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# Date Fiber Concentrate: Chemical Compositions, Functional Properties and Effect on Quality Characteristics of Beef Burgers

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## ABSTRACT

Chemical composition of second-grade dates (with hard texture) from Tunisian Deglet Nour cultivar was similar to that of commercial dates. Date fiber concentrate (DFC) was extracted and characterized in terms of chemical composition and techno-functional properties. DFC showed interesting functional properties. In fact, it presented high water binding capacities (WBC) and oil binding capacities (OBC) reaching 15.82 g/g and 11.31 g/g, respectively. These values were higher than those reported for the most fruits and vegetable fiber concentrates. The use of DFC in beef burger formulations improves cooking properties, e.g. increase cooking yield and decrease shrinkage and minimize production cost without negatively affecting their sensory properties. Results indicate the potentially functional and economic utility of *Phoenix dactylifera* L. flesh from dry dates as new source of dietary fiber.

Key words: *Phoenix dactylifera* L., second-grade dates, fiber concentrate, techno-functional properties, beef burgers

## INTRODUCTION

Date (*Phoenix dactylifera* L.) has always played an important part in the economic and social lives of people in arid and semi-arid regions of the world. Fruit of the date palm is composed of a flesh (pulp) and seed (pits) (1). The world production of dates increased considerably during the past 30 years. In fact, the production has tripled from 2,289,511 tones in 1974 to 6,772,068 tones in 2004(2). Tunisia is currently the world's tenth largest producer and first exporter of dates in value. During the last eight years, Tunisian production has reached an average of 120,000 tons per year with dominance of Deglet Nour cultivar (about 60% of the total production), that has a very substantial sensory quality and a high commercial value(2).

This production progress is unfortunately accompanied by a substantial increase of loss during pickup process, storage, commercialization and conditioning process(3). These "lost dates" could amount to more than 30,000 tones per year in Tunisia and near 2,000,000 tones per year globally(4,5). The "lost dates" are commonly named "date by-products" that are composed by low grade and second grade dates. They are not consumed by human because of several factors: non-appreciated texture (too soft or too hard), contamination by fungus and/or infestation by insects, or simply because they are disregarded in comparison to more attractive dates. Presently, very little use is made of these by-products and they are either discarded or used in limited cases for animal feed(5). Research on second and low grade dates has not been a true reflection of the importance and potential of this crop(5). Scientific studies on "second- and low-grade dates" were especially focused on their biologic transformation especially aiming production of biomass and various other compounds such as citric acid, oxytetracycline and ethanol(5). Practically, most of these works were not concretized as industrial projects.

Dates with a hard texture are classified in Tunisia as second grade dates. They are safe for human consumption and may possess high value components such as sugars and fibers that could be separately extracted and valorized(5-7). The present work is a contribution to valorize second-grade dates from the Tunisian cultivar

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(Deglet Nour) by extraction of DFC and survey of its techno-functional properties. The extracted DFC was added in beef burger formulations at different levels in order to evaluate their effect on quality characteristics (e.g. nutritional value, proximate composition, cook loss, dimensional change, and sensorial quality, etc.) and to reduce production cost.

## MATERIALS AND METHODS

I. *Origin of Dates*

This study examined second grade dates of the most abundant cultivar in Tunisia, Deglet Nour. The samples were previously sorted and only fruits with texture defect (relatively hard or dry) were kept. These fruits, having the same origin (Degach region, South of Tunisia), were collected at "Tamr stage" (full ripeness). Twenty kilograms from each cultivar were directly divided into bags of 1 kg and kept at 4°C until analysis.

II. *Extraction of DFC*

DFC was extracted from the whole dates, which were previously maintained in hot water (100 g/600 mL) at 70°C for 15 min to facilitate elimination of seeds. The mixture was filtered on a fine sifter (0.318 mm diameter) in order to separate insoluble residues. These operations (extraction and filtration) were repeated five times until obtaining dough exempted from sugars. This was confirmed by checking the presence of sugar in the washing (section IV). Drying of the obtained humid DFC was achieved by lyophilization. The gotten extract was then ground to have a mealy aspect. The obtained DFC was maintained at 4°C. It is worthy to note that the DFC yield reached about 8.37 ± 0.48 g/100 g of dates.

III. *Origin of Pea Fiber Concentrate (PFC)*

PFC was provided by CHAHIA Company (Sfax, Tunisia). It was purchased from F.P.S GROUPE MANE (Marne La Vallee, France).

IV. *Proximate Analysis of Dates and DFC*

All analytical determinations were performed at least in triplicate. Values of different parameters were expressed as the mean ± standard deviation ( ± S.D.).

Dry matter, crude lipid, crude protein and ash were determined according to the AOAC methods[8]. Data were expressed as percent of dry weight. Crude lipid was estimated by a petroleum ether extraction procedure (Merck, for analysis) using an automatic soxhlet SER1 48 Solvent Extractor (Velp Scientifica, Europe). Total nitrogen was determined by the Kjeldahl method. Protein was calculated using the general factor (6.25).

To determine total ash, samples were ignited and incinerated in the muffle furnace at about 550°C for 8 h. The mineral constituents (Ca, Na, K) were analyzed separately, using an atomic absorption spectrophotometer (Hitachi Z6100, Japan). Phosphorus content (P) was determined by the phosphomolybdovanate method[9].

Reducing sugars content was estimated using the DNS method by measurement of the optical density at 540 nm with glucose as standard[10,11]. Samples were previously clarified using Carrez reagent as described in the AFNOR norm[11]. The clarified solution was composed of 15% potassium ferrocyanide (w/v) (Carrez I) and 30% zinc acetate (w/v) (Carrez II). Total carbohydrate content was determined by the same method, after acid hydrolysis at 100°C for 1 h.

Total dietary fiber content was determined using the enzymatic-gravimetric method of Prosky *et al.*[12]. Briefly, the defatted samples were treated by heat-stable alpha amylase, protease and amyloglucosidase to remove protein and starch. Then, the samples were filtered, washed (with water, 95% ethanol and acetone), dried and weighed to determine insoluble fibers. Soluble fibers were precipitated by addition of 95% ethanol to the filtrate. Then, the precipitates were filtered and washed with 78% ethanol, 95% ethanol and acetone. After that, the residues (soluble fibers) were dried and weighed. The obtained values were corrected for ash and protein. Total dietary fiber content was determined by summing insoluble and soluble fibers.

Water activity was measured by a NOVASINA aw Sprint TH-500 Apparatus. The measurement was performed at 25°C.

Water binding capacity (WBC) was measured according to the method described by Mac-Connel *et al.*[13]. Hundred milligrams of DFC were added to 10 mL of distilled water in a 50 mL centrifuge tube and stirred overnight at 4°C. Then the mixture was centrifuged at 14,000 *g* for 20 min. The free water was decanted and absorbed water was then determined.

Oil binding capacities (OBC) was measured according to Lin *et al.*[14]. Hundred milligrams of DFC were added to 10 mL of corn oil in a 50 mL centrifuge tube. The content was stirred then the tubes were centrifuged at 1,500 *g* for 30 min. The free oil was decanted and absorbed oil was determined.

V. *Techno-Functional Properties*

(I) *Incorporation of DFC in Beef Burgers*

Beef burgers were manufactured in CHAHIA Company (Sfax, Tunisia). They were kept at -20°C until further analysis. DFC was incorporated into beef burgers using the formulations described in Table 1. Percentages of crude lipid, spices and conservative additives were unchanged compared to the control sample, whereas the rate of meat decreased with the increase of the content in

**Table 1.** Formulations for beef burgers with date fiber concentrate (DFC)

| Ingredients (%) | Control | Test 1* | Test 2* | Test 3* |
|---|---|---|---|---|
| Meat | 62.82 | 54.41 | 46 | 37.59 |
| Fat | 12.56 | 12.56 | 12.56 | 12.56 |
| Water | 15.07 | 22.98 | 30.89 | 38.8 |
| Spices | 9.05 | 9.05 | 9.05 | 9.05 |
| PFC | 0.5 | 0.5 | 0.5 | 0.5 |
| DFC | 0 | 0.5 | 1 | 1.5 |
| Total | 100 | 100 | 100 | 100 |

*Meat was partially replaced by water and 0.5% DFC (Test 1), 1% DFC (Test 2) and 1.5% DFC (Test 3).

DFC. Meat was partially replaced by DFC and water. The reduced meat quantity was calculated based on the WBC of the fibers according to the following relation:

$(Q_F + Q_F \times WBC) = Q_v$

$Q_F$: quantity of added fibers (g); ($Q_F \times WBC$): quantity of added water (g); $Q_v$ : the reduced meat quantity (g).

(II) *Proximate Analyses of Beef Burgers*

Dry matter, ash and water activity ($a_w$) were measured as described in section IV.

Water holding capacity (WHC) of raw beef burger was measured after centrifugation as described by Besbes *et al.*[15]. A sample of 5 g was centrifuged at 9500 *g* for 30 min at 10°C. The centrifuged tubes were drained for 15 min. Water holding capacity was expressed as follows:

WHC = (initial moisture – loss of water) × 100 / initial moisture

(III) *Cooking Measurement*

Burgers of every formulation were cooked in the same way, while using an oven grill maintained at 200°C (15 min). They were turned over at 7.5 min interval to ensure uniform cooking. The weight, thickness and diameter of 3 beef burgers from each batch were measured at room temperature before and after cooking to calculate cook loss, reduction in diameter and increase in thickness. The following calculations were performed:

Cook loss = [(RBW – CBW) × 100) / RBW]

Diameter reduction = [(RBD – CBD) × 100) / RBD]

Thickness increase = [(RBT – CBT) × 100) / RBT]

**RBW**: raw burger weight, **CBW**: cooked burger weight, **RBD**: raw burger diameter, **CBD**: cooked burger diameter, **RBT**: raw burger thickness, **CBT**: cooked burger thickness.

(IV) *Sensory Evaluation*

Samples were prepared by cooking as described earlier. They were held at 65°C for 30 min before sensory evaluation. Samples were presented in a homogeneous way, i.e. identical conditions of conservation, preparation and presentation. Samples were presented in an anonymous way with a simple coding of 3 numbers. Beef burgers were evaluated for flavor and texture (i.e. juiciness and appearance). The mean value of these sensory properties was evaluated as overall acceptability. Burgers were evaluated based on 5 point hedonic scale, where 1 represented dislike extremely and 5 represented like extremely. Hedonic evaluation was done by an untrained panel consisting of 36 students and staff from the National School of Engineer (Sfax, Tunisia).

VI. *Statistical Analysis*

Analytical values were determined, using three independent determinations. Values of different parameters were expressed as the mean ± standard deviation ($\overline{x}$ ± S.D.). The analysis of the beef burgers were conducted on 3 separate processing tests.

One-way analysis of variance (ANOVA) was used to determine significant differences ($P < 0.05$) between DFC and PFC (fiber origin is the factor).

Ducan's test was used to access the differences between burgers. Statistical analyses were performed on statistical analysis package STATISTICA (Release 5.0 Stat Soft Inc. Talsa, OK).

## RESULTS AND DISCUSSION

I. *Chemical Composition of "Second-Grade Dates"*

The proximate composition of "second-grade dates" from Deglet Nour cultivar is presented in Table 2. Results showed predominance of the total carbohydrates (84.9%) and fibers (9.7%) with a relatively low content in lipid (0.5%) and protein (2%). The carbohydrate fraction of Deglet Nour cultivar was essentially formed by non-reducing sugars (56.6% of total carbohydrates, characteristic of this studied variety[16]. The reducing sugars were essentially formed by glucose and fructose[17,18].

Dates also contained significant amount of minerals. The potassium concentration was the highest. These results were in general agreement with those reported for date fruits[16].

The composition of second grade dates was similar to that of commercial dates having a high sensory quality[5,16,17]. Indeed, they are rich in high value elements, such as sugars and fibers, to be valorized. Second grade dates (with hard texture) had relatively low $a_w$ (0.638), protecting them against all bacterial degradations. However, dates could be infected by yeasts if they are badly stocked i.e. at a relatively high temperature and at a high relative humidity[5].

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II. *Chemical Composition of Functional Fibers*

Dietary fiber consists of non-digestible carbohydrates and lignin that are intrinsic and intact in vegetal products. They have beneficial physiologic effects in humans[19]. Table 3 presents the average composition of the extracted DFC and the commercial pea fiber concentrate (PFC). PFC presented higher dry matter content (91.02% *vs.* 86.50%) and higher fiber content (90.95% *vs.* 84.65%, dry matter basis) than those of DFC. However, protein and lipid presented higher proportion (dry matter basis) in DFC (10.08% *vs.* 5.43% and 3.14% *vs.* 0.71%, respectively) than PFC. These differences could be mainly attributed to different origins of the fibers and extraction procedures.

It is worth noting that the protein yield (in relation to total proteins) reached nearly 26% in DFC (result not shown). This relatively high level could be due to the presence of insoluble proteins in dates, but also to the solubility reduction of the initially soluble proteins, during the thermal treatment (70°C, 15 min)[20].

Although DFC presented a lower dry matter content compared to PFC, the two fiber extracts yielded practically the same $a_w$ value. This could be due to the richness of DFC with components having higher water retention capacity such as fibers and proteins.

It is interesting to note that the studied fiber concentrates (FC) could be stocked safe from the humidity at ambient temperature without risk of development of the micro-organisms, because their $a_w$ values were lower than 0.6[21].

III. *Techno-Functional Properties of DFC*

(I) *Water and Oil Binding Capacities*

Functional properties of fibers were mainly related to their good effects on human health. High dietary fiber diets are associated with the prevention of some diseases, such as colon and rectum cancer, abdominal hernias, varicose veins, diabetes, diverticular, obesity, and coronary heart diseases[19,22].

Hydration properties of fibers are related to their ability to retain water. Fibers with high hydration properties could increase stool weight and potentially decrease the rate of nutrients absorption in the intestine and could also enhance viscosity of the added food[22]. A significant difference ($P < 0.05$) was observed between the WBC of DFC and PFC, namely 15.82 g/g and 3.08 g/g, respectively (Figure 1). WBC value of DFC obtained in this study was higher than those reported for most fruit and vegetable fiber concentrates. For example, citrus fibers and orange fibers, known for their high hydration properties, presented a lower WBC (< 11 g/g)[23,24].

The high WBC of DFC suggests that it could be used as a functional ingredient in food formulations, in order to reduce dehydration during the storage; to modify

**Table 2.** Proximate composition of second grade dates

| Main constituents | Deglet-Nour pulp |
|---|---|
| Dry matter (wt. %) | 82.73 ± 0.87 |
| Total carbohydrates[(1)] | 84.99 ± 0.07 |
| Reducing sugar[(1)] | 36.87 ± 0.50 |
| Total dietary fiber[(1)] | 9.71 ± 0.25 |
| Protein[(1)] | 2.05 ± 0.15 |
| Lipid[(1)] | 0.51 ± 0.05 |
| Ash[(1)] | 2.64 ± 0.01 |
| Phosphorus[(2)] | 63.59 ± 1.10 |
| Sodium[(2)] | 9.17 ± 0.20 |
| Potassium[(2)] | 857.60 ± 0.88 |
| Calcium[(2)] | 45.98 ± 0.98 |
| Water activity ($a_w$) | 0.618 ± 0.02 |

[(1)]In g/100 g dry matter basis. [(2)]In mg/100 g of dry matter. All values given are means of three determinations.

**Table 3.** Chemical composition of date fiber concentrate (DFC) and pea fiber concentrate (PFC)

| | DFC | PFC |
|---|---|---|
| Dry matter (wt. %) | 85.50 ± 0.85$^a$ | 91.02 ± 0.18$^b$ |
| Total dietary fiber[(1)] | 84.65 ± 0.20$^a$ | 90.95 ± 0.15$^b$ |
| Protein[(1)] | 10.08 ± 0.05$^a$ | 5.43 ± 0.27$^b$ |
| Lipid[(1)] | 3.14 ± 0.12$^a$ | 0.71 ± 0.08$^b$ |
| Ash[(1)] | 2.03 ± 0.09$^a$ | 2.87 ± 0.05$^b$ |
| Water activity ($a_w$) | 0.513 ± 0.01$^a$ | 0.525 ± 0.008$^a$ |

**[(1)]**In % dry matter basis. Values given are means of three determinations. Means in the same row with different letters are significantly different ($P < 0.05$).

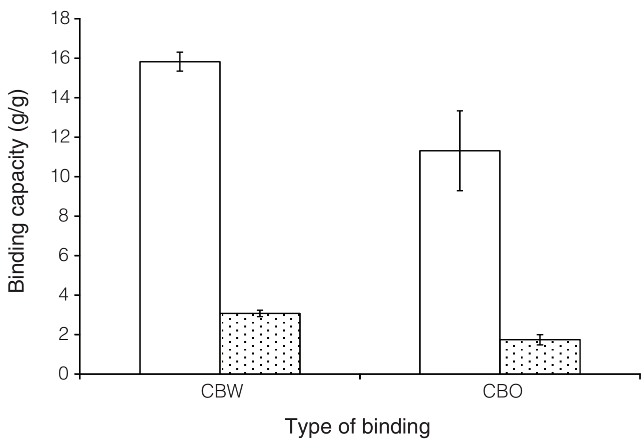


**Figure 1.** Water and oil binding capacities of fiber concentrate. □: date fiber concentrate (DFC); ▨pea fiber concentrate (PFC); WBC: In g water/g fiber; OBC: In g oil/g fiber.

texture and viscosity and to reduce energetic value. Thus, hydration properties of DFC would serve to improve the sensory and nutritional properties of food products.

Figure 1 also shows that DFC exhibited significantly higher ($P < 0.05$) oil binding capacity (OBC) than PFC (11.31 g/g *vs.* 1.74 g/g). The OBC of DFC was higher than the most fruit and vegetable fiber concentrates. Figuerola *et al.*(22) reported that OBC ranged from 0.60 g/g for apple fiber concentrate to 1.81 g/g for orange fiber concentrate. López *et al.*(25) reported an OBC value of 5.81 g/g for artichoke fiber concentrate. DFC could be very interesting for holding fat during industrial processing and the storage or during culinary preparations such as frying and cooking. In fact, fibers having high OBC could be used to stabilize products rich in fat.

The WBC and OBC values could be related to the origin of the fibers and their processing that affect significantly composition, physical structure, porosity and particle size of fibers.

(II) *Effect on Beef Burgers Characteristics*

Results of physico-chemical characteristics of raw burgers are presented in Tables 4. Incorporation of DFC in beef burgers formulations did not affect significantly ($P > 0.05$) $a_w$ values. No significant difference ($P > 0.05$) in dry matter content was observed between the control, 0.5% DFC and 1% DFC. This could be explained by the fact that meat, containing already a considerable amount of water, has been partially replaced by a mixture having slightly superior water content (DFC + Water). Besides, the method used for dry matter determination was not sensitive to detect statistical differences between control, 0.5% DFC and 1% DFC. However, the quantity of added water for 1.5% DFC was more important, followed by significantly decreased dry matter ($P < 0.05$). This result supports the findings of Naveena *et al.*(26) for chicken patties made with ragi flour.

Ash content was lower ($P < 0.05$) in Burger added with DFC at 1% and 1.5%. Water holding capacity (WHC) of raw beef burger increased significantly ($P < 0.05$) with DFC levels. This could be attributed to the high water binding capacity (WBC) of DFC.

Cooking properties of beef burgers are shown in Table 5. There has been an increase ($P < 0.05$) in cooking yield with the DFC levels. In fact, the high cook loss was from the control sample due to the high loss of moisture and fat during cooking. DFC decreased cooking loss because of its high ability to keep moisture and fat in the matrix. This statement was supported by the study of Aleson-Carbonell *et al.*(27) on the incorporation of lemon albedo fibers in beef burger formulation. Similar results were obtained by Mansour and Khalil(23) and Turhan *et al.*(28), who have used wheat fibers and hazelnut pellicles

**Table 4.** Physico-chemical properties of raw beef burgers formulated with different levels of date fiber concentrate (DFC)

| Parameters | DFC level (%) | | | |
|---|---|---|---|---|
| | Control<br>0 | Test 1*<br>0.5 | Test 2*<br>1 | Test 3*<br>1.5 |
| Dry matter (wt. %) | 32.43 ± 0.05$^a$ | 32.97 ± 0.84$^a$ | 32.59 ± 0.22$^a$ | 30.03 ± 0.50$^b$ |
| Ash(1) | 6.39 ± 0.52$^a$ | 6.19 ± 0.74$^a$ | 4.96 ± 0.25$^b$ | 4.90 ± 0.13$^b$ |
| Water holding capacity (WHC) (%) | 9.08 ± 0.83$^a$ | 13.67 ± 0.59$^b$ | 14.23 ± 0.19$^b$ | 19.11 ± 0.25$^c$ |
| Water activity ($a_w$) | 0.961 ± 0.001$^a$ | 0.961 ± 0.001$^a$ | 0.962 ± 0.001$^a$ | 0.963 ± 0.001$^a$ |

(1)In % dry matter basis. All values given are means of three determinations. Means in the same row with different letters are significantly different ($P < 0.05$).
*Meat was partially replaced by water and 0.5% DFC (Test 1), 1% DFC (Test 2) and 1.5% DFC (Test 3).

**Table 5.** Cook loss and dimensional changes of beef burgers, formulated with different levels of date fiber concentrate (DFC)

| Parameters | DFC level (%) | | | |
|---|---|---|---|---|
| | Control<br>0 | Test 1*<br>0.5 | Test 2*<br>1 | Test 3*<br>1.5 |
| Cook loss (%) | 27.37 ± 0.56$^a$ | 26.55 ± 0.12$^b$ | 25.89 ± 0.23$^c$ | 25.24 ± 0.15$^d$ |
| Diameter reduction (%) | 31.63 ± 0.32$^a$ | 23.68 ± 0.25$^b$ | 19.38 ± 0.19$^c$ | 18.37 ± 0.10$^d$ |
| Thickness increase (%) | 60 ± 0.44$^a$ | 55 ± 0.31$^b$ | 40 ± 0.25$^c$ | 40 ± 0.17$^c$ |

All values given are means of three determinations. Means in the same row with different letters are significantly different ($P < 0.05$).
*Meat was partially replaced by water and 0.5% DFC (Test 1), 1% DFC (Test 2) and 1.5% DFC (Test 3).

in beef burger formulations.

Control beef burgers showed more reduction in diameter ($P < 0.05$) by cooking as compared to DFC added beef burger. Reduction in diameter decreased significantly ($P < 0.05$) with % DFC levels. These results supported the finding of Turhan *et al.*[28] in low-fat beef burgers made with hazelnut pellicles. The reduction in diameter was the results of the denaturation of meat proteins and loss of water and fat. The increase of DFC in beef burger formulations could contribute to reduce this phenomenon due to their high water and fat binding capacities.

As in case of cook loss and reduction in diameter, the highest increase in thickness was observed in the control beef burgers. The samples formulated with 1% and 1.5% DFC levels had the lowest increase in thickness. This response could be attributed to the binding and the stabilizing properties of DFC which restricted the distortion of the product at the time of cooking.

The improvement in cooking performance, due to the addition of DFC, appears to be related with their high WBC and OBC.

Sensory traits for cooked beef burgers with different DFC levels are shown in Table 6. Beef burgers with DFC had generally acceptable scores. There was no negative effect of DFC addition, up to 1%, on flavor, texture and overall acceptability. However at 1.5% DFC addition, a reduction ($P < 0.05$) in texture score and then in overall acceptability was observed. We can therefore conclude that sensory study showed that the addition of DFC at respective levels of 0.5% and 1% not affected meaningfully ($P > 0.05$) the taste, the texture and the overall acceptability of beef burgers. On the other hand, an addition to a level of 1.5% DFC requires either the additional binding and/or gelling agents to prevent the decay of the product during cooking, or reduced added-water level in beef burger formulation. Turhan *et al.*[28] showed also that the highest overall acceptability scores were recorded for the control sample and the low-fat burgers with 1% of hazelnut pellicles.

**Table 6.** Sensory properties of beef burgers, formulated with different levels of date fiber concentrate (DFC)

| Parameters | DFC level (%) | | | |
|---|---|---|---|---|
| | Control 0 | Test 1* 0.5 | Test 2* 1 | Test 3* 1.5 |
| Flavor | $3.13^a$ | $3^a$ | $2.93^a$ | $2.70^a$ |
| Texture | $3.26^a$ | $3.06^a$ | $2.85^a$ | $2.43^b$ |
| Overall acceptability | $3.19^a$ | $3.03^a$ | $2.89^a$ | $2.56^b$ |

All values given are means of thirty six determinations. Means in the same row with different letters are significantly different ($P < 0.05$).

*Meat was partially replaced by water and 0.5% DFC (Test 1), 1% DFC (Test 2) and 1.5% DFC (Test 3).

## CONCLUSIONS

The use of DFC could improve the cooking properties of beef burger due to their high water and oil binding capacities. The increased fiber content constitutes an additional nutritional benefit for the consumer and permits a reduction of the rate of meat incorporation that passes from ~ 63% in the control to ~ 46% in the product with 1% DFC level (Table 1). At this level, this substitution could permit a reduction of the production cost without affecting sensorial descriptors of the product to which the consumer is familiarized. The use of DFC may be an alternative to conventional fibers in meat products.

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