Comparison of two jam making methods to preserve the quality of colored carrots

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In this study, carrot jams were developed using either precooked vegetable (common method) or short cooking times (mild method). Jams were prepared using four carrot types: a commercial one and three local landraces (orange, purple and yellow). The parameters assessed were total phenols, antioxidant activity, β-carotene, potassium content, color and sensory evaluation. Mild method caused lower color differences than common method, when comparing the jams to raw carrots. Antioxidant activity, total phenols and potassium content loss were also lower in mild method. Both methods improved β-carotene retention in jams. Following sensory analysis, products obtained by mild method showed the best scores for taste and overall acceptability, with the highest scores being registered for purple jam. In particular, high correlations between antioxidant activity, total phenols and purple products (both raw products and jams) were emphasized by principal component analysis. In conclusion, the mild method described in this paper helps to preserve the overall quality of perishable vegetables, such as local carrots.

1. Introduction

Currently, there is considerable demand for fruits and vegetables because they are considered rich sources of some essential dietary micronutrients and dietary fiber, and more recently they have been recognized as important sources of a wide array of phytochemicals that may benefit human health (Yahia, 2010). Nevertheless, many such products are seasonal and perishable; their nutritional value and taste are at their best directly after harvesting, decreasing as time elapses until the food is spoilt (Osvald & Stirm, 2008).

The seasonality and perishability of vegetables explain the need to apply preservation technologies (Giannakourou & Taoukis, 2003), including jam making. This technology is very typical in fruit preservation (Kansci, Koubala, & Lape, 2003). According to European Union Council Directive 2001/113/EC, 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. For the fruit processing industry, this technology is very common, so many studies have reported the effects of jam making on different fruits (Basu & Shivare, 2010; Grigelmo-Miguel & Martín-Bellos, 1999; Rababah et al., 2011; Watanabe, Yoshimoto, Okada, & Nomura, 2011; Wicklund et al., 2004). Nevertheless, jams can also be produced from vegetables such as tomatoes, carrots, sweet potatoes, cucumbers and pumpkins (European Commission, 2001).

The traditional jam market has been stable during the last few years as a consequence of changes in consumption practices and the presence of alternative or new products on the market (Grigelmo-Miguel & Martín-Bellos, 1999). Accordingly, the jam industry needs to improve its competitiveness and develop new products, such as vegetable jams, which may well be a way of achieving this objective.

Carrot (Daucus carota L.) is one of the most ideal vegetables, due to its versatility in culinary uses and its phytochemical contents, especially phenols (Babic, Amiot, Ngugen-The, & Aubert, 1993), polyacetylenes (Hansen, Purup, & Christensen, 2003; Kidmose et al., 2004) and carotenoid compounds (Block, 1994). The appreciable levels of different compounds make carrot a functional food with significant healthy properties (Hager & Howard, 2006) and anticancer activity (Sharma, Karki, Thakur, & Attri, 2011). Moreover, some studies have demonstrated that colored carrots, especially purple and black roots, have higher nutritional and healthy qualities compared to the commercial type (Alasalvar, Grigor, Zhang, Quantick, & Shahidi, 2001; Cefola, Pace, Renna, Santamaria, Signore, & Serio, 2012; Grassmann, Schnitzler, & Habegger, 2007; Kirca, Ozkan, & Cemeroğlu, 2006).

Considering these interesting characteristics and the absence of data on vegetable jams, the objective of the present study was to
evaluate the different technologies used in fruit preservation on colored carrots.

For jam making, some authors recommend precooking fruits and vegetables in order to obtain a puree (Dutta, Dutta, Raychaudhuri, & Chakraborty, 2006; Gliemmo, Latorre, Gerschenson, & Campos, 2009; Porretta & Porretta, 1999, chap. 7; Provesi, Dias, & Amante, 2011), while others describe methods of jam making using raw puree or pulp (Rababah et al., 2011; Wicklund et al., 2004). In summary, high-texture fruits and vegetables (such as apple, pear, pumpkin, quince) are precooked before jam making, while low-texture products (such as cherry, fig, orange, strawberry) are generally processed in the raw state. Starting from this remark, the aims of the present work were: i) to apply and compare the two jam making methods, which differ mainly according to whether they include a precooking step, using colored carrots; ii) to evaluate the effect of these two methods on the consumer acceptability of carrot jams; iii) to evaluate the preservation in jams of the main quality traits of raw carrots.

The general goal was to obtain carrot jams that retain the nutritional quality of the vegetable and also appeal to consumers.

2. Materials and methods

2.1. Materials

One commercial carrot type (‘Presto’) and three local landraces (orange, purple and yellow) were collected from a local farm located in Southern Italy, and transported to the laboratory in refrigerated containers. Sixty carrots (4 carrot types × 5 roots × 3 replications) were analyzed as raw products. The same carrots were used to prepare 24 jam samples (4 carrot types × 2 processing technologies × 3 replications), analyzed as detailed below. Fruttapec 3:18 was purchased from Cameo, Desenzano del Garda (BS), Italy. Sucrose was purchased from Euro Sfìr Italia, Foggia, Italy. Lemon juice was purchased from Star, Agrate Brianza (MB), Italy.

2.2. Jam making

Carrot jams were obtained by two methods (named common and mild), which differentiated for the ingredients and for processing. In both methods the content of the carrot pulp incorporated was over 60%, in order to obtain a carrot “extra jam” (European Commission, 2001) with a reduced sugar content.

After processing, jams were hot-packed at 85 °C (Rababah et al., 2011) in sterilized jars and immediately sealed with a cover to reduce the inner air pressure after cooling. To preserve nutritional value, according to Wicklund et al. (2004), samples were stored at 4 °C until the time of analysis, carried out as described in the following paragraphs.

2.2.1. Common method

Common method (Fig. 1(a)) was obtained using as ingredients fresh carrots (667 g kg⁻¹) and commercial sucrose (333 g kg⁻¹). As shown in Fig. 1(a), carrots were washed, peeled, cut into 2 cm thick slices, and boiled (98.5 ± 1.0 °C) in tap water for 30 min. After cooking, carrots were homogenized for 2–3 min, using a food processor (Bravosiamic FP 500, De’Longhi Appliances, Treviso, Italy), obtaining a carrot puree. Finally, sucrose was added to the carrot puree and this mixture was cooked (105.0 ± 1.0 °C) for 15 min.

2.2.2. Mild method

In mild method (Fig. 1(b)) ingredients used were fresh carrots (627.5 g kg⁻¹), commercial sucrose (274.5 g kg⁻¹), lemon juice (78.5 g kg⁻¹) and Fruttapec 3:18 (19.5 g kg⁻¹), as pectin source.

Fig. 1. Flow chart of common (a) and mild method (b); ‘( )’: minutes of cooking or boiling.

Carrots were washed, peeled and processed through a centrifugal juicer (Kenwood JE560, Kenwood Electronics Italy, Milan) to shred the carrots and obtain the two components (fibrous pulp and juice), which subsequently were mixed in order to obtain a raw puree. Lemon juice was immediately added to reduce oxidation; then, Fruttapec 3:18 and sucrose were added under manual agitation and the mixture was cooked (105.0 ± 1.0 °C) for 5 min.

2.3. Respiration rate, temperature coefficient (Q₁₀), firmness and dry weight

The respiration rate (mL CO₂ kg⁻¹ h⁻¹) of raw carrots was measured using a closed system at 0, 4, and 20 °C (Kader, 1992). Fresh roots (about 300 g for each carrot type) were put into 6 L sealed plastic jars, where carbon dioxide was allowed to accumulate until the value of a standard gas mixture containing carbon dioxide and nitrogen (0.1–99.9% Sapiò, Milan, Italy) was reached. Then, a 1 mL gas sample was taken from the head space through a rubber septum and injected into the gas chromatograph (Agilent p200 micro GC, Santa Clara, CA, USA) equipped with dual columns and a thermal conductivity detector. Carbon dioxide was analyzed with a retention time of 16 s and a total run time of 120 s on a 10 m PPU column at a constant temperature of 70 °C.

Q₁₀ values were also calculated for each carrot type using the formula reported by Labuza (1982). Firmness was measured on whole peeled raw roots with a machine texture analyzer (Zwick-Line Z0.5, Zwick/Roel, Ulm, Germany), using a puncture method and expressed in Newton (N).

Next, in order to measure dry weight, chopped carrots and jam were maintained in a forced-draft oven at 65 °C until constant weight was reached.

2.4. Determination of total phenols, antioxidant activity and β-carotene

The following extraction procedure was used for determining both total phenols and antioxidant activity. Five grams of chopped carrots or jams were homogenized in a methanol: water solution (80:20) for 1 min, and then centrifuged at 5 °C and 6440 × g for 5 min.
Total phenols were determined according to the method of Singleton and Rossi (1965), using a UV-1800 Shimadzu spectrophotometer (Shimadzu, Kyoto, Japan). Total phenols were reported in milligrams of gallic acid (GA) equivalents per 100 g \(^{-1}\) fresh weight (fw).

Antioxidant assay was performed following the procedure described by Brand-Williams, Cuvelier, and Berzet (1995) with minor modifications. The diluted sample, 50 \(\mu\)L, was pipetted into 0.95 mL of diphenylpicrylhydrazyl (DPPH) solution to initiate the reaction. The absorbance was read after 40 min at 515 nm. Trolox was used as a standard and the antioxidant activity was reported in milligrams of Trolox equivalents 100 g \(^{-1}\) fw.

The AOAC method (AOAC, 2000) was used for determining \(\beta\)-carotene by a spectrophotometric assay. To obtain the calibration curve, the \(\beta\)-carotene standard supplied by Sigma–Aldrich (Milan, Italy) was used. Next, the \(\beta\)-carotene content was calculated on the basis of the calibration curve and data were expressed as mg \(\beta\)-carotene 100 g \(^{-1}\) fw.

2.5. Inorganic cation content

Sodium, potassium, magnesium, and calcium were determined on raw carrots or jams as reported by Serio, De Gara, Caretto, Leo, and Santamaria (2004) with minor modifications. Briefly, 25 g of carrots or jams were homogenized with distilled water (1:4, w/v) in a blender. The filtered solution was diluted and analyzed by ion chromatography ( Dionex model DX120; Dionex Corporation, Sunnyvale, CA) with a conductivity detector, using an IonPac CG12A pre-column and an IonPac CS12A separation column.

2.6. Color analysis

Color analysis of raw roots or jams was conducted with a colorimeter (CR-400, Konica Minolta, Osaka, Japan) equipped with illuminant D65, in reflectance mode and in the CIE \(L^*\) (lightness), \(a^*\) (redness) \(b^*\) (yellowness) color scale. Color was measured at five points on each carrot surface or jam layer for a total of 50 measurements for each carrot or jam. Hue angle \((h^* = \arctan (b^* / a^*))\), from primary \(a^*\) and \(b^*\) readings, was then calculated. The colorimeter was calibrated with a standard reference having \(L^*\), \(a^*\) and \(b^*\) values of 97.55, 1.32 and 1.41, respectively.

2.7. Sensory evaluation of jam

A selected group of 10 assessors (made up of 5 females and 5 males, aged between 24 and 50 years old), previously involved as members of the trained descriptive analysis panel for jams, was trained to describe the attributes of carrot jams. All evaluation sessions were held in the laboratory at the Institute of Sciences of Food Production. The sensory evaluation of carrot jams was carried out 2 days after jam making. Color, odor,一致性, and overall acceptability of each carrot jam were evaluated using a hedonic scale from 9 to 1 (9 = like extremely, 8 = like very much, 7 = like moderately, 6 = like slightly, 5 = neither like nor dislike, 4 = dislike slightly, 3 = dislike moderately, 2 = dislike very much, 1 = dislike extremely) (Basu & Shivare, 2010; Grigelmo-Miguel & Martin-Belloso, 1999). All jams were presented to the panellists at room temperature under normal lighting conditions in transparent plastic glass coded with random, three-digit numbers. Each panellist evaluated 24 samples (4 carrot jams \(\times\) 3 replications \(\times\) 2 methods). The sensorial test was divided into sessions, in which the panellists evaluated 3–5 samples at a time, working in individual booths and drinking water for oral rinsing. The average value scores of all sensory evaluations were used in the analysis.

2.8. Data analysis

For a visual analysis of the data, principal component analysis (PCA) (PRINCOMP procedure, SAS software, Cary, NC, USA) was performed on mean centered and standardized (unit variance scaled) data prior to analysis. The data matrix submitted to PCA was made up of 12 observations — 3 products (raw carrots, common and mild jams) \(\times\) 4 carrot types (commercial carrot, orange, yellow and purple local landraces) — and 11 physicochemical variables — 4 color parameters \((L^*, a^*, b^*, h^*)\) and 7 chemical properties \((\text{Na}, K, Mg, Ca, total phenols, antioxidant activity, } \(\beta\)-carotene content)\). PCA was applied in order to obtain an interpretable overview of the main information. To detect statistical significance, ANOVA was applied (GLM procedure, SAS software) and means were separated by the Student–Newman–Keuls (SNK) test.

3. Results and discussions

3.1. Respiration rate, temperature coefficient \((Q_{10})\), firmness and dry weight of raw carrots

Respiration rate, \(Q_{10}\), firmness and dry weight are presented in Table 1. Respiration rate was significantly higher in purple and yellow local landraces at 20 °C. Measurement of respiration rate is useful when investigating the physiology of many vegetables (Kader, 1986). A continuously high rate of respiration is often associated with a shortened shelf life (Day, 1990). The \(Q_{10}\) value, which indicates the \(n\) fold decrease in shelf life caused by a 10 °C temperature increase (Labuza, 1982), was significantly higher in all local landraces, especially in the purple and yellow types. As reported by Kader (2002), \(Q_{10}\) is inversely correlated with shelf life. These results were confirmed by firmness measurements. Commercial carrots showed a mean firmness 28% higher than local landrace carrots (Table 1). This difference could be attributed to the higher dry weight of commercial types in comparison with orange, yellow and purple carrots (Table 1). All these results indicate that the local landrace carrots are perishable and difficult to store as raw products.

3.2. Antioxidant activity, total phenols, \(\beta\)-carotene and inorganic cation content of raw carrots and jams

The antioxidant activity, total phenols, \(\beta\)-carotene and potassium content of raw carrots and jams are shown in Fig. 2. Common method caused a reduction in antioxidant activity in all jams (from 36% in purple jam to 92% in commercial jam) compared to raw roots (Fig. 2A). By contrast, mild method did not affect antioxidant activity.
activity in purple jam (Fig. 2A), whereas it led to a 44% increase in antioxidant activity in yellow type and a 20% and 80% decrease, respectively, in orange and commercial roots. Generally, mild method caused lower antioxidant activity losses in all jams than common method compared to raw carrots. The higher antioxidant activity losses by common method could be attributed to the prolonged heat treatment of carrot tissues (Soto-Zamora, Yahia, Brecht, & Gardea, 2005) and by the absence of lemon juice, which in mild technology functioned as a possible protective ingredient against oxidation (González-Molina, Moreno, & García-Viguera, 2009).

As was the case for antioxidant activity, after jam making by mild method total phenols were also not significantly different from the raw carrots in purple (67.6 ± 0.91 mg GA 100 g⁻¹ fw in roots and 67.3 ± 0.95 mg GA 100 g⁻¹ fw in jam) and yellow (16.4 ± 1.18 mg GA 100 g⁻¹ fw in roots and 16.8 ± 0.50 mg GA 100 g⁻¹ fw in jam) jams (Fig. 2B). They decreased by 12% and 43%, respectively, in orange and commercial jams compared to raw carrots. In contrast, after making by common method, total phenols decreased in all jams, from 46% to 56% in comparison to raw carrots. This trend indicated that common method caused much more pronounced phenol losses compared to raw carrots than mild method. According to Gonçalves, Pinheiro, Abreu, Brandão, and Silva (2010), the higher phenol losses caused by common jam making method could be attributed to its longer cooking times.

There was no significant difference in β-carotene content between common and mild jams obtained using purple carrots (Fig. 2C). In addition, after mild method, β-carotene content increased by between 18% (commercial jam) and 184% (yellow jam) compared to raw roots. The latter increase could explain the previously reported rise in antioxidant activity. Interestingly, after common method, β-carotene content increased by between 156% (commercial jams) and 300% in yellow and orange jams compared to raw roots. These results are in agreement with data reported by Miglio, Chiavarro, Visconti, Fogliano, and Pellegrini (2008) on boiled carrots and also observed by Pinheiro Sant’Ana, Stringheta, Cardoso Brandão, and Cordeiro de Azeredo (1998). These authors concluded that boiling was the step that led to the greatest stability of β-carotene in commercial carrots compared to other cooking methods. So, the boiling of carrots, before the final cooking in common method, probably improved β-carotene retention in jams.

Potassium content decreased in orange jam after mild method (2617 ± 408 mg kg⁻¹ fw in roots and 2105 ± 29 mg kg⁻¹ fw in jam) and increased by between 12% and 25% in commercial, yellow and purple jams compared to raw carrots (Fig. 2D). By contrast, after common method, potassium content decreased significantly by between 28% and 58% in all jams compared to raw carrots. Common jam making method caused more severe potassium losses compared to raw carrots than mild method, probably due to leaching during the boiling of carrot slices (Schoth, Allen, Schvanveeld, Hendricks, & Anderson, 1997). These results demonstrated the great nutritional quality of jams obtained through mild method compared to jams obtained through common method. Apart from potassium, the content of other cations, Na⁺, Mg²⁺, and Ca²⁺ was not so high in raw carrots, showing average values of 5512, 88.0 and 231.6 mg kg⁻¹ fw, respectively (data not shown). Their contents did not significantly change in jams, whether mild or common, compared to raw carrots, since a reduction of less than 20% was measured in average for Na⁺, Mg²⁺, and Ca²⁺ (data not shown), with no significant differences among jams (either for color and methods) due to the high variability detected in the raw carrots, which also was found in jams.

Fig. 2. Antioxidant activity (A), total phenols (B), β-carotene content (C), and potassium content (D) of raw roots and jams obtained from commercial ( ), orange ( ), purple ( ), and yellow ( ) carrots (n = 3). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)
On the other hand, potassium is considered to be the most important ion in the mineral composition of raw carrots, a serving portion (100 g fw) of raw carrots considered in this study supplying 4.8% of Adequate Intake for potassium, approximately equal to 4,700 mg per day (National Research Council, 2005).

3.3. Color analysis

The color parameters, measured through changes in $L^*$ and $h^*$ values for raw carrots and jams are shown in Fig. 3. Generally, except for the purple carrots, jam method caused a significant decrease in $L^*$. Mild method caused a smaller decrease in this value in commercial, orange and yellow carrots than the common method. As for the $h^*$ value, mild jam making method did not affect the color in yellow (Fig. 3G) and commercial jams (Fig. 3E) compared to raw carrots. In addition, through mild method, $h^*$ increased by 18% and 103%, respectively, in orange (Fig. 3H) and purple (Fig. 3F) jams as compared to carrot roots. On the other hand, common jam making method caused a significant increase in $h^*$ values in all jam types as compared to carrot roots. In particular, it was 5%, 12%, 32% and 4-fold higher, respectively, in yellow (Fig. 3K), commercial (Fig. 3I), orange (Fig. 3L) and purple types (Fig. 3J). These data indicated that mild method caused less color differences in jams compared to raw carrots than common method. The effect of common method on jam color could be attributed to its longer cooking times (Trejo Araya et al., 2009) and to oxidation due to the absence of lemon juice (González-Molina et al., 2009).

3.4. Sensory evaluation

The different carrot jams varied in sensory profile (Fig. 4). The jams differed significantly in color, taste and overall acceptability. As for color (Fig. 4A), the panellists preferred the purple mild jam (8.4 ± 0.5), while they neither like nor dislike the purple common jam (5.2 ± 2.2). On testing the other carrot jams (mild or common), the panellists assessed them as “like moderately” (7.0 on the average), without showing score differences among them. These results confirmed data obtained using the colorimeter, especially in purple jams. Although, colorimeter showed significant differences among all jams, the panellist perceived relevant differences only between common and mild purple jams. This might be related to the high presence of anthocyanins in these roots (Arscott & Tanumihardjo, 2010), the main pigments responsible of purple jam color, which was affected by jam making methods. While, mild method preserved the purple jam color as previously reported, common method caused a browning, which affected negatively the visual quality and thus the color acceptability of these jams.

As for the taste (Fig. 4B), the purple mild jam was liked very much (7.4 ± 1.1), whereas the panellists neither liked nor disliked the commercial mild jam (5.3 ± 1.9) (Fig. 4B). Despite for acceptability (Fig. 4C), all jams were considered suitable and scores ranged between “like slightly” (5.7 ± 1.6) in commercial mild and “like very much” (7.9 ± 0.5) in purple mild jam. The panellists preferred mild jams to common jams in terms of taste and overall acceptability, with the exception of jams made from commercial...
carrots. Lower taste and overall acceptability scores registered in mild jam obtained from commercial carrots could be attributed to the greater firmness of these carrots as reported above (Table 1). In particular, we can hypothesize that commercial carrots need more cooking time to obtain a jam with better sensory quality. So, for this kind of carrots, the common technology may be preferred. Moreover, we can hypothesize that the addition of lemon juice as antioxidant component in mild jams might have affected the taste, color, and overall acceptability of these products. However, this is not true for the commercial mild jams. For these samples the high root firmness affected the jam fibrousness, which influenced as main factor (also in presence of lemon juice) the taste and the overall acceptability evaluation.

As for the odor the panellist did not found significant differences among all samples (Fig. 4D).

These colored carrots are particularly rich in volatile compounds, responsible of the characteristic flavor as previously well reported by Alasalvar et al. (2001). Since we added a commercial lemon juice, without a particular flavor, we can suppose that the contribution to the final odor might be insignificant, explaining the absence of difference in the sensorial evaluation of odor between common and mild samples.

Finally, as for consistency all jams were appreciated (mean score 7.03), without significant differences among samples (Fig. 4E). Starting from this result, it is possible to assert that the addition of a pectin source allowed to reduce considerably the cooking time in mild method without affect the perceived final consistency.

3.5. Principal component analysis

Principal component analysis allowed us to visualize and summarize all the differences highlighted by the ANOVA results. The eigenvalues of the correlation matrix showed that the first three Principal Components (PCs) explained 83% of the total variance. The first two PCs explained 41.09% and 29.67%, respectively. The PCA biplot (Fig. 5) showed that total phenols and antioxidant capacity were highly correlated reciprocally and with the same positive direction as PC1, being located to the right in the plot. They were responsible for most of the variance captured by PC1. Sodium content and, especially, \( \text{P/C1} \) were located to the left in the plot, inversely correlated with PC1 and with total phenols and antioxidant capacity. On the same side, but with less influence on the PC1 spanning variation, were \( L^* \) and \( b^* \) (Fig. 5). Examining the product distribution (Fig. 5), we find raw purple carrot and purple mild jam.

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**Fig. 4.** Sensory evaluation (scale 1–9) of jams by common and mild methods. (A) Color, (B) taste, (C) overall acceptability, (D) odor, and (E) consistency. A: significant for \( P < 0.001 \); B and C: significant for \( P < 0.05 \); D and E: not significant. Hedonic scale: 9 = like extremely, 8 = like very much, 7 = like moderately, 6 = like slightly, 5 = neither like nor dislike, 4 = dislike slightly, 3 = dislike moderately, 2 = dislike very much, 1 = dislike extremely.
Table 1: Color parameters and antioxidant activity of raw carrots and different types of jam.

<table>
<thead>
<tr>
<th>Sample</th>
<th>L</th>
<th>a</th>
<th>b</th>
<th>Ca (mg/100g)</th>
<th>Mg (mg/100g)</th>
<th>K (mg/100g)</th>
<th>TP (mg/100g)</th>
<th>AA (mg/100g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raw carrots</td>
<td>65.5</td>
<td>15.9</td>
<td>38.1</td>
<td>41.09%</td>
<td>35.0%</td>
<td>41.09%</td>
<td>291</td>
<td>104</td>
</tr>
<tr>
<td>JamCOran</td>
<td>68.2</td>
<td>17.8</td>
<td>41.4</td>
<td>41.09%</td>
<td>35.0%</td>
<td>41.09%</td>
<td>291</td>
<td>104</td>
</tr>
<tr>
<td>JamMComm</td>
<td>66.9</td>
<td>16.2</td>
<td>39.8</td>
<td>41.09%</td>
<td>35.0%</td>
<td>41.09%</td>
<td>291</td>
<td>104</td>
</tr>
<tr>
<td>JamMOran</td>
<td>66.9</td>
<td>16.2</td>
<td>39.8</td>
<td>41.09%</td>
<td>35.0%</td>
<td>41.09%</td>
<td>291</td>
<td>104</td>
</tr>
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Fig. 5. PCA biplot describing the variation of some physicochemical properties of four different colored carrots analyzed as raw/fresh (Fresh Commercial-FrComm, Fresh Orange-FrOran, Fresh Purple-FrPurp and Fresh Yellow-FrYell), mild jam (JamM) and common jam (JamC) in their raw state. These results, confirming the ANOVA results, highlighted that purple carrots are rich in antioxidants and phenols and that these traits are not greatly modified by the mild jam processing method.

4. Conclusions

In this paper, two different jam making methods were applied and compared on different colored carrots. As regards sensory evaluation, the jams produced by both methods were considered acceptable. Nevertheless, the jam obtained through mild method satisfied consumer acceptability more than jam obtained through common method, especially for the purple type. Moreover, mild method preserved the color and most of the antioxidant activity and total phenols of raw carrots more than common method. It could therefore be concluded that the overall quality of perishable vegetables, such as local carrots, can be preserved by using the mild method described in this paper. In addition, from a technological point of view, mild method helps the food processing industry to decrease production costs, with shorter working and cooking times compared to common method. This method, applied in this research for the first time on different types of carrots, could be applied to other nutrient-rich vegetables that are difficult to store in their raw state, and that require a making method aimed to preserve their quality and freshness, as required by consumers. Nevertheless, more information about the effect of storage on the preservation of quality in mild processed jams could be needed before any hypothetical industrial implementation.

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References


1 *Key references.


