properties of Muffins Enriched**  
2 **with Date Fruit (*Phoenix dactylifera* L.) Fiber Concentrates.**

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15

16 **ABSTRACT**

17 Secondary varieties of date from Tunisia are underutilized due to their low commercial  
18 quality. Fiber concentrates (DFC) can be obtained from these fruits after a steam pre-  
19 treatment. DFCs were evaluated as a source of antioxidant dietary fiber for bakery  
20 products. Muffins were prepared with 2.5 and 5% flour substitution with DFCs obtained  
21 by treatments at 165 and 180 °C. The DFC-doughs presented a similar yield to the  
22 control but the muffins reached a lower volume. The density increase did not imply an  
23 increase in texture. In fact, the muffins with DFC-165 were the softest tested, although  
24 they had lower cohesiveness and springiness. The proximate composition was similar  
25 among samples. The DFC-muffins had higher antioxidant capacity than the control, and

26 obtained good scores in the sensory evaluation. DFC-165 is a valuable ingredient for  
27 baked goods, but its effect on fat rancidity and staling delays should be confirmed.

28

### 29 **KEYWORDS**

30 Secondary date varieties, date fiber concentrate, bakery, sensory evaluation, antioxidant  
31 activity

32

### 33 **RUNNING HEAD**

34 Quality of muffins enriched with date fiber.

35

### 36 **PRACTICAL APPLICATIONS**

37 Listing dietary fiber on the ingredient label of a product is always viewed positively by  
38 consumers. Several dietary fibers coming from underutilized varieties of Tunisian dates  
39 were added to bakery products. In some cases, texture and organoleptic characteristics  
40 of fortified muffins were the best tested, increasing also their antioxidant activity. From  
41 a technological point of view, the addition of date dietary fiber could also extend the  
42 self-life of baked goods due to a delay of staling and fat rancidity caused by storage.

## 43 INTRODUCTION

44 Dietary fiber benefits for the gut are widely recognized, a fact that has led to its  
45 consideration as a nutrient (FDA, 1993). The key for obtaining the level of fiber intake  
46 recommended for adults in western societies is the availability of high quality foods  
47 with high dietary fiber contents. Bakery products are good candidates for fiber  
48 supplementation because they are consumed all over the world and by people of all  
49 ages. In addition to traditional cereal derived fibers (Baixauli *et al.* 2008; Gómez *et al.*  
50 2010), new ones are being developed based on fruits and vegetables, such as apple  
51 pomace (Massodi *et al.* 2002), mango fruit (Vergara-Valencia *et al.* 2007), cactus  
52 (Ayadi *et al.* 2009; Kim *et al.* 2012) and green tea leaves (Lu *et al.* 2010). The use of  
53 fiber in baked good formulations could also help in extending its shelf-life because  
54 dietary fiber delays staling due to its water holding capacity (Gómez *et al.* 2007), and  
55 also inhibits lipid oxidation if its antioxidant capacity is high enough (Lu *et al.* 2010).  
56 Date fruit is a highly nutritious food, and its chemical composition has been reported by  
57 various researchers (Ismail *et al.* 2008; Biglari *et al.* 2009). It is a rich source of  
58 carbohydrates, dietary fiber, several vitamins (A, B1, B3, C), and macro-elements like  
59 phosphorus, iron, potassium and calcium. Tunisia is considered to be one of the most  
60 important producers of the Deglet Nour date variety (66% of total production). The rest  
61 of the varieties are characterized by a low commercial quality and they are known as  
62 secondary cultivars, although their nutritional and functional characteristics are similar  
63 to those of Deglet Nour (Mrabet *et al.* 2012). Attempts have been made to convert these  
64 unused varieties into value added products in order to increase the economic feasibility  
65 of date industries. A hydrothermal pre-treatment at different conditions has been  
66 assayed for obtaining a date fiber concentrate (DFC) with antioxidant properties which  
67 could be easily incorporated into food formulation (Mrabet *et al.* 2014). Due to its

68 pleasant chocolate/coffee flavor, it fits especially well with bakery or dairy products.

69 The reactor used in this pre-treatment can be easily scaled-up and its development in  
70 date producing areas could be of great interest from economical and social points of  
71 view.

72 The aim of this work has been to study the quality of muffins containing two different  
73 DFCs in 2.5 and 5% wheat flour substitution. Physicochemical, nutritional, and  
74 sensorial characteristics have been evaluated in dough and muffins. Their antioxidant  
75 properties have also been determined as an important reason for the use of DFC in food  
76 supplementation. High consumer acceptability could be a great support for Tunisian  
77 secondary date varieties valorization.

78

## 79 **MATERIALS AND METHODS**

### 80 **Materials**

81 DFCs were obtained after the steam treatment of secondary date varieties from Tunisia  
82 at different temperatures (165 and 180 °C, DFC-165 and DFC-180 respectively)  
83 (Mrabet *et al.* 2014). The wet treated material was freeze-dried and ground to a fine  
84 powder (< 0.5 mm). Wheat flour, fresh whole eggs, sugar, baking powder and  
85 sunflower oil were purchased from the local market.

86 4-Morpholinoethanesulfonic acid (MES), protease from *Bacillus licheniformis*,  
87 amyloglucosidase solution from *Aspergillus niger*, tris(hydroxymethyl) aminomethane  
88 (Tris), 2,2-diphenyl-1-picrylhydrazyl (DPPH• free radical), 2,2'-azobis(2-  
89 amidinopropane) dihydrochloride (ABAP, 97% purity), 2-thiobarbituric acid (minimum  
90 98% purity), 1-butanol (minimum 99% purity) were purchased from Sigma-Aldrich  
91 Química (Madrid, Spain). Amylase thermostable Thermamyl 120 L was from Novo  
92 Nordisk Pharma (Madrid, Spain). Hexane, sodium hydroxide, and acetic acid were from

93 Panreac Química S.A. (Barcelona, Spain). Ethanol was purchased from Alcoholes del  
94 Sur (Córdoba, Spain). Sodium dodecylsulphate (SDS, p.a.) was obtained from Merck  
95 (Darmstadt, Germany).

96

### 97 **Muffin preparation**

98 Muffin dough was prepared in a Thermomix (Vorwerk, Wuppertal, Germany). The  
99 whole eggs (180 g) and sugar (140 g) were placed in the bowl and mixed at speed 4 for  
100 4 min. Wheat flour, DFC and baking powder (5 g) were carefully mixed in. Control  
101 dough was prepared with 170 g wheat flour, and this ingredient was substituted by  
102 DFCs in a 2.5 and 5% (4.25 and 8.5 g DFC respectively) in DFC-enriched dough  
103 formulation. Sunflower oil (180 g) and flour mix were added and then mixed on speed 6  
104 for 20 seconds. After 20 min standing, the dough was deposited into muffin paper cups,  
105 and each one was filled with 40 g of dough. The muffins were baked in a conventional  
106 oven for 17 min at 200 °C. After baking, the muffins were removed from the oven tray  
107 and left 1 h for cooling; then, they were placed in plastic bags for further analyses. The  
108 oven and oven tray was always the same, the tray was placed at the same level in the  
109 oven and the number of muffins baked was always the same. Two muffin batches were  
110 prepared in different days. All the determinations were done from each batch at least in  
111 triplicate, except for sensory evaluation which was developed only from the second one.  
112 The muffins were prepared the day before texture analyses and sensory evaluation.

113

### 114 **Physical characteristics of dough and muffins**

115 The physical characteristics of the dough, including loss rate and dough yield, were  
116 measured for each muffin. The baking loss rate and the dough yield for each type of

117 dough were expressed using the percentage of weight of the muffin after baking and the  
118 weight of the dough:

$$119 \quad \% \text{ baking loss} = (W_d - W_m) \times 100/W_d;$$

120 Where  $W_d$  was the weight of dough and  $W_m$  the weight of muffin. The dough yield is  
121 100-% baking loss.

122 The rapeseed displacement method was used for determining the volume of the  
123 muffins.

124

### 125 **Proximate composition of muffins**

126 Samples of the different preparations were analyzed for moisture by freeze drying. Fat  
127 was extracted with hexane using a Soxhlet apparatus. The extraction process continued  
128 for 6 h. The solvent was evaporated on a rotary evaporator under reduced pressure and  
129 the percentage of fat was determined gravimetrically. The dry and defatted residues  
130 were used for the analysis of protein, ash and total dietary fiber contents. Protein  
131 content was determined by the Kjeldahl method and applying a factor of 6.25 to convert  
132 the total nitrogen into protein content. Ash was determined according to the AOAC  
133 method 923.03 by incinerating samples in a muffle furnace at 550 °C to white ash. The  
134 carbohydrate content was calculated by subtracting the contents of crude protein, fat,  
135 ash, and moisture from 100 g of muffin (Morillas-Ruiz and Delgado-Alarcón, 2012).  
136 The energy values were obtained using the factors of 4, 9, and 4 Kcal/g for protein, fat,  
137 and carbohydrate, respectively. The proximate compositions presented are mean values  
138 from triplicate determinations.

139 The dietary fiber content was determined using the protocol described by Lee *et al.*  
140 (1992) with slight modifications. Briefly, three replicates (1 g each) of dry defatted  
141 muffin were suspended in 40 mL of MES-Tris buffer and treated with 50  $\mu$ L of

142 Thermamyl (heat-stable  $\alpha$ -amylase) at 100 °C for 15 min and then digested with 100  $\mu$ L  
143 of a 50 mg/mL protease solution (60 °C, 30 min), followed by incubation with 100  $\mu$ L  
144 of amyloglucosidase (60 °C, 1 h) to remove protein and starch. Then, four volumes of  
145 96% hot ethanol were added to the hydrolysate and the total volume was passed through  
146 the sintered glass crucible (no. 2) using the Fibertec E system (1023 filtration module).  
147 The retained fiber was dried overnight at 105 °C in an air oven, and weighed. Protein  
148 and ash were determined from fiber residue for weight correction.

149

#### 150 **Color determinations of muffin crumb**

151 The color determinations of the crumb from the midsection of the muffins were  
152 measured using a color measurement spectrophotometer BYK-Gardner, Color-view  
153 model (Columbia, Maryland, USA) set for Hunter  $L$  (lightness),  $a$  (redness),  $b$   
154 (yellowness), and  $\Delta E$  (total color difference) values. The results of the Hunter  $L$ ,  $a$ , and  
155  $b$  values were averaged from 10 replications.

156  $\Delta E$  was calculated as follows  $\Delta E = ((L_1 - L_2)^2 + (a_1 - a_2)^2 + (b_1 - b_2)^2)^{1/2}$ , where  $L_1$ ,  $a_1$ , and  
157  $b_1$  are  $L$ ,  $a$  and  $b$  values for each sample and  $L_2$ ,  $a_2$ , and  $b_2$  are  $L$ ,  $a$  and  $b$  values for the  
158 color standard.

159

#### 160 **Texture profile analysis of muffins**

161 The texture profile analysis of samples (2 x 2 x 2 cm) from the midsection of the  
162 muffins was measured using an Instron texturometer model 1011, series IX. An  
163 aluminium 25 mm diameter cylindrical probe was used in a double compression test to  
164 penetrate to 50% depth, at 1 mm/s speed test, with 30 s delay between the first and  
165 second compression. The texture parameters (firmness, gumminess, chewiness,  
166 cohesiveness, and springiness) were calculated from the texture profile graphic as

167 explained by Gómez *et al.* (2007). The texture parameters of each muffin formulation  
168 were averaged from 10 replicates.

169

#### 170 **Determination of antioxidant properties**

171 Two assays for the evaluation of antioxidant properties were carried out. The antiradical  
172 capacity of the dry defatted residue was evaluated as described by Fuentes-Alventosa et  
173 al (2009). Between 3 and 20 mg of the samples were transferred to an eppendorf tube  
174 (for weights of <3 mg, fibers had to be diluted with cellulose as an inert material), and  
175 the reaction was started by adding 1 mL of the DPPH• reagent (3.8 mg/50 mL  
176 methanol). After 30 min of continuous stirring, the samples were centrifuged, and the  
177 absorbance of the cleared supernatants was measured (in triplicate) at 480 nm. EC50  
178 was also calculated and the antiradical capacity expressed as  $\mu\text{mol}$ s of Trolox  
179 equivalent per gram of sample by means of a dose-response curve for Trolox.

180 The inhibition capacity of secondary oxidation was evaluated by a modification of the  
181 thiobarbituric acid reactive species (TBARS) method (Rodríguez *et al.* 2007) on the  
182 extracted muffin fat. Sixty  $\mu\text{L}$  of fat and 5  $\mu\text{L}$  of ABAP were added to an Eppendorf  
183 tube (1.5 mL capacity) and made up to 0.1 mL with distilled water (in quadruplicate).  
184 Afterwards, 150  $\mu\text{L}$  20% acetic acid (pH 3.5) and 150  $\mu\text{L}$  of 0.8% (w/v) thiobarbituric  
185 acid in 1.1% SDS (w/v) were dosified into each tube. This mixture was stirred in a  
186 Vortex and heated at 80 °C during 1 h. After cooling at room temperature, 0.5 mL of 1-  
187 butanol were added, stirred and centrifuged at 12,000 rpm during 3 min. The absorbance  
188 of the butanol layer was measured at 540 nm. The antioxidant effectiveness was  
189 calculated as the per cent inhibition of oxidation (%I) as described by Sánchez-Alonso  
190 and Borderías (2008):  $\%I = (c-s/c) \times 100$ , where c = absorbance of plain muffin



191 (control),  $s$  = absorbance of the sample. High levels of %I indicate greater antioxidant  
192 effectiveness.

193

#### 194 **Preliminary sensory evaluation**

195 Hedonic sensory tests were conducted by 25 untrained panelists recruited from the Food  
196 Biotechnology Department staff (Instituto de la Grasa, CSIC, Sevilla, Spain). Muffins  
197 were evaluated on the basis of acceptability of their appearance, odor, flavor, texture  
198 and overall preference by a hedonic 9-point scale where 9 means most liked and 1 most  
199 disliked. The control muffin was presented simultaneously with the rest of the samples  
200 and was evaluated in random order among panelists. The samples were placed on white  
201 plates and were identified with random numbers. During the panel session, water was  
202 provided to panelists to minimize any residual effect before testing a new sample. Odor,  
203 flavor, texture and overall evaluation were carried out in 2 cm-cube muffin crumb  
204 samples. For determining appearance, whole muffins were presented to panelists.

205

#### 206 **Statistical analysis**

207 The results are expressed as the average value of at least three repetitions. To assess the  
208 differences among samples, a multiple-sample comparison was performed using the  
209 Statgraphics Plus program Version 2.1. Multivariate analysis of variance (ANOVA),  
210 followed by Duncan's multiple comparison test, was performed to differentiate among  
211 the groups. The level of significance was  $P < 0.05$ . Correlation coefficients ( $r$ ) were  
212 determined using simple regression analysis at the 95% significant level.

213

## 214 **RESULTS AND DISCUSSION**

### 215 **Physical characteristics of muffin dough**

216 The physical characteristics of muffin dough containing different percentages of DFC  
217 are shown in Table 1. Except for the addition of DFC-180 at 2.5%, doughs with date  
218 fibers presented the same or significantly better results than the control. The dough  
219 yield increased in two of the assayed conditions and the loss rate was lower in the same  
220 assays. These results could be related to an increase in the muffin water retention  
221 capacity due to the presence of DFC with moderate water holding capacity (WHC), 8.50  
222 and 6.01 mL water/g of DFC-165 and DFC-180 respectively (Mrabet *et al.* 2014), as is  
223 described for other fiber-enriched baked products (Kim *et al.* 2012). During baking, gas  
224 is produced and vapor pressure increases due to liquid expansion caused by heating.  
225 Therefore, baking loss is produced by the gas escape from the baking dough, which  
226 implies the structural transformation of baked goods and decreases in the shelf life of  
227 products (Choi *et al.* 2007). Adequate water content in the dough will confer a moist  
228 and fresh texture on muffins which will influence consumer acceptability. However,  
229 muffin volume was lower when DFC was added and, as a consequence, its density was  
230 higher. The decrease in the percentage of gluten and the increase in that of cellulose in  
231 the dough have been reported to weaken the gluten matrix responsible for retaining  
232 gases in baked foods (Baldi *et al.* 1965). So, the higher the percent of fiber in the dough,  
233 the lower the cake volume will be, as reported by other authors working with green tea  
234 powder (Lu *et al.* 2010) and apple pomace (Massodi *et al.* 2002). The opposite results  
235 were found adding cladode powder from *Opuntia ficus indica* and cereal fibers up to 10  
236 and 24%, respectively (Ayadi 2009; Gómez *et al.* 2010). These authors concluded that  
237 not only the percentage of added fiber but also factors such as fiber chemical  
238 composition, fiber size and cake formula have great influence on dough density and  
239 viscosity, characteristics that are related with gas retention and cake volume.  
240

## 241 **Proximate composition of muffins**

242 Moisture was the only component that did not show significant differences (Table 2).  
243 During baking, the muffin dough with DFC had a lower capacity for retaining carbon  
244 dioxide formed from baking powder during twenty minutes standing. However, water  
245 did not escape from the dough, which implied that DFC could retain water, just as  
246 wheat flour did. The content of moisture in the cakes with dietary fiber added could be  
247 linked to fiber WHC. The WHC of DFC was relatively low, 6-8 mL water/g DFC  
248 (Mrabet *et al.* 2014), taking into account that native date dietary fiber had a WHC of  
249 around 15 mL/g (Mrabet *et al.* 2012). With higher WHC, cake moisture could increase  
250 with fiber addition, as it did with cheonnyuncho fiber (*Opuntia humifusa*), where  
251 moisture significantly increased from 30 to 32% by adding up to 9% of this cactus fiber  
252 (Kim *et al.* 2012).

253 Fat content increased significantly with the addition of DFC-165, partially caused by the  
254 higher content of fat of this fiber than DFC-180, 6.8 and 6.0 % respectively (Mrabet *et*  
255 *al.* 2014). As a consequence, the energy value of both samples (DFC-165 treatment, at  
256 2.5 and 5% level) was significantly higher than the others. The fat present in DFC  
257 comes from the disintegration of date seed during hydrothermal treatment (Mrabet *et al.*  
258 2014). Date seed oil has been studied by other authors, and its composition in vitamins,  
259 minerals and fatty acids made it valuable for food formulation (Nehdi *et al.* 2010; Habib  
260 *et al.* 2013). Besbes *et al.* (2005) studied the effects of heating on date seed oil and they  
261 concluded that this oil resisted thermal treatment over a long period of time (30-40 h).  
262 So, baking time would probably not affect the quality parameters of date fat.

263 Protein, ash and carbohydrate showed little variations among the samples. The amount  
264 of dietary fiber increased with the addition of DFC, from 1.88% in the control to 2.24  
265 and 2.29% with 2.5% fiber addition, and to 2.43 and 2.55 for 5% addition. Apart from

266 the nutritional point of view, these results are of great interest for baked good producers,  
267 because the amount of fiber could be directly related to shelf-life. However, this aspect  
268 has to be confirmed in further studies about the delaying effect of DFC on baked food  
269 staling.

270

### 271 **Color and texture characteristics of muffins**

272 The crumb color of samples was greatly affected by the replacement of wheat flour with  
273 DFC. This product was very dark, similar to ground coffee, with DFC-165 being a little  
274 lighter than DFC-180, probably due to Maillard reactions and/or to other condensation  
275 reactions caused by proteins, sugars and phenols naturally present in date pulp at high  
276 treatment temperatures. In Table 3 all color data are presented, expressed by Hunter  $L$ ,  
277  $a$ ,  $b$  and  $\Delta E$  values corresponding to lightness, redness, yellowness, and total color  
278 differences, respectively.  $L$  decreased with the addition of DFC from near 50 to 15-20  
279 depending on the degree of flour substitution, not having significant differences  
280 between both DFCs. The same results were found for  $b$ : yellowness decreased as  
281 percent of replacement went up. Redness ( $a$ ) had its maximum value in the muffins  
282 made with DFC-165 at 2.5%. The original color of this DFC was reddish brown and had  
283 slight differences with the other DFC (dark brown). This reddish shade was responsible  
284 for the highest value of  $a$  in that sample.  $\Delta E$  values increased with DFC percentages  
285 from about 30 in the control to 56-58 in 2.5% samples and 62 in 5% ones. The different  
286 origin of DFCs did not have any significant effect.

287 Texture characteristics are also resumed in Table 3. Firmness is the maximum force  
288 recorded in the texture analyzer and is related to gumminess and chewiness. Both  
289 parameters are the most easily correlated with sensory analyses through trained panels  
290 (Esteller *et al.* 2004). Cohesiveness quantifies the internal resistance of food structure,

291 and springiness gives information about the after stress recovery capacity after the delay  
292 between compressions.

293 The softest muffins were obtained with DFC-165 in both 2.5 and 5%. The firmness of  
294 the control did not show significant differences with those of DFC-180 samples.

295 Gumminess and chewiness decreased with DFC addition. In these parameters, the  
296 higher percentage of DFC-165 led to lower values. These results were opposite to others  
297 found in the bibliography (Gómez *et al.* 2010; Lu *et al.* 2010; Kim *et al.* 2012), where  
298 the addition of fiber always correlated with firmness increases. Probably, the chemical  
299 composition of DFC or the dough formulation of muffins could also have some  
300 influence on these texture parameters.

301 In general, cohesiveness and springiness decreased with the addition of 5% DFC, not  
302 having significant differences between the control and the 2.5% addition. These results  
303 were in agreements with previously reported results (Gómez *et al.* 2010; Lu *et al.* 2010;  
304 Kim *et al.* 2012). The four analyzed characteristics correlated with muffin volume, with  
305 the lowest correlation being with the firmness ( $r=0.6749$ ) and the highest with the  
306 cohesiveness ( $r=0.9365$ ). Similar relationships were found for bread and layer cakes  
307 (Gómez *et al.* 2008; 2010) and they could be related to the quantity of air retained by  
308 the dough.

309

### 310 **Antioxidant properties**

311 The antioxidant properties were measured in two muffin fractions. The radical  
312 scavenging capacity was measured from the dry defatted muffin residue and expressed  
313 as  $\mu\text{mols Trolox equivalent/g dry defatted muffin}$ . The inhibition capacity of lipid  
314 peroxidation was assayed in the fat extracted by Soxhlet and expressed as per cent  
315 inhibition of oxidation (%I). The results for both assays are presented in Figure 1.

316 The antiradical activity increased as the percent of added fiber went up (Figure 1 (a)).  
317 Muffins with DFC-165 had stronger activity than those with DFC-180 due to the higher  
318 initial activity and phenol content of the former (312.19  $\mu\text{mol}$ s Trolox equivalent per  
319 gram and 4.24% phenols in DFC-165, and 240.46 and 3.91 in DFC-180 (Mrabet *et al.*  
320 2014)). The same effects were found when other antioxidant fibers were added to baked  
321 goods, such as green tea powder to sponge cake (Lu *et al.* 2010), and fiber concentrate  
322 from mango fruit to cookies and bread (Vergara-Valencia *et al.* 2007).  
323 Together with staling, fat oxidation is another determinant factor for controlling bakery  
324 shelf-life. An inhibition of oxidation near 40% was obtained with the addition of 2.5%  
325 DFC-165 and about 30% inhibition with 2.5% DFC-180 (Figure 1 (b)). This difference  
326 was in agreement with DFC composition, as was mentioned for antiradical activity.  
327 However, when fiber percentages increased from 2.5 to 5% the inhibition decreased to  
328 nearly 20% for both DFCs. This may be due to the fact that date fiber could be less  
329 effective at 5% substitution level than at 2.5%. This fact must be confirmed in further  
330 studies. This is the first time that an assay for measuring oxidation inhibition has been  
331 applied to baked goods, although in muscle-based products these studies are very  
332 common. Fish or meat-based products are very different in structure and characteristics  
333 from baked goods but all of them have the common interest of delaying fat rancidity  
334 during their shelf-life. Keeping in mind these differences, qualitative similar results  
335 were observed when antioxidant fiber was added to meat and fish-products. The  
336 addition of tomato or beet root fiber to chopped cooked chicken products reduced lipid  
337 oxidation between 3-43%, depending on the assay conditions (Cava *et al.* 2012).  
338 Working with minced fish-muscle, red grape antioxidant fiber inhibited oxidation up to  
339 77% over nine months' frozen storage (Sánchez-Alonso and Borderías, 2008). It is clear  
340 that the addition of antioxidant dietary fiber to food products is of great interest, not

341 only from a technological point of view but also with the aim of improving their  
342 nutritional and functional characteristics.

343

#### 344 **Sensory evaluation**

345 The effects of DFC supplementation on the sensory characteristics of muffins are  
346 presented in Table 4. The average results showed that all the samples had good scores,  
347 between 6-8 on a 9-point scale. Only the muffins with 5% DFC-180 seemed to have  
348 lower acceptability, especially due to their flavor. Taking into account that these are  
349 preliminary results, after the statistical study only a few significant differences were  
350 found ( $P < 0.05$ ) and they affected only the DFC-180 muffins. Compared with the  
351 control, the muffins made with DFC-165 did not show any differences in the five  
352 evaluated characteristics. Few significant differences were found when comparing  
353 muffins with different DFCs, although the DFC-180 muffins led to the lowest scores.  
354 The later samples had significant differences in odor (2.5 and 5%), flavor and texture  
355 (only 5%) when compared with the control. As a consequence, both samples reached  
356 the lowest overall evaluation. It is interesting to remark that flour substitution seems to  
357 have a limit for consumer acceptability, and beyond it the scoring goes down. This fact  
358 has been described for *O. ficus indica* cladode fiber (Ayadi *et al.* 2009) and apple  
359 pomace (Sudha *et al.* 2007) where a limit of 5 and 10% substitution was found,  
360 respectively. In the case of DFC-180 °C, the limit was overpassed in this study but not  
361 for DFC-165, where a wider range of fiber-addition should be tested.  
362 Baixeli *et al.* (2008), working with fiber-enriched muffins, concluded that the  
363 information given to consumers was a relevant factor for their acceptance. Without  
364 information they gave a low score to enriched muffins but with information the score  
365 increased. But not only the information but also consumers' attitude was important in

366 the valuation. In the reported study, high health conscious panelists gave better ratings  
367 than low ones. It is clear that the acceptability of a healthy new food depends on several  
368 factors and among them, the information and consumers' health consciousness play a  
369 decisive role in the decision of sacrificing taste and texture attributes for health and  
370 wellness. In our study, panelists were informed about muffin fiber enrichment but not  
371 about the nutritional and/or functional benefits.

372

### 373 **CONCLUSIONS**

374 The fortification of wheat flours by DFC-165 leads to dough with a higher baking yield  
375 than the control. Although muffin volume decreased and its density increased, it did not  
376 imply higher values in instrumental texture parameters. In fact, these muffins were the  
377 softest tested. They also showed good acceptability by untrained panelists, similar to  
378 that of the control. From nutritional and functional points of view, the addition of this  
379 DFC was very interesting because, besides the increase in dietary fiber content, the  
380 antioxidant activity tested by two *in vitro* assays was much higher than that of the  
381 unfortified muffins. Further studies on muffin shelf-life are needed in order to assert the  
382 capacity of this fiber to delay staling and/or fat rancidity caused by storage. Although  
383 the dough behavior, the nutritional composition and the texture profile of DFC-180  
384 enriched muffins were very similar to those of DFC-165, the use of that fiber was not so  
385 highly recommended: the former muffins had lower antioxidant activities than the last  
386 ones and also lower scores in consumer acceptability, which is a determinant factor for  
387 the use of a new ingredient in food industries. These results support the use of  
388 secondary date varieties as a valuable source of antioxidant dietary fiber and are and  
389 important boost for their valorization.

390



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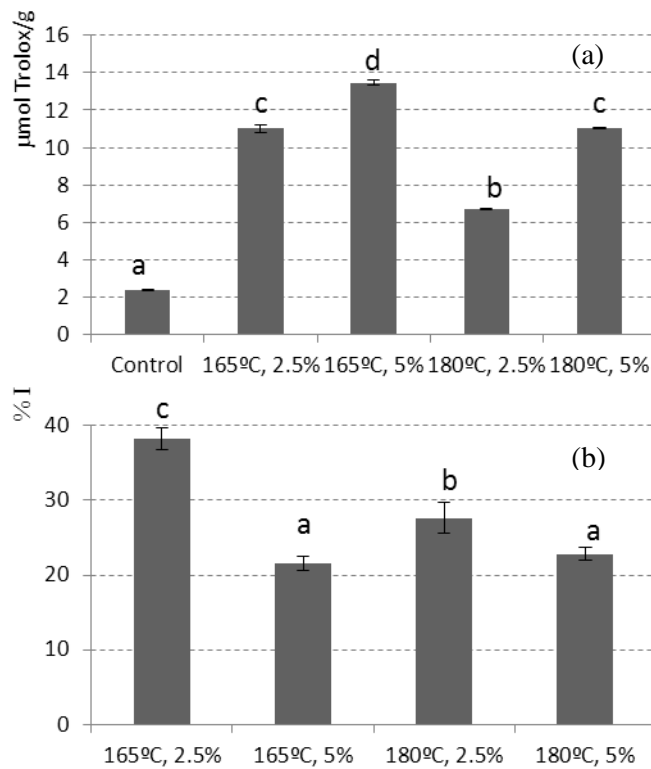
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**FIG. 1.** ANTIOXIDANT ACTIVITY OF MUFFINS WITH VARIOUS LEVELS OF DIFFERENT DATE FIBER CONCENTRATES. SUBFIG. (a): ANTIRADICAL ACTIVITY OF DRY DEFATTED SAMPLES EXPRESSED AS  $\mu\text{MOL TROLOX/G}$ . SUBFIG. (b): CAPACITY OF SECONDARY OXIDATION INHIBITION OF EXTRACTED FAT FROM DIFFERENT MUFFIN FORMULATIONS EXPRESSED AS PERCENTAGE OF INHIBITION  $\%I = (C-S/C) \times 100$ , WHERE C = ABSORBANCE OF PLAIN MUFFIN (CONTROL), S = ABSORBANCE OF SAMPLE.

**TABLE 1.** DOUGH YIELD, LOSS RATE, VOLUME AND DENSITY OF MUFFINS WITH VARIOUS LEVELS OF DIFFERENT DATE FIBER CONCENTRATES.

		Dough yield (g/100g)	Loss rate (g/100g)	Volume (mL/40g dough)	Density (g/mL muffin)
Control		91.61±0.41 b	8.38±0.41 c	104.83±1.24 c	0.38±0.00 a
DFC-165°C	2.5%	93.02±0.45 d	6.97±0.45 a	102.64±4.84 b	0.39±0.02 b
	5%	91.77±0.38 b	8.22±0.38 c	97.56±1.60 a	0.41±0.01 c
DFC-180°C	2.5%	90.65±0.62 a	9.34±0.62 d	101.81±1.90 b	0.39±0.01 b
	5%	92.48±0.50 c	7.51±0.50 b	101.56±1.25 b	0.39±0.00 b

Values are the means of ten replicate assays. Means bearing the same symbol are not significantly different at the 5% level as determined by the Duncan multiple-range test.

DFC.- date fiber concentrate.



**TABLE 2. PROXIMATE COMPOSITION (G/100G) OF MUFFINS WITH VARIOUS LEVELS OF DIFFERENT DATE FIBER CONCENTRATES.**

		Moisture	Fat	Protein	Ash	Carbohydrate	Dietary fibre	Kcal/100g
Control		14.63±0.42 a	22.01±1.21 a	7.37±0.12 a	1.07±0.01 d	54.91±0.12 d	1.78±0.04 a	447.23±0.03 a
DFC-165°C	2.5%	14.50±0.12 a	25.48±0.35 b	8.18±0.25 b	0.99±0.01 ab	50.75±0.19 a	2.18±0.02 b	465.32±0.05 d
	5%	14.06±1.92 a	24.79±0.56 b	7.77±0.08 ab	0.99±0.01 ab	52.38±0.09 b	2.29±0.02 c	463.76±0.05 c
DFC-180°C	2.5%	13.93±0.07 a	22.48±0.57 a	7.91±0.13 b	0.96±0.00 a	54.66±0.12 cd	2.18±0.06 b	452.64±0.01 b
	5%	14.80±0.63 a	22.21±1.17 a	7.76±0.24 ab	1.01±0.02 b	54.26±0.26 c	2.28±0.03 c	447.22±0.09 a

VALUES ARE THE MEANS OF AT LEAST TRIPLICATE ASSAYS. MEANS BEARING THE SAME SYMBOL ARE NOT SIGNIFICANTLY DIFFERENT AT THE 5% LEVEL AS DETERMINED BY THE DUNCAN MULTIPLE-RANGE TEST. DFC.- DATE FIBER CONCENTRATE.



**TABLE 3.** COLOR VALUES, TEXTURAL PROPERTIES AND SENSORY CHARACTERISTICS OF MUFFINS WITH VARIOUS LEVELS OF DIFFERENT DATE FIBER CONCENTRATES.

	Control	DFC-165 °C		DFC-180 °C	
	0	2.5%	5%	2.5%	5%
Crumb color <sup>a</sup>					
<i>L</i>	48.82±3.37 c	22.10±2.50 b	14.99±1.81 a	19.78±1.93 b	15.11±1.13 a
<i>a</i>	0.29±0.13 a	3.07±0.23 c	2.36±0.74 b	2.22±0.15 b	2.08±0.11 b
<i>b</i>	13.34±0.94 c	7.22±0.93 b	4.69±1.01 a	6.35±0.62 b	4.57±0.37 a
$\Delta E$	29.71±2.88 a	55.72±2.39 b	62.59±1.67 c	57.78±1.87 b	62.41±1.10 c
Texture profile <sup>a</sup>					
Firmness (g)	1436.77±67.37 b	1164.51±202.62 a	1151.25±138.35 a	1332.76±145.64 b	1372.53±103.45 b
Gumminess (g)	792.67±72.89 d	618.26±128.86 b	508.52±116.30 a	713.02±118.91 cd	661.90±47.42 bc
Chewiness (g)	724.9±82.52 d	561.15±135.33 b	447.46±114.23 a	651.62±124.85 cd	592.79±46.29 bc
Cohesiveness	0.55±0.04 c	0.52±0.03 c	0.43±0.06 a	0.53±0.03 c	0.48±0.04 b
Springiness	0.91±0.04 b	0.90±0.04 ab	0.87±0.03 a	0.91±0.03 b	0.89±0.03 ab

<sup>a</sup> Values are the means of ten replicate assays. Means bearing the same symbol are not significantly different at the 5% level as determined by the

Duncan multiple-range test. DFC.- Date fiber concentrate.

**TABLE 4. SENSORY CHARACTERISTICS OF MUFFINS WITH VARIOUS LEVELS OF DIFFERENT DATE FIBER CONCENTRATES.**

	Control	DFC-165 °C		DFC-180 °C	
	0	2.5%	5%	2.5%	5%
Appearance	7.20±1.47 <sup>a</sup> abc	7.29±1.14 bc	7.75±1.05 c	6.42±1.50 a	6.46±1.85 ab
Odor	7.04±1.51 b	6.37±1.87 ab	6.58±1.44 ab	6.04±1.74 a	5.87±1.64 a
Flavor	6.87±1.56 b	6.33±1.62 ab	6.67±1.46 b	6.25±1.45 ab	5.62±1.80 a
Texture	7.67±1.21 b	7.12±1.23 ab	7.33±1.40 ab	7.33±1.18 ab	6.83±1.62 a
Overall Evaluation	7.33±1.28 c	6.71±1.46 abc	6.92±1.11 bc	6.54±1.12 ab	6.04±1.51 a

<sup>a</sup> Values are the means of 25 panelists' tests in a 9-point hedonic scale with 1, 5, and 9 representing extremely dislike, neither like nor dislike, and extremely like, respectively. Means bearing the same symbol are not significantly different at the 5% level as determined by the Duncan multiple-range test. DFC.- Date fiber concentrate.

