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Colour and rheological properties of non-conventional grapefruit jams: Instrumental and sensory measurement

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ABSTRACT

Alternative methods with which to obtain grapefruit jams have been applied. These include the use of osmotic dehydration (OD) and/or microwave energy (MW), as an alternative to conventional heating, and the incorporation of bamboo fibre together with pectin in order to increase the jam's consistency. Colour, consistency and rheological behaviour were measured and sensory evaluation was carried out to compare product quality. When compared to the fresh fruit, the greatest colour changes took place in those jams processed by MW and conventional heating, both of them showing lower L^*, a^*, b^* and chrome values than the rest of the samples obtained by applying osmotic dehydration. By adding bamboo fibre, the colour of OD samples approaches that of fresh fruit. The higher yield stress, greater consistency and more viscoelastic behaviour was displayed by jams obtained by combining OD and MW processes. In the sensory analysis, the judges awarded this sample a better score. The sensory attribute product coverage in mouth was closely related to viscosity at a shear rate of 120 s^{-1} and consistency.

1. Introduction

Traditional jams and confitures are widely consumed by several groups of consumers at breakfast and in dairy products, bakery products and confectionery. They usually contain diverse sugars, essences, flavours, colouring foodstuffs, thickening agents, and consumable acids, and are preserved by appropriate methods (Kurz, Munz, Schieber, & Carle, 2008). Pectin is primarily used in the food industry as a gelling agent for jams, jellies, and other foods (El-Nawawi & Heinkel, 1997). Nevertheless, other kinds of fibre could be used, depending on their impact on the final quality of the product. Numerous fibres have been isolated and characterized from completely different sources and incorporated into a wide variety of foods (Rosell, Santos, & Collar, 2009). Bamboo dietary fibre can be obtained from the structure building components of the bamboo leaves. Some biologically active components in bamboo leaves and their potential health benefits have been widely studied (Lu, Wu, Shi, Dong, & Zhang, 2006; Lu, Wu, Tie, Zhang, & Zhang, 2005). The addition of bamboo fibre to fruit jams would contribute to increase the daily intake of dietary fibre and nutritive compounds.

Jams are a source of fruit which supply nutrients and antioxidant compounds. However, significant amounts of the beneficial fruit properties are lost due to the intense heat treatments applied to the fruit when elaborating jam. In order to better preserve jam quality, the osmotic dehydration process and the use of microwave energy have been proposed as alternatives to the traditional jam procedure. Osmotic dehydration at mild temperature is a technique that can be used to obtain jam without being so aggressive to the fruit (García-Martínez et al., 2002). On the other hand, a review by Vadivambal and Jayas (2007) about changes in quality of microwave-treated agricultural products concluded that microwave heat treatment has many advantages compared to conventional methods and the quality of microwave-treated products is better or equal to that of conventional drying. The use of microwave energy has also been proposed as an alternative to traditional heat pasteurization in order to better preserve the natural organoleptic characteristics and essential thermolabile nutrients of grapefruit juice (Igual, García-Martínez, Camacho, & Martínez-Navarrete, 2010). The shorter processing time required with this technology respect to conventional heating, due to the high penetration power of microwaves, seems to be responsible for this. Thus, microwave heat treatment does appear to have a high potential for the processing of agricultural products in the near future.

Variations in the manufacture will produce evident differences in the physical and sensory properties of the formulated products

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Nomenclature

a^*	CIE-$L^*a^*b^*$ colour coordinate
a_w	water activity
b^*	CIE-$L^*a^*b^*$ colour coordinate
$C_{ab}{}^*$	chrome
G'	storage modulus
G''	loss modulus
$h_{ab}{}^*$	hue angle
k	Herschel–Bulkley rheological constant (Pa*s^n). Consistency parameter
L^*	CIE-$L^*a^*b^*$ colour coordinate
n	Herschel–Bulkley rheological constant. Flow index parameter
RHA	relative hysteresis area
V_i	viscosity obtained at i s^{-1} (i = 40, 80 or 120 s^{-1})
ΔE	total colour difference
σ	shear stress (Pa)
σ_o	yield stress (Pa)
$\dot{\gamma}$	shear rate (s^{-1})

and these differences could influence consumer acceptance. An attractive colour is one of the most important quality characteristics for the grapefruit jam processing industry, besides the typical sweet–sour grapefruit flavour and convenient jam consistency (Wicklund et al., 2005). Measurement of colour and consistency are a complex subject since it depends on consumer appreciation. For this reason, it is important to carry out a sensory analysis with an adequate number of assessors and establish the possible relationships between the instrumental measurements of the physical properties and sensory characteristics. CIE-$L^*a^*b^*$ colour coordinates and the colour attributes of hue angle and chrome have been widely used in the objective measuring of food colour. On the other hand, jam consistency may be related not only to empirical measurements but also to fundamental rheological parameters, such as viscosity or loss and storage moduli.

The aim of this work was to compare the colour and consistency of different grapefruit jams obtained by both conventional and non-conventional techniques. Non-conventional methods included osmotic dehydration, microwave application and bamboo fibre incorporation. Sensory and instrumental analyses were performed to evaluate consistency and colour.

2. Materials and methods

2.1. Raw materials

2.1.1. Fruit

Grapefruits (*Citrus paradise* var. Star Ruby) from the city of Murcia were purchased from a local supermarket. The mean values (and standard deviation) of a_w, x_s, x_w and pH of grapefruit used were 0.988 (0.003), 0.120 (0.009), 0.8669 (0.0003) and 3.28 (0.02), respectively. Grapefruits were manually peeled, removing albedo and flavedo, and cut perpendicularly to the fruit axis, into 10 mm thick half slices.

2.1.2. Sucrose and osmotic solution

Food grade commercial sucrose was used to prepare jams. This was added directly to the fruit to formulate conventional and microwave (MW) jams. To obtain the product by osmotic dehydration (OD), a 65 °Brix osmotic solution (OS) was prepared by mixing the sucrose with distilled water.

2.1.3. Gelling agent

Citrus peel high metoxy pectin (60% degree of esterification, Fluka Biochemika, Switzerland) and bamboo fibre (VITACEL®, Rosenberg, Germany) were used.

2.2. Jam preparation procedures

The following procedures were applied to obtain a 40–60 °Brix product, as described by the Spanish quality norm for fruit jam (RD 670/1990, BOE N° 130, 1990). In all the cases, the jam was placed in sterile glass jars and stored at room temperature for 24 h till analysis.

2.2.1. Conventional process

Fresh fruit (67 g grapefruit/100 g mixture) was pre-cooked at 85 °C for 10 min, added with the sugar and potassium sorbate (32.99 and 0.01 g/100 g mixture, respectively) and cooked at 95–100 °C for 20 min more. An electrical food processor (Thermomix TM 21, Vorwerk, Valencia, Spain) was used for the process.

2.2.2. Microwave process

Fresh fruit (67 g grapefruit/100 g mixture) was pre-cooked (900 W, 5 min), added with the sugar and potassium sorbate (32.99 and 0.01 g/100 g mixture, respectively) and cooked at 900 W for 10 min more. A household microwave (Moulinex 5141 AFW2, Valencia, Spain) was used for the process.

2.2.3. Osmotic process

Half slices of peeled grapefruit were placed at 5000 Pa pressure for 10 min in the OS (ratio OS:fruit 5:1). Afterwards the atmospheric pressure was restored for 10 min more in order to promote the impregnation of the fruit with the OS. Finally, samples with the OS were heated to 40 °C (water bath P-Selecta Precisterm, Barcelona, Spain) with continuous stirring (200 rpm, Heidolph Instruments, RZR 2020; Schwabach, Germany) for 3 h, reaching ≈30 °Brix. Osmo-dehydrated samples, potassium sorbate (0.01 g/100 g jam) and pectin (1 g/100 g jam) or pectin (1 g/100 g jam) + bamboo fibre (1 g/100 g jam) were ground together with part of the OS to obtain a jam with 60 g fresh fruit/100 g jam, and as gelling agent. The jams thus obtained were referred as OD and ODBF, respectively.

2.2.4. Combined osmotic-microwave process

Jams obtained by means of the osmotic process described in paragraph 2.2.3 were cooked at 900 W for 5 min to obtain OD + MW and ODBF + MW samples.

2.3. Analysis

2.3.1. Physicochemical properties

Moisture content (x_w), °Brix and water activity (a_w) were determined both for fresh grapefruit and all the formulated jams. The x_w was determined by drying the sample to constant weight at 60 °C in a vacuum oven (AOAC method 934.06, 2000). °Brix were measured in previously homogenized samples with a refractometer at 20 °C (Zeiss, ATAGO Co., Ltd., NAR-3T refractometer, Tokyo, Japan). A dew point hygrometer (G.B.X. Instrumentation Scientifique, FA-st lab, Romans Sur Isere, France) was used to measure a_w. pH was measured by means of a CRISON pH-meter. Each analysis was carried out in triplicate.

2.3.2. Colour measurement

CIE-$L^*a^*b^*$ colour coordinates (10° observer and D65 illuminant) were obtained from the reflection spectrum (Minolta, CM 3600D, Tokyo, Japan). Four replicates were carried out for each sample.