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

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ABSTRACT

Secondary varieties of date from Tunisia are underutilized due to their low commercial quality. Fiber concentrates (DFC) can be obtained from these fruits after a steam pre-treatment. DFCs were evaluated as a source of antioxidant dietary fiber for bakery products. Muffins were prepared with 2.5 and 5% flour substitution with DFCs obtained by treatments at 165 and 180 ºC. The DFC-doughs presented a similar yield to the control but the muffins reached a lower volume. The density increase did not imply an increase in texture. In fact, the muffins with DFC-165 were the softest tested, although they had lower cohesiveness and springiness. The proximate composition was similar among samples. The DFC-muffins had higher antioxidant capacity than the control, and obtained good scores in the sensory evaluation. DFC-165 is a valuable ingredient for baked goods, but its effect on fat rancidity and staling delays should be confirmed.

KEYWORDS

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

RUNNING HEAD

Quality of muffins enriched with date fiber.

PRACTICAL APPLICATIONS

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

INTRODUCTION

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

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

MATERIALS AND METHODS

Materials

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

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

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

Muffin preparation

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

Physical characteristics of dough and muffins

The physical characteristics of the dough, including loss rate and dough yield, were measured for each muffin. The baking loss rate and the dough yield for each type of dough were expressed using the percentage of weight of the muffin after baking and the weight of the dough:

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

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

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

Proximate composition of muffins

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

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

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

Color determinations of muffin crumb

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

Δ*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 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 color standard.

Texture profile analysis of muffins

The texture profile analysis of samples (2 x 2 x 2 cm) from the midsection of the muffins was measured using an Instron texturometer model 1011, series IX. An aluminium 25 mm diameter cylindrical probe was used in a double compression test to penetrate to 50% depth, at 1 mm/s speed test, with 30 s delay between the first and second compression. The texture parameters (firmness, gumminess, chewiness, cohesiveness, and springiness) were calculated from the texture profile graphic as explained by Gómez *et al.* (2007). The texture parameters of each muffin formulation were averaged from 10 replicates.

Determination of antioxidant properties

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

The inhibition capacity of secondary oxidation was evaluated by a modification of the thiobarbituric acid reactive species (TBARS) method (Rodríguez *et al.* 2007) on the extracted muffin fat. Sixty μL of fat and 5 μL of ABAP were added to an Eppendorf tube (1.5 mL capacity) and made up to 0.1 mL with distilled water (in quadruplicate). Afterwards, 150 μL 20% acetic acid (pH 3.5) and 150 μL of 0.8% (w/v) thiobarbituric acid in 1.1% SDS (w/v) were dosified into each tube. This mixture was stirred in a Vortex and heated at 80 ºC during 1 h. After cooling at room temperature, 0.5 mL of 1-butanol were added, stirred and centrifuged at 12,000 rpm during 3 min. The absorbance of the butanol layer was measured at 540 nm. The antioxidant effectiveness was calculated as the per cent inhibition of oxidation (%I) as described by Sánchez-Alonso and Borderías (2008): %I = (c-s/c) x 100, where c = absorbance of plain muffin (control), s = absorbance of the sample. High levels of %I indicate greater antioxidant effectiveness.

Preliminary sensory evaluation

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

Statistical analysis

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

RESULTS AND DISCUSSION

Physical characteristics of muffin dough

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

Proximate composition of muffins

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

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

Protein, ash and carbohydrate showed little variations among the samples. The amount of dietary fiber increased with the addition of DFC, from 1.88% in the control to 2.24 and 2.29% with 2.5% fiber addition, and to 2.43 and 2.55 for 5% addition. Apart from the nutritional point of view, these results are of great interest for baked good producers, because the amount of fiber could be directly related to shelf-life. However, this aspect has to be confirmed in further studies about the delaying effect of DFC on baked food staling.

Color and texture characteristics of muffins

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

Texture characteristics are also resumed in Table 3. Firmness is the maximum force recorded in the texture analyzer and is related to gumminess and chewiness. Both parameters are the most easily correlated with sensory analyses through trained panels (Esteller *et al.* 2004). Cohesiveness quantifies the internal resistance of food structure, and springiness gives information about the after stress recovery capacity after the delay between compressions.

The softest muffins were obtained with DFC-165 in both 2.5 and 5%. The firmness of the control did not show significant differences with those of DFC-180 samples. Gumminess and chewiness decreased with DFC addition. In these parameters, the higher percentage of DFC-165 led to lower values. These results were opposite to others found in the bibliography (Gómez *et al.* 2010; Lu *et al.* 2010; Kim *et al.* 2012), where the addition of fiber always correlated with firmness increases. Probably, the chemical composition of DFC or the dough formulation of muffins could also have some influence on these texture parameters.

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

Antioxidant properties

The antioxidant properties were measured in two muffin fractions. The radical scavenging capacity was measured from the dry defatted muffin residue and expressed as μmols Trolox equivalent/g dry defatted muffin. The inhibition capacity of lipid peroxidation was assayed in the fat extracted by Soxhlet and expressed as per cent inhibition of oxidation (%I). The results for both assays are presented in Figure 1.

The antiradical activity increased as the percent of added fiber went up (Figure 1 (a)). Muffins with DFC-165 had stronger activity than those with DFC-180 due to the higher initial activity and phenol content of the former (312.19 μmols Trolox equivalent per gram and 4.24% phenols in DFC-165, and 240.46 and 3.91 in DFC-180 (Mrabet *et al.* 2014)). The same effects were found when other antioxidant fibers were added to baked goods, such as green tea powder to sponge cake (Lu *et al.* 2010), and fiber concentrate from mango fruit to cookies and bread (Vergara-Valencia *et al.* 2007).

Together with staling, fat oxidation is another determinant factor for controlling bakery shelf-life. An inhibition of oxidation near 40% was obtained with the addition of 2.5% DFC-165 and about 30% inhibition with 2.5% DFC-180 (Figure 1 (b)). This difference was in agreement with DFC composition, as was mentioned for antiradical activity. However, when fiber percentages increased from 2.5 to 5% the inhibition decreased to nearly 20% for both DFCs. This may be due to the fact that date fiber could be less effective at 5% substitution level than at 2.5%. This fact must be confirmed in further studies. This is the first time that an assay for measuring oxidation inhibition has been applied to baked goods, although in muscle-based products these studies are very common. Fish or meat-based products are very different in structure and characteristics from baked goods but all of them have the common interest of delaying fat rancidity during their shelf-life. Keeping in mind these differences, qualitative similar results were observed when antioxidant fiber was added to meat and fish-products. The addition of tomato or beet root fiber to chopped cooked chicken products reduced lipid oxidation between 3-43%, depending on the assay conditions (Cava *et al.* 2012). Working with minced fish-muscle, red grape antioxidant fiber inhibited oxidation up to 77% over nine months' frozen storage (Sánchez-Alonso and Borderías, 2008). It is clear that the addition of antioxidant dietary fiber to food products is of great interest, not only from a technological point of view but also with the aim of improving their nutritional and functional characteristics.

Sensory evaluation

The effects of DFC supplementation on the sensory characteristics of muffins are presented in Table 4. The average results showed that all the samples had good scores, between 6-8 on a 9-point scale. Only the muffins with 5% DFC-180 seemed to have lower acceptability, especially due to their flavor. Taking into account that these are preliminary results, after the statistical study only a few significant differences were found ($P<0.05$) and they affected only the DFC-180 muffins. Compared with the control, the muffins made with DFC-165 did not show any differences in the five evaluated characteristics. Few significant differences were found when comparing muffins with different DFCs, although the DFC-180 muffins led to the lowest scores. The later samples had significant differences in odor (2.5 and 5%), flavor and texture (only 5%) when compared with the control. As a consequence, both samples reached the lowest overall evaluation. It is interesting to remark that flour substitution seems to have a limit for consumer acceptability, and beyond it the scoring goes down. This fact has been described for *O. ficus indica* cladode fiber (Ayadi *et al.* 2009) and apple pomace (Sudha *et al.* 2007) where a limit of 5 and 10% substitution was found, respectively. In the case of DFC-180 ºC, the limit was overpassed in this study but not for DFC-165, where a wider range of fiber-addition should be tested.

Baixauli *et al.* (2008), working with fiber-enriched muffins, concluded that the information given to consumers was a relevant factor for their acceptance. Without information they gave a low score to enriched muffins but with information the score increased. But not only the information but also consumers' attitude was important in the valuation. In the reported study, high health conscious panelists gave better ratings than low ones. It is clear that the acceptability of a healthy new food depends on several factors and among them, the information and consumers' health consciousness play a decisive role in the decision of sacrificing taste and texture attributes for health and wellness. In our study, panelists were informed about muffin fiber enrichment but not about the nutritional and/or functional benefits.

CONCLUSIONS

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

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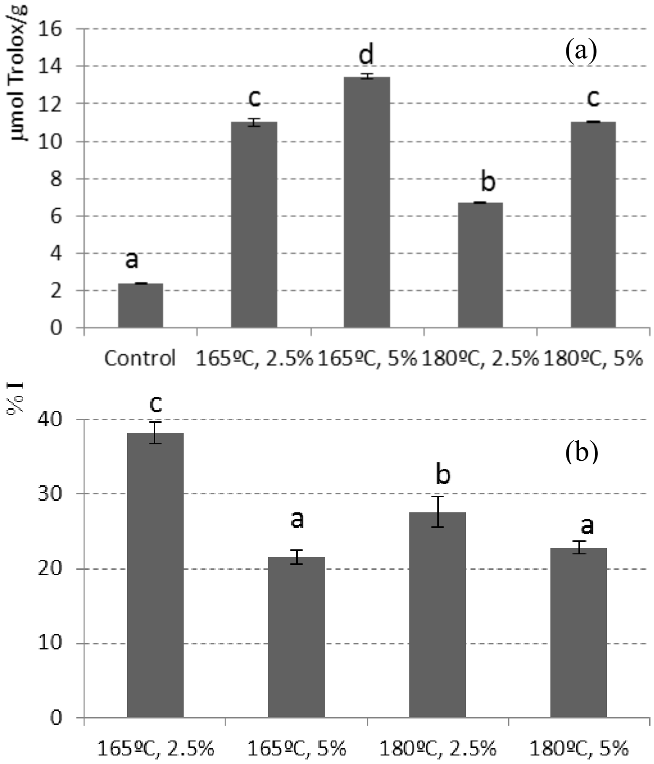

FIG. 1. ANTIOXIDANT ACTIVITY OF MUFFINS WITH VARIOUS LEVELS OF DIFFERENT DATE FIBER CONCENTRATES. SUBFIG. (a): ANTIRADICAL ACTIVITY OF DRY DEFATTED SAMPLES EXPRESSED AS µMOL TROLOX/G. SUBFIG. (b): CAPACITY OF SECONDARY OXIDATION INHIBITION OF EXTRACTED FAT FROM DIFFERENT MUFFIN FORMULATIONS EXPRESSED AS PERCENTAGE OF INHIBITION %I= (C-S/C) X 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[a]					
L	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
a	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
b	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
ΔE	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[a]					
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

[a] 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[a] 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

[a] 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.