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ORIGINAL RESEARCH PAPER

THE COOKING INFLUENCE ON THE CHARACTERISTICS OF COMPOTES BASED ON PRICKLY PEAR AND DATE SYRUPS

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Abstract: The Mech-Degla and Frezza dates (sorting gaps of the Deglet-Nour date) are Algeria's most common varieties of dates (*Phoenix dactylifera* L.). These dry dates are rich in sugars and can be transformed into various food products like syrup, which is used as a natural sweetener. This work aims to study the influence of cooking on the physicochemical properties of compote prepared from prickly pear and date syrup, compared to control compote. The date syrup is characterized by a high content of sugars (61.90 - 64.70 %), total acidity (0.20 - 0.21 %), ash (3.90 - 3.91 %), and total polyphenols (17.17 - 17.24 %). The prickly pear is a very water-rich fruit with a content of 84 % and a total soluble solids content of 14.5 %. Three formulas of compotes are elaborated on the prickly pear sweetened with two date syrups (Mech-Degla and Freeza) and with sucrose (control). Also, a strong impact of cooking on the compote's physicochemical properties was established, especially, on the polyphenol contents that decrease after cooking, in addition to the titratable acidity, and the *p*H. The DPPH decrease to 52 - 68 % compared to the fruit and syrups DPPH (62.5 – 80.66 %).

Keywords: *compotes, cooking influence, DPPH, Frezza syrup, Mech-Degla syrup, polyphenols, prickly pear*

INTRODUCTION

The prickly pear - *Opuntia ficus Indica* (L.) Mill. - is a plant originating from Mexico and belonging to the Cactaceae family. This plant can also be found in all American hemispheres and grows worldwide, such as in Africa, Australia, and the Mediterranean basin [1, 2]. *Opuntia ficus Indica* is gaining interest worldwide because it can grow where no other crops can. In addition to its use in the diet, prickly pear is also used for healthcare due to its high content of polyphenols and antioxidant, anti-inflammatory, and anxiolytic properties [3 – 5]. The prickly pear is juicy with a subtle floral aroma having a soft and delicately sweet taste. The prickly pear provides varied and interesting vitamin contributions: vitamin C (6.76 mg / 100 g), vitamin E and D (96.80 and 1.40 µg / 100 g, respectively). The amount of *β*-carotene is 28.01 µg / 100 g, the phenolic content of fruit juice is 123.56 mg / 100 g and the antioxidant activity is 39.18 %.
Elshehy *et al.* [6] demonstrated that prickly pears cladodes and fruits can be considered functional food, due to their valuable fibers, vitamins, minerals, fatty acids, phenolic compounds, and antioxidant contents.
The date is the date palm fruit, named *Phoenix dactylifera* L. Dates are particularly rich in carbohydrates and mineral elements including K, Ca, and Mg, dietary fibers, and vitamins [7]. Indeed, macromolecules and other essential micronutrients: flavonoids, phenolic compounds, and anthocyanins are also present in the date. Because of its antioxidant activity, the date can be used for hypertension treatment, diabetes, and cancer [8].
These fruits of arid and semi-arid zones are considered important foods for their population. However, a large part of this production is neither consumed nor valorized. Therefore, processing and preservation remain the best solution.
Processing is a new approach to achieving new food formulations such as juices, jams, compotes, or others, according to the standards and consumers' requirements [9].
Fruit compote is considered one of the most popular and appreciated canned foods. The compote is tasty, adds vitamin nutrition, and may have other healing properties [10].
The term 'compote' is reserved for products obtained by cooking the edible part of one or more fruit species, whole or in pieces, sieved or not, and sugar(s), without significant concentration. They can be sifted or contain pieces. Their sugar value varies between 16 and 40 % depending on the product [10].
Organoleptic criteria are also to be considered to find the ideal combination for fruit compotes, hence the need for several combination tests. The compotes' texture, consistency, color, and smell depend on those of the fruits used. For physicochemical criteria, the fruit's *p*H and sugar content are important [11].
This study aims to discover the cooking influence on the physicochemical properties of the compote developed based on prickly pear and date syrup. Mech-Degla and Frezza date syrups are used to replace refined white sugar.
This study also includes the physicochemical characterization of prickly pear, and date syrup used as raw material. Also, the determination of polyphenols and antioxidant activity, by the DPPH test, of the fruits used and compotes developed is presented.
Until now, no study has been carried out on the cooking influence on the characteristics of compotes based on prickly pear and date syrup.

MATERIAL AND METHODS

Plant Material

Dates

The two varieties of dates used in this study were Mech-Degla (dry date) and Frezza (sorting gaps of Deglet-Nour date). These dates were harvested in October 2021 from the palm groves of Biskra - Algeria.

Prickly pear

The prickly pear fruit studied was harvested in September 2021, from Theniet El Abed - Algeria. The fruits used were collected, cleaned and peeled, blanched in steam for 5 min, and then frozen at -15 ºC until use.

The manufacturing process of the compotes

Three compotes were elaborated on the prickly pear sweetened with two date syrups (Mech-Degla and Freeza) and sucrose.
The preparation was carried out according to the diagram in Figure 1.

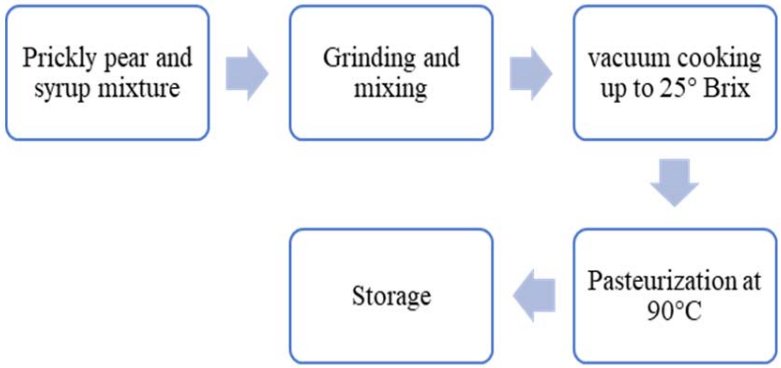

Figure 1. *Process of compote elaboration*

Physicochemical characterization of prickly pear, dates syrup, and compotes

The moisture content was determined by drying each product at 103 ± 2 °C, in an oven at atmospheric pressure to a constant weight. The water content equals the mass loss [12]. The soluble dry residue (determined by refractometer Abbe Refractometer), means the aqueous solution sucrose concentration with the same refractive index as the product being analyzed, under certain preparation conditions and at 20 °C [13].
The *p*H was determined according to NF (1970) method using *p*H-meter type HANNA HI 2210, at 20 °C. According to the potential difference between two *p*H meter electrodes immersed in an aqueous solution [14].
The titratable acidity analysis measures all the H^+ ions available in the medium, whether they are dissociated or ionized. The aqueous solution acidity was titrated with a sodium

hydroxide solution (NaOH) and the phenolphthalein indicator, according to the NF V05-101 method [15].
The total sugar contents were determined according to Dubois' method [16], the concentrated sulfuric acid causes, at hot, the departure of several water molecules from the mono and disaccharide. This dehydration was accompanied by the hydroxymethylfurfural (HMF) formation in the hexose case and furfural in the pentose case. These compounds condense with phenol to give colored complexes (yellow-orange). The coloration intensity is proportional to the sugar concentration.
The optical density was measured at 488 nm with a UV-vis spectrophotometer type Shimadzu. A 0.5 mL of a solution was added, 0.5 mL of phenol (5 %), and 3 mL of sulfuric acid.
Regarding the determination of ash content, the muffle furnace, type Heraeus, method of incineration was used. A sample was weighed in porcelain capsules and placed in the oven until whitish ash is obtained [17].
Colorimetry consists of data and methods set for objective color quantification. The color space L^*, a^*, b^*, defined by the International Commission on Illumination (CIE) is an approximately uniform three-dimensional space in terms of chromatic differences [21]. The measurement was performed by a colorimeter, Minolta Camera, Japan.
These tests were performed for each sample of (prickly pear, date syrups, and compotes).
All used chemicals were analytically pure.

Determining polyphenol content

For extracting, 3 g of the sample was mixed in a methanol/water solvent (80/20 % v/v) for 24 hours with stirring, then filtered on filter paper, and concentrated with a rotavapor, obtaining thus the extract. After extracting a polyphenol determination was performed by the Folin-Ciocalteu method [18]. The total polyphenols were determined colorimetrically according to the method described by Meda et *al*. [19]. The blue coloration intensity is proportional to the phenolic compounds content present in the medium, giving an absorption maximum at 760 nm. Obtaining thus the extract, 0.5 mL of each extract was dissolved in 5 mL of distilled water and mixed for 1 minute.
1 mL of Folin-Ciocalteu reagent was added and left to react for 5 minutes. Then, 1 mL of 7.5 % sodium carbonate was added. The mixture was vortexed and incubated in the dark for 1 hour. The blank was the methanol with the Folin-Ciocalteu, distilled water, and sodium carbonate [20]. These tests were performed for each sample of prickly pear, date syrups, and compotes. The results were reported in mg GAE /100 g FW (fresh weight).

Determining antioxidant activity of prickly pear, dates syrup, and compotes

The antioxidant capacity was determined by scavenging the DPPH radical as the Farag method [22]. This method depends on the purple DPPH radical reduction to a yellow-colored DPPH. As the free radical source, 50 µL of each extract at different concentrations was added to 1.950 mL of DPPH solution (0.025 $g \cdot L^{-1}$).

Equal methanol and DPPH amounts were used as control. After incubation for 30 min in the dark, scavenging capacity was measured by monitoring the decrease in absorbance at 515 nm.
The lower absorbance of the reaction mixture indicated higher free radical-scavenging activity. The DPPH radical scavenging activity was calculated according to the following equation 1:

$$(\%)\ DPPH = [(A_0 - A_1) / A_0] \times 100 \quad (1)$$

where: A_0 is the absorbance of the control [nm];
A_1 is the absorbance of the sample [nm].
The experiments were performed in triplicates.

Statistical analysis

The results are expressed as mean ± standard deviation (n = 3). The XLSTAT (2014.5.03) software is used for the analysis of variance (ANOVA), followed by the Tukey HSD test. Data is considered statistically significant when $p < 0.05$.

RESULTS AND DISCUSSION

Physicochemical characterization of prickly pear

The physicochemical results of prickly pear are mentioned in Tables 1 and 2.

Table 1. *Physicochemical characterization of prickly pear*

Parameters	Prickly pear
*p*H	5.5±0.01
Moisture [%]	84.0±0.72
Brix [%]	14.5±0.28
Dry matter [%]	11.0±0.72
Titratable acidity [g citric acid /100 g]	0.45±0.09
Total polyphenols [mg GAE /100 g FW]	25.18±1.02
Total sugar [g/100 g]	11.5±0.06
Ash [%]	1.97±0.72

Different lowercase letters in the same row indicate a significant difference ($p \leq 0.05$).

Table 2. *Prickly pear colors*

Parameters	Prickly pear
L^*	45.93±1.3
a^*	+12.34±0.77
b^*	+27.99±0.98

L^* = lightness or luminance;
a^* = chromatic component (red-green);
b^* = chromatic component (yellow-blue).

The water content of prickly pear pulp is 84 %. This value is close to that found by Tonelli and Gallouin [23] and Chiteva and Wairagu [24] who gave contents between 87 and 89 %, respectively.
The Brix degree refers to the soluble dry matter (SDM) rate. In this study, the Brix level found for prickly pear is 14.5 %. This value is higher than that given by Bouzoubaâ [25] for cacti grown in Morocco. But it is similar to that reported by Chouigui [26], which is 15 %. Also, the Brix mentioned by Stavi [27], is cited as between 13.5 - 14.5 % for a yellow-orange prickly pear.
The *p*H of the prickly pear fruit extract is slightly acidic 5.5. This value is almost identical to that given by Bouzoubaa [25], who mentioned the values 5.80 - 5.92 for the Achefri and Amouslem varieties.
It is also identical to those mentioned by Mazari and Mahdeb [28], who gives the values of 5.91 to 5.93, for the Meridef and Chegaga sites in (Souk-Ahras) eastern Algeria.
The titratable acidity of the fruit is 0.45 %. This result found is close to that mentioned in other studies [27], where the results are between 0.55 to 0.57 % for a yellow-orange prickly pear. It is also identical to that of the apple which is 0.4 % [29].
The total sugar content of the prickly pear is 11.5 %. This value is lower than the results given by Bouzoubaâ [25], which finds values ranging from 13.5 % to 15.87 % for different varieties studied in Morocco. It also remains lower than the results given by Mazari and Mahdeb [28], who found values of 13.25 to 14.8 %.
The ash content represents the total amount of fruit mineral salts. The ash content is 1.97 % of dry weight (DW), this result is higher than those of Mazari and Mahdeb [28], which is 0.26 - 0.44 % DW. This difference is due to the fruit's richness in mineral elements.
According to Table 1, the prickly pear polyphenols content is about 25.18 mg GAE /100 g FW. The results obtained are lower than those obtained by Bouzoubaâ *et al.* [25], which are between 28.94 and 44.72 mg GAE /100 g FW. Several authors found that total polyphenols seem to present stability during refrigerated storage [30, 31].
The characteristic fruit colors are shown in Table 2. According to the results, the fruit color is reddish yellow (low value of a^* and b^*).

Antioxidant power of prickly pear

According to the DPPH activity results, the prickly pear shows very high activity compared to other fruits, with a value of 80.66 %. These results are comparable to those cited by Bargougui et *al.* [32]. But they are higher than those found by Osorio-Esquivel et *al*. [33]. So, prickly pear can be considered a functional food because of its high antioxidant content.

Physicochemical characterization of date syrups

The date syrups characteristics are mentioned in Tables 3 and 4.
The *p*H of Mech-Degla and Frezza syrup is slightly acidic, it was between 4.88 and 4.97 respectively. No significant difference was found between the syrup's *p*H. These results are close to those found for Deglet-Nour and Ghars varieties [34]. Similarly, the author [35] detects that the date syrup acidity is due to the organic acids present in the date fruits.

Table 3. *Physicochemical characterization of date syrups*

Parameters	Mech-Degla Syrup	Frezza Syrup
*p*H	04.88±0.01 [b]	04.97±0.005 [b]
Moisture [%]	32.56±0.10 [b]	31.51±0.84 [b]
Brix [%]	65.20±0.17 [b]	65.50±0.17 [b]
Dry matter [%]	67.44±0.10 [b]	68.49±0.84 [b]
Titratable acidity [g citric acid /100g]	00.20±0.84 [b]	00.21±0.64 [b]
Total polyphenols [mg GAE /100g FW]	17.17±1.00[b]	17.24±0.83 [b]
Total sugar [g/ 100g]	61.90±0.37 [b]	64.70 ±0.11 [c]
Ash [%]	03.90±0.53 [b]	03.91±0.53 [b]

Different lowercase letters in the same row indicate a significant difference ($p \leq 0.05$).

Table 4. *Syrups color*

Parameters	Mech Degla Syrup	Frezza Syrup
L^*	38.54±1.75[a]	38.7±1.51[a]
a^*	-0.62±0.25[a]	-0.18±1.0 [b]
b^*	+13.7±0.2[a]	+13.68±0.2[a]
ΔE	27.54±1.77	41.05±1.82

Different lowercase letters in the same column indicate a significant difference ($p \leq 0.05$).
L^* = lightness or luminance; a^* = chromatic component (red-green);
b^* = chromatic component (yellow-blue).

The Brix of Mech-Degla and Frezza syrups are very high (between 65.2 and 65.6 % respectively). So, it is considered a good sweetener. According to the Al-Farsi et *al* [36], the syrup concentration is related to the soluble solids content and depends on the extraction methods used. No significant difference was found between the syrups Brix.
Concerning the phenolic contents, there is no significant difference between the two syrups Mech-Degla and Frezza, which are 17.17 and 17.24 mg GAE / 100 g FW, respectively. These polyphenol contents are much lower than those quoted by Al-Farsi *et al.* [36], which are between 96 and 162 mg GAE / 100 g FW. This difference is due to the variety used and the technical conditions of extraction and obtaining.
The ash content of date syrups ranges between 3.9 - 3.91 %. These results are close to those of Mimoini [37], who reports an ash content ranging between 2.1 and 4 %.
The contents of mineral elements can vary not only with the date variety used, but, also varies according to the techniques, the extraction conditions, and during date cooking [38].
The color of the three syrups is mentioned in Table 4. a^* values are negative for both syrups, with a significant difference, which means that the color tends toward green. According to Noui [39], this can be explained by the reaction between some phenolic acids and iron or by the type of treatment used.

Antioxidant power of date syrups

Several research types have shown the important antioxidant activity of dates and their syrups [40, 36]. The antioxidant activity of the two syrups Mech-Degla and Frezza are respectively 62.55 and 71.66 %, as shown in Table 5. These values are comparable to

those of Noui [39], concerning Mech-Degla syrup, and higher than those of Abbès et *al*. [40].
These results show a significant difference between the antioxidant activity of the two syrups (Mech-Degla and Frezza).

Table 5. *Antioxidant power of date syrups*

Parameter	Mech Degla Syrup	Frezza Syrup
DPPH [%]	62.55±0.17^{b}	71.66±0.5^{c}

Different lowercase letters in the same row indicate a significant difference ($p \leq 0.05$).

Physicochemical characterization of compotes

The physicochemical results of compotes are mentioned in Tables 6 and 7.

Table 6. *Physicochemical characterization of compotes*

Parameters	Compote 1	Compote 2	Compote 3
Moisture [%]	73.50±0.14^{a}	74.65±0.21^{b}	70.60±0.28^{c}
Dry matter [%]	26.50±0.14^{a}	25.35±0.21^{b}	29.40±0.28^{c}
*p*H	04.54±0.06^{a}	04.50±0.03^{a}	04.47±0.01^{a}
Brix [%]	26.40±0.20^{a}	26.90±0.17^{b}	26.60±0.11^{ab}
Titratable acidity [g citric acid /100g]	00.53±0.06^{a}	01.00±0.06^{b}	00.44±0.06^{c}
Total sugars [%]	10.30±1.55^{a}	12.30±0.67^{ab}	12.71±0.87^{b}
Ash [%]	06.90±0.42^{a}	06.31±0.43^{a}	04.30±0.14^{b}
Polyphenols [mg GAE /100g FW]	29.49±1.08^{a}	18.91±1.68^{b}	13.24±0.71^{c}

Different lowercase letters in the same row indicate a significant difference ($p \leq 0.05$)

Table 7. *The compotes color*

Parameters	Compote 1	Compote 2	Compote 3
L*	27.73±0.15^{a}	27.10±1.57^{a}	22.30±1.05^{b}
a*	04.60±0.70^{a}	04.16±0.76^{b}	04.56±1.22^{a}
b*	26.80±0.43^{a}	28.13±0.60^{b}	21.60±0.26^{c}
Δ*E*	38.84±0.85^{a}	39.28±1.84^{b}	31.38±2.6^{c}

Different lowercase letters in the same column indicate a significant difference ($p \leq 0.05$).
*L**= lightness or luminance; *a** = chromatic component (red-green);
*b** = chromatic component (yellow-blue).

The water content of the three compotes ranged from 70.6 - 74.65 %. This value is close to that mentioned by Ciqual [42], which reports an average value of 74.30 %.
The water content decreases after cooking because of the water evaporation with heat.
The compotes have a slightly acidic *p*H, between 4.47 - 4.54, without significant difference. This limit of *p*H can promote the yeasts and mold's multiplication, at the same time hindering bacteria development except for acidophiles [43]. This variation can be explained by several factors; such as the temperature effect during cooking on organic acids, and the different mineral content of the syrups used. No difference was observed between the *p*H of the three compotes prepared.
The compotes Brix is between 26.4 and 26.9 %, which has a slight difference. This value is identical to that given by Andriatsitohaina [11], who find a Brix of 26 for an apple compote. According to Guy [44], for standard apple sauce, the sugar content is

above 24 g / 100 g. The Brix increases after the syrup addition. The compote Brix sweetened by sucrose syrup is close to that of two other compotes.
A significant difference was observed between the titratable acidity of the three compotes, which is between 0.44 and 1 %.
The sugar content is between 10.3 - 12.71 %, these values are lower than those reported by Ciqual [42], which are 21.0 - 23.8 % (FW) for compotes based on various fruits. This content is influenced by the initial content fruits are used for the compote's elaboration. The highest content is that of compote prepared with sucrose. The increase in this value after cooking is due to the water evaporation from the compote.
A clear difference in ash content of the three compotes, which are between 4.3 - 6.9 % was observed. The highest value was recorded for Compote 1, which is based on Mech-Degla syrup. The compote with the lowest ash content is Compote 3 (based on sucrose syrup). This result is explained by the date syrup's richness in minerals.
The polyphenol content is between 18.91 - 29.49 mg GAE / 100 g FW, the difference indicates that the Mech Degla-based compote is the richest in polyphenols. These results are similar to that given by Noui [39], who finds 28.12 mg GAE /100 g for the apple-peach compote sweetened by the mixture (date syrup and sucrose), and 12.23 mg GAE /100 g for the compote sweetened by sucrose.
The results obtained show that the compotes polyphenol content is decreased after cooking (Table 6). Therefore, there is a remarkable cooking influence on the polyphenol composition. Then it has a negative influence on the biochemical composition and the nutritional value of the finished product.
According to the results of the characteristic compotes color which is indicated in Table 7, a significant difference exists between the three compotes. It was noticed also that the *L* values decrease after the syrup addition and during cooking.

Antioxidant power of compotes

As shown in Table 8, a clear difference is observed for the antioxidant activity of the three compotes elaborated with prickly pear and the syrups Mech-Degla, Frezza, and sucrose, which is 58, 68, and 52 %, respectively. These values are lower than those found by Noui [39], which is 91.9 % for apple and apricot date syrup-based compote.
DPPH values are decreased in all three compotes after cooking. This decrease is explained by the cooking effect and the influence of preparation conditions on phenolic existence.
Despite this decrease in the DPPH value, the elaborated compotes still have an important value from the nutritional and antioxidant point of view.

Table 8. *Antioxidant activity of compotes*

Parameter	Compote 1	Compote 2	Compote 3
DPPH [%]	58.00±0.17^{a}	68.00±0.1^{b}	52.00±0.5 ^{c}

Different lowercase letters in the same row indicate a significant difference ($p \leq 0.05$).

CONCLUSION

This work aims first to characterize and transform the prickly pear into standard compote prepared by three types of syrup: the syrup of dates Mech-Degla and Frezza, and the sucrose syrup.
Also, the purpose was to study the influence of cooking on the properties of the prepared compotes.
The prickly pear fruit studied is rich in polyphenol 25.18 mg / 100 g FW, rich in water and contains an average total sugar content of 14.5 g / 100 g. It has also, an important antioxidant activity.
The physicochemical analysis results of the used date syrups showed that they have a very important nutritional value, despite the low content of polyphenols. The high content of mineral elements is explained by the high ash content (3.9 mg / 100 g DW).
Therefore, in the formulation of compotes, date syrup can substitute refined white sugar.
Regarding the studied compotes, the Brix increase to 26.4 - 26.9 %, which is higher compared to the fruit. Cooking and adding syrup decrease the water content from 84 to 70.4 - 74.6 %.
After cooking, the three compotes' color is changed and the polyphenol content decreases with a notable change for the Frezza and sucrose compotes, from 25.18 to 13.24 - 18.91 mg GAE / 100 g FW.
The DPPH activity of all compotes elaborated decreased after cooking compared to the initial value. So, cooking has a significant influence on the compote's physicochemical characteristics and antioxidant activity, but the elaborated compotes still have an important value from the nutritional and antioxidant point of view.
According to their nutritional value, the prepared compotes can be classified as follows: Mech-Degla date syrup compote then Frezza date syrup compote, and finally sucrose syrup compote.

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