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Research Article

PHYSICOCHEMICAL CHARACTERIZATION AND SENSORY ANALYSIS OF JAMS PRODUCED FROM *OPUNTIA FICUS-INDICA* CLADODES

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ABSTRACT

Objective: This study focuses on the production and evaluation of the physicochemical and sensory qualities of two jams, J1 and J2, produced from *Opuntia ficus-indica* cladodes. J1 made from cladodes with the addition of lemon juice and J2 made from cladodes with added 1/3 orange pulp and lemon juice.

Methods: The moisture content is determined by drying the fresh cladodes in an oven at 103°C. The soluble solids content is determined by measuring the Brix at 20°C using a digital refractometer. Total soluble sugar content was examined using the phenol-sulfuric acid colorimetric method using a spectrophotometer ultraviolet (UV)-visible spectroscopy. Sensory evaluation was carried out by 20 panelists. The individual quality features were evaluated using significance factors: Color, texture, aroma, and taste. For instrumental color analysis, the measurement was carried out with the use of spectrophotometer UV-visible, the results were expressed using the CIE (L*, a*, and b*) system.

Results: The physical and chemical analysis results give fairly appreciably results on average for total sugars (55.4 and 58.76%), Brix (65 and 67%), humidity (29.79 and 29.89%), and acidity (0.45 and 0.48 g/100 g). The sensory results give for color (3.73 and 6.42), for taste (4.89 and 5.21), for odor (3.00 and 3.57), and texture (4.21 and 4.21). The physicochemical analyses for cladodes showed a rich content for water 92.74, the total sugar content is 5.53.

Conclusion: These elaborate jams meet the accepted international standards for jams. The sensory evaluation revealed that J2 was the most appreciate in terms of color, odor, texture, and taste.

Keywords: Cactaceae family, Acidity, Sugars content, Brix degree, pH.

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INTRODUCTION

Opuntia ficus-indica (L.) miller belongs to the genus *Opuntia* to the *Cactaceae* family of the order *Caryophyllales*, usually named prickly pear or nopal cactus, is the *Cactaceae* plant with the greatest economic relevance in the world [1], original from arid, and semi-arid regions of America, including Mexico [2] and cultivated as a significant nutrient and food source [3]. It is widely cultivated in the semi-dry area in Algeria for its high adaptation to the harsh desert environment. It is used for fruit production for its rich content of vitamin, its antioxidant properties, and presents an important amount of minerals and fibers [4]. Nowadays, there are several studies about its phenolic content and antioxidant activity, which may provide potential health benefits [5-7], anti-inflammatory wound healing, hypoglycemic, and antimicrobial activities [8], production of bioethanol and biogas [9], animal nutrition [10-12], and phytoremediation [13-15]. Prickly pear is mostly known for its fruits, but its cladodes are consumed as well, mainly in Mexico. They are commonly consumed fresh, but additionally, prickly pear fruits can be consumed dehydrated, as juice concentrates, jams, and syrups and as fruit gummies, among others [16,17]. Besides, cladodes can be stored canned and consumed as juices or stored as a dehydrated powder. Cactus cladodes are well-known for their high content of polysaccharides such as pectin, lignin, mucilage, cellulose, and hemicellulose [18]. Many of these polysaccharides have been used in several industries in the food industry such as nano- and micro-encapsulation of bioactive compounds and super-plasticize [19,20] in the pharmaceutical industry such as anti-ulcer, anti-inflammatory, cytoprotective, and cholesterol-lowering activities [21,22]. The present study is aimed at the production and evaluation of the physicochemical and sensory qualities of jam produced from *O. ficus-indica* cladode from the Timgad region (Batna, semi-dry area). According to European Union Council Directive 2001/113/EC [23], jams are a mixture brought to a suitable gelled consistency, of sugars, with the pulp and/or puree of one or more kinds of fruit and water. Concentration is carried to at least 65% soluble solids for all jam, with some requiring up to 68% solids to achieve the desired qualities. Not <45 parts of the fruit are permitted for every 55 parts of sugar.

METHODS

Plant material and preparation

Materials Prickly pear cladodes were harvested in March 2018 from the area of Timgad (Batna) and selected to retain only healthy cladodes. They were brushed under tap water to remove spines, peeled to remove wax, and chopped into small pieces and homogenized into a fine form using a food grinder (HELIX) than filtered through a sieve to eliminate waste from the juice and pulp. The juice and pulp are mixed in similar proportions with sugar (w/w) and allowing the mix to soak for 24 h (let macerate for 24 h). The mix is then cooked to acquire the necessary final total soluble solid content [24] of 65° Brix. We prepared two jams: Jam1 (J1) made from cladodes with the addition of lemon juice and jam 2 (J2) made from cladodes with added 1/3 orange pulp and lemon juice.

Physical characterization of cladodes

The axial dimensions of fruits were measured with a caliper and ruler. The cladodes were weighed on an analytical balance (Sartorius Quintix).

Chemical analysis

The moisture content is determined by drying the fresh cladodes in an oven Memmert SLE 400 at 103°C until a constant weight

was reached [25]. The titratable acidity is measured according to AFNOR [26]. The pH is measured by a pH meter (CORNING) at 20°C. The soluble solids content is determined by measuring the Brix at 20°C using a digital refractometer, Schmidt HAENSCH 22523 type, AR200 [26]. Ash content was determined by combustion of the sample in a muffle furnace at 550°C [25]. The total soluble sugar content was examined using the phenol-sulfuric acid colorimetric method using a spectrophotometer ultraviolet (UV)-visible spectroscopy, Shimadzu) at 490 nm [27]. Reducing sugars were determined by Fehling's test. The sucrose content is determined by the difference between the total sugar content and the reducing sugars present in the sample [28].

Sensory analysis

Sensory evaluation was carried out by 20 panelists, fulfilling the requirements for sensory sensitivity, according to the requirements of ISO 3972 and ISO 6658 [29,30] recommended conditions, using a 9-point Hedonic scale where 1-disliked extremely, 2-disliked very much, 3-disliked moderately, 4-disliked slightly, 5-neither liked nor disliked, 6-liked slightly, 7-liked moderately, 8-liked very much, and 9-liked [31]. The individual quality features were evaluated using significance factors: The external appearance of the product surface, structure, color, consistency, aroma, and taste.

Instrumental color analysis

Measurement of upper surface color was carried out with the use of spectrophotometer UV-visible, Shimadzu UV- 120-01, with reference to illuminant D65 and a visual angle of 10°. The results were expressed using the CIE (L*, a*, and b*) system [32]. The established color parameters were as follows: L* (lightness) 0 - is black and 100 is white; a*redness (+) greenness (−); b* yellowness (+) blueness (−); and C*the color saturation value (Chroma) as well as h° – the hue angle. The measurements are carried out on the cladodes; the device cell is positioned directly on the fruit to perform the measurement. The results represent the mean and standard deviation of three measurements, according to Giannou *et al.* [33]. The color index E was calculated according to the CIE formula [32]:

$$E = [(L^*)^2 + [(a^*)^2 + (b^*)^2]^{1/2}.$$

Statistical analysis

Statistical analysis results were expressed as mean±standard deviation and analyzed by Stat Box (6.0). Newman–Keuls test (p<0 05) was used to determine the significant differences between mean values. All analyses were conducted in triplicate.

RESULTS AND DISCUSSION

Physical characterization of cladodes

The average weight of studied cladodes is 454±44.9 g, this value is close to that found by Sadok *et al.* [34] (Table 1), that is, 342 g. The data relating to the measurements of the studied cladodes are evaluated on average at 30.3 cm in length by 16 cm in width and 2.29 cm in thickness. These values are close to those found by Sadok *et al.* [34], which give an interval of (24.5–30.2) for the length of 11.8–13.6 for the width. They are also close to that of Boutakiout *et al.* [35], 15–25 cm in length and 9–13 cm in width.

Physicochemical characterization of fresh cladode

The results of the physicochemical cladode's composition are shown in Table 2. The cladodes are rich in water, with an average content of 92.9±0.57%, this result is very close when compared to the value observed by Sadok *et al*. [34], a variety from the Blida region of 93.6%. The dry matter content is 7.26±0.57, this value is low compared to the value obtained by Sadok *et al*. [34] 13.8%. The ash content is 0.72±0.01%, this value is lower compared to that obtained by Abdessemed *et al*. [4], which is 1.90%. As for the organic matter content of 6.53±0.01%, close to that obtained by Abdessemed *et al*. [4], which is 6.19%. The value of total sugars is 5.53±0.1%, close to that obtained by Sadok *et al*. [34], which is 5.79%. With regard to reducing sugars, our value is 1.64±0.32%, close to that found by Sadok *et al*. [34], which is 1.95%. For sucrose, our cladodes contain 3.89%, which indicates a high-energy value. The pH is 4.75±0.02, close to that observed by Boutakiout *et al*. [35], which varies from 4.44 to 4.77. The titratable acidity is 0.42±0.03% close to that observed by Sadok *et al*. [34], which ranges from 0.21% to 0.52%. The 5.50° B value of Brix is close to that published by Boutakiout *et al*. [35], which varies from 5.10 to 11.0° Brix.

Physicochemical characteristics of elaborated jams

The significant water content of around 29.8% for J1 and 29.7% for J2, they are the range of values found by Espiard [36] and Frédot [39] (Table 3), that is, ≤40%. Knowledge of the humidity of the jam provides information on the aptitude of the product for storage and possible microbial development. According to Espiard [36] and Frédot [39], jams must contain a maximum of 40%. Our results are <40%, this contributes to improving the microbiological stability of the jam. Ashes represent almost the same content for both types of jam. They vary from 0.24±0.05% and 0.26±0.02%, these contents are very low compared to other jams. Total sugars present 58.7±1.92 /100 g for J1, 55.4 g±1.10 g/100 g for J2, the elaborate jams slightly different from the author's standard [38] (65.0–70.0 g/100 g dry matter). The reducing sugars are around 7.97±1.25 g/100 g for J1 and from 11.3±1.25 g/100 g for J2. Sucrose is around 50.79±1.31 g/100 g for J1 and 44.07±0.65 g/100 g for J2. The pH analyzes represented in Table 4 mark different

Table 1: Physical characterization of the cladode

Characteristic	Values	References
Cladode weight (g)	454±44.9	342 [34]
Length (cm)	30.3±1.60	24.5–30.2 [34]
Width (cm)	16.0±0.50	11.8–13.6 [34]
Thickness (cm)	2.29±2.08	/

Table 2: Physicochemical characterization of cladode

Parameters	Values	References
Moisture (%)	92.7±0.57	88.0–95.0 [34]
Dry matter (DM) %	7.26±0.57	12.0–15.4 [34]
Organic material (% DM)	6.53±0.01	/
pH 20 °C	4.57±0.02	4.44–4.77 [35]
°Brix %	5.50±0.50	5.10–110 [35]
Titratable acidity (g/100 g)	0.42±0,03	0.21–0.52 [34]
Total sugars (%) (g/100 g) (% DM)	5.53±0.10	3.00–7.00 [34]
Reducing sugars (g/100 g) (% DM)	1.64±0.32	1.13–4.01 [34]
Sucrose (g/100 g) (% DM)	3.89±0.45	/
Ash (g/100 g) (% DM)	0.72±0.01	/

Table 3: Physicochemical characterization of jams

Parameters	J1	J2	References
Moisture (%)	29.8±1.32	29.7±1.05	≤40 [36-39]
Dry matter %	70.1±1.22	70.2±1.00	/
Organic material %	69.8±0.02	69.9±0.05	/
pH 20°C	3.10±0.02	3.40±0,10	3.00–3.50 [37]
Brix %	67.0±0.26	65.0±0.10	65.0–67.0 [37]
Titratable acidity (g/100 g)	0.45±0.01	0.48±0.03	/
Total sugars (%) (g/100 g)	58.7±1.92	55.4±1.1	65.0–70.0 [38]
Reducing sugars (g/100 g)	7.97±1.25	11.3±1.25	/
Sucrose (g/100 g)	50.7±1.31	44.0±0.65	/
Ash % (g/100g) DM	0.26±0.02	0.24±0,05	/

Table 4: pH and Brix of jams after 21 days, at room temperature

After 21 days, at room temperature			
pH	3.40±0.08	3.50±0.02	3.00–3.50 [37]
Brix %	68.0±0.3	67.0±0.2	65.0–67.0 [37]

Table 5: Sensory characteristic

Sample	L	a	b	h	C
Cladodes	48.2±0.17	–80.7±1.32	30.7±0.58	168±0.51	32.0±0.39
J1	35.2±0.58	–1.00±0.02	16.4±0.38	95.5±0.86	16.4±0.69
J2	36.0±0.65	1.60±0.06	20.7±0.67	85.6±0.15	20.7±0.48

Table 6: Sensory characteristic of jams

Parameters	J1	J2
Color	3.73±1.33	6.42±1.30
Taste	4.89±0.03	5.21±1.12
Odor	3.00±0.21	3.57±0.47
Texture	4.21±0.54	4.21±0.42

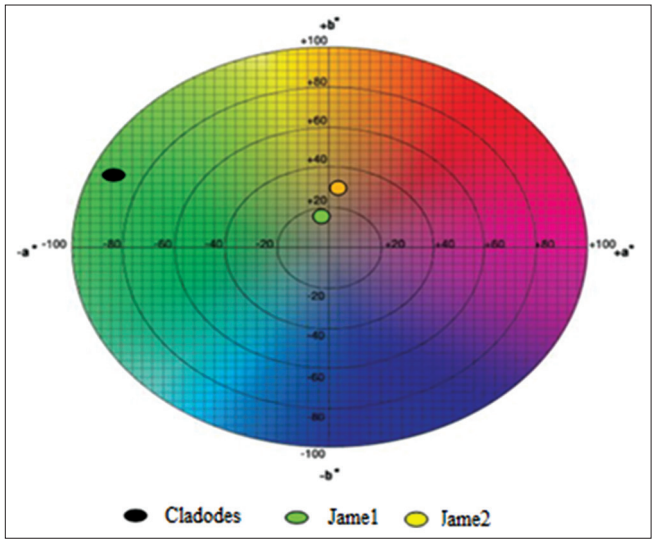

Fig. 1: Color analysis. Positioning of the color of cladodes and prepared jams on the chromatic circle

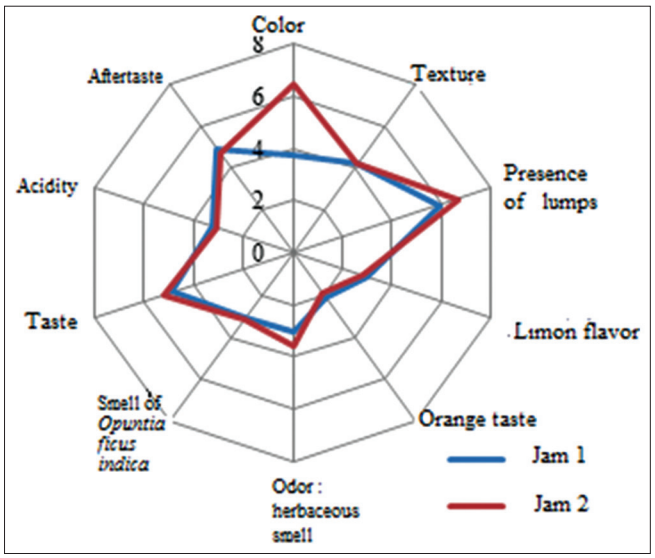

Fig. 2: Sensory analysis

values and which oscillate between (3.10 and 3.40). The jam results are in the Codex Alimentarius interval, for the two jams on the 1st day of preparation, and between 3.40 and 3.50 after 21 days (at room temperature 24–25°C) (Table 4). The acidity informs us about the degree of freshness of the jam and the good control of the manufacturing process. The value found for the two jams (0.45±0.01 g/100 g and 0.48±0.03 g/100 g).

Color test

Color is a complex sensory quantity, which is broken down to be quantified into five simple quantities: L*, a*, b*, C*, and h [40] dL*=difference in clarity. If L* is positive, the sample is lighter and when L* is negative, the sample is darker. da*=Deviation on the red/green axis. The color redder if a* positive and more green when a* is negative. db*=Deviation on the yellow/blue axis. The color is more yellow when b is positive and bluer if b negative. dC*=Chroma deviation or saturation. If C is positive, the sample is less saturated. dh deviation of the Chromatic Tonality. From the results mentioned in Table 5, we observe a slight loss of the clarity L of the two jams. A decrease in the intensity of color a and b. A decrease in C saturation and h tone. We deduce that the change in the overall color results from cooking, the addition of ingredients (lemon juice, orange pulp, and sucrose) induces the discoloration of the product during cooking (Fig. 1).

Sensory analysis

The results of the sensory analysis of prepared jams are summarized in Table 6. The scores for color ranged from 3.73±1.33 to 6.42±1.30, for taste from 4.89 to 5.21, for odor from 3.00 to 3.57, and for texture from 4.21 to 4.21. The sensory evaluation revealed that J2 was the most appreciate in terms of color, odor, texture, and taste (Fig. 2).

CONCLUSION

The results obtained in our work allowed us to draw the following conclusions, the prepared jams have a Brix degree of 65% for J1 and 67% for J2. The incorporation of lemon juice and orange pulp in the formulation of these jams allowed them to be enriched with micronutrients. The taste test revealed that the jam made by adding orange pulp is the best. To this end, it would be good to make these recommendations: Extend the field of study to other fruits or a mixture of prickly pear to others fruit to develop other quality products (jam, jelly, syrup, and candy) in the innovation framework; vary, for the jam of *O. ficus-indica,* other parameters such as sugar, fruit, and acid levels consider other more cost-effective uses of cladodes, namely, dietetics, cosmetics, and therapeutics.

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AUTHORS' CONTRIBUTIONS

Legrine Kamal and Benaouana Djahida carried out the experiment. Abdessemed Dalila conceived the original idea, directed the project, and wrote the manuscript.

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