VITAMIN CONTENT AND ANTIOXIDANT CAPACITY OF GRAPEFRUIT JAMS AND CANDIES OBTAINED BY DIFFERENT DEHYDRATION METHODS

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Abstract: The use of alternative process to jam and candy traditional elaboration such as osmotic dehydration, microwave energy or combined methods may be interesting in order to obtain sensory, nutritional and functional high-value products. The aim of this work was to evaluate the effect of different processes on grapefruit vitamin content (C, A and E) and antioxidant capacity. Among studied vitamins, vitamin C played the higher role in the antioxidant capacity of grapefruit products. Traditional and microwave heating for jams elaboration and vacuum osmotic dehydration followed by a heating step for candies obtention are the recommended treatments to obtain high vitamin C content products.

Keywords: grapefruit products, vitamins, osmotic dehydration, microwave, hot air

INTRODUCTION

Vitamins C, A and E are considered some of the major non-enzymatic antioxidants in the body (Halliwell, 1994) and produce health beneficial effects by scavenging free radicals, in particular vitamin C (Xu et al., 2008). Grapefruit is an important dietary source of bioactive compounds, whose beneficial effects are ascribed, in part, to its high vitamins content. However, its bitter taste limits its popularity among consumers as fresh fruit and traditionally it has been used in European production of jams and beverages. The application of prolonged heat treatments to the fruit, such as in the case of jams, can lead to important losses of the beneficial properties of these citrus fruits. Osmotic dehydration at mild temperature (30-40 ºC) is a technique that can be used to obtain jam without being so aggressive to the antioxidant compounds of the fruit (García-Martínez et al., 2002; Igual et al., 2010). Furthermore, vacuum application for a short period of time at the beginning of the osmotic process has beneficial effects on process kinetics and fruit quality in many fruits and also helps to reduce energy costs, especially in candying processes (Barat et al., 2002). The use of microwave energy could be proposed as an alternative to traditional heating in order to better preserve the natural organoleptic characteristics and essential thermolabile nutrients, since shorter process time are usually required (Astigarraga-Urquiza and Astigarraga-Aguirre, 1995). The aim of this work was to evaluate the effect of different jam and candy processes on grapefruit vitamins content and antioxidant capacity.

MATERIALS AND METHODS

Raw materials

Grapefruits (Citrus paradise var. Star Ruby) from the city of Murcia were purchased from a local supermarket. For osmotic dehydration (OD), fruit pieces were peeled and cut perpendicularly to the fruit axis, into 10 mm thick half slices. Food grade commercial sucrose was used. Citrus peel pectin (60% degree of esterification, Fluka Biochemika, Switzerland) was selected as gelling agent.

Jams preparation procedures

Jams were obtained by traditional (TJ), microwave (MWJ), osmotic (ODJ) and combined osmotic-microwave (OD+MWJ) processes according to Igual et al. (2010) to reach a 40-60 °Brix product, as described in the Spanish quality norm for fruit jam approved by RD 670/1990, BOE Nº 130, 1990. Briefly, to obtain TJ and MWJ the fruit was precooked, sugar added and cooked. To obtain ODJ and OD+MWJ, grapefruit was previously vacuum pulse osmodehydrated in a 65 °Brix sucrose solution, after what it was mixed with a part of the used OS and pectin. Where appropriate, the mixture was subjected to gentle heating in the microwave.

Candies preparation procedures

Candies were obtained by traditional (TC), osmotic (ODC), osmotic with a final hot air drying step (OD+HADC), osmotic with a final microwave drying
step (OD+MWC) and osmotic with a final drying step combination of hot air and microwave energy (OD+HAD+MWC) according to Igual (2011). Briefly, a 65 °Brix sucrose solution was used to dehydrate grapefruit at atmospheric or vacuum pulse pressure (TC and ODC, respectively) and the latter were also submitted to a heating step (OD+HADC, OD+MWC and OD+HAD+MWC).

**Analytical determinations**

The determination of vitamins was performed by high performance liquid chromatography (HPLC (Jasco)) with UV-visible detector (MD-1510), column Zorbax SBC-18 5 (C18 Teknokroma). For the analysis of vitamin C dehydroascorbic was reduced to ascorbic acid using the DL-dithiothreitol (DTT) reagent (Sigma-Aldrich) (Sanchez-Mata et al., 2000; Sánchez-Moreno et al., 2003). Ascobic acid was quantified according to Xu et al., (2008). Vitamins A and E were determined following the methodology of Munzuroglu et al., (2003). Antioxidant capacity was assessed using the free radical scavenging activity of the samples evaluated with the stable radical DPPH+ (Sanchez-Moreno et al., 2003). Significant differences among treatments were stabilised by means of the analysis of variance (ANOVA) (p<0.05). Furthermore, a correlation analysis between antioxidant activity and analyzed vitamins with a 95 % significance level was carried out. All statistical analyses were performed using Statgraphics Plus 5.1.

**RESULTS AND DISCUSSION**

Tables 1 and 2 show vitamins content in fresh grapefruit (FG) batches used for each product formulation, corresponding osmo-dehydrated grapefruit (ODG), jams and candies. Fresh fruit values coincide with that found by Leong and Shui (2002) and Chun et al. (2006). Vitamin C has been used as reference in different industrial processes since its presence ensures a high nutritional quality of the final product due to its easy degradation (Klimczak et al., 2007). Nevertheless, some authors observed that vitamin C showed great thermal stability at the low pH of citrus fruits (Sánchez-Moreno et al., 2003). In this study, Vitamin C was shown to be more stable to thermal treatments than to osmotic dehydration, due to its high water soluble character (Peiró et al, 2006). Jams obtained by osmotic treatments (ODJ, OD+MWJ) showed the lowest vitamin C content. No significant differences were observed in jams obtained by the traditional or microwave methods (TJ, MWJ). Loss of vitamin C after jam processing of fruits has been widely reported (Jawaheer et al., 2003). For candies, TC showed the greatest loss in this vitamin (58%).

Vitamin A was shown more or less equally stable to thermal treatment than to osmotic dehydration, while vitamin E was better maintained during osmotic dehydration process. The candied with highest loss of the content in these vitamins (46%) was OD+HADC, possibly because of oxidation caused by oxygen from air currents applied during the drying process by hot air (Lesková et al., 2006).

Table 1. Mean values (with standard deviation) of vitamins A, C and E (mg /100 g fresh grapefruit) in fresh grapefruit and jams obtained by application of different methods.

<table>
<thead>
<tr>
<th>Samples</th>
<th>Vitamin A</th>
<th>Vitamin C</th>
<th>Vitamin E</th>
</tr>
</thead>
<tbody>
<tr>
<td>FG</td>
<td>1.23 (0.02)</td>
<td>36.5 (0.3)</td>
<td>0.283 (0.012)</td>
</tr>
<tr>
<td>ODG</td>
<td>0.89 (0.04)</td>
<td>31.8 (0.2)</td>
<td>0.134 (0.003)</td>
</tr>
<tr>
<td>TJ</td>
<td>0.393 (0.012)</td>
<td>35.5 (0.3)</td>
<td>0.086 (0.002)</td>
</tr>
<tr>
<td>ODC</td>
<td>0.30 (0.05)</td>
<td>30.3 (0.7)</td>
<td>0.113 (0.006)</td>
</tr>
<tr>
<td>OD+MWJ</td>
<td>0.24 (0.02)</td>
<td>30.3 (0.4)</td>
<td>0.084 (0.006)</td>
</tr>
<tr>
<td>MWJ</td>
<td>0.29 (0.03)</td>
<td>35.9 (0.4)</td>
<td>0.088 (0.010)</td>
</tr>
</tbody>
</table>

Table 2. Mean values (with standard deviation) of vitamins A, C and E (mg /100 g fresh grapefruit) in fresh grapefruit and candies obtained by application of different methods.

<table>
<thead>
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<tbody>
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<td>0.283 (0.012)</td>
</tr>
<tr>
<td>TC</td>
<td>1.18 (0.03)</td>
<td>15.1 (0.3)</td>
<td>0.281 (0.013)</td>
</tr>
<tr>
<td>ODC</td>
<td>0.94 (0.02)</td>
<td>28.08 (0.08)</td>
<td>0.265 (0.002)</td>
</tr>
<tr>
<td>OD+HADC</td>
<td>0.65 (0.04)</td>
<td>30.0 (0.7)</td>
<td>0.152 (0.009)</td>
</tr>
<tr>
<td>OD+MWC</td>
<td>0.933 (0.018)</td>
<td>30.7 (0.2)</td>
<td>0.278 (0.005)</td>
</tr>
<tr>
<td>OD+HAD+MWC</td>
<td>0.871 (0.009)</td>
<td>28.3 (0.6)</td>
<td>0.260 (0.007)</td>
</tr>
</tbody>
</table>

Figure 1 show mean values of %DPPH of fresh grapefruit, osmo-dehydrated fruit, jams and candies. Fresh grapefruit % DPPH was similar to orange juice (Klimczak et al., 2007). Microwave and traditional cooking caused a decrease in percentage of DPPH of 54-59%, while those produced by osmotic dehydration and combined method presented % DPPH significantly lower (decrease in around 70%). The traditional method of candied caused the most significant decrease of % DPPH (78%), while ODC, OD+HADC, OD+MWC and OD+HAD+MWC treatments decreased significantly this parameter by 56%, 64%, 59% and 63% respectively.

In order to explain the influence of the quantified vitamins in this study on the antioxidant capacity of the samples, Pearson correlation statistical analyses were performed. Vitamin C played the mayor role in the antioxidant capacity of grapefruit products (r=0.8550, p<0.05), followed by the vitamin A (r=0.6918, p<0.05). Other studies (Xu et al., 2008) confirm the existence of a positive relationship.
between vitamin C of a fruit and its antioxidant capacity.

Fig. 1. Mean values and standard deviation of antioxidant capacity (%DPPH) in fresh grapefruit, osmo-dehydrated grapefruit, jams and candies. Same letters indicate homogeneous groups according to the statistical analysis (p<0.05) for each product.

CONCLUSIONS

From a nutritional and functional point of view, treatments that lesser affected the bioactive compounds of grapefruit jam and candy would be the recommended. When considering vitamins, special attention must be paid on Vitamin C, as it plays the higher role in the antioxidant capacity of grapefruit products. In the case of jams traditional and microwave heating and for candies vacuum osmotic dehydration followed by an step of microwave drying would be the selected treatments.

ACKNOWLEDGEMENTS

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REFERENCES


