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Development of a novel Zn fortified table olive product

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ABSTRACT

This work explores novel Zn fortified table olive presentations, using "Aceituna Aloreña de Málaga" as the model matrix. The addition of $ZnCl_2$ to the packing brine led to novel products with limited changes in colour and improved instrumental firmness. Partial Least Square (PLS) analysis linked the physicochemical characteristics and the sensory scores to the products, allowing for their characterization. The control had the highest scores for saltiness and bitterness as well as for the kinaesthetic sensations. The addition of 0.50 g/L $ZnCl_2$ led to a product with average physicochemical and sensory characteristics. The product added with 0.75 g/L $ZnCl_2$ had the highest titratable acidity and acid scores and the lowest pH while showing average values for the other variables. The olives prepared with 1.00 g/L $ZnCl_2$ produced a presentation with high firmness and Zn content in flesh but the lowest scores for the kinaesthetic sensations, bitterness and saltiness. Overall, the product with 0.75 g/L $ZnCl_2$ in the packing brine could be a good potential for novel Zn fortified table olive presentations. The consumption of 10 olives (50 g of flesh) of these fruits would supply around 79% of the recommended daily intake of Zn (or ~12% in 15 g of an olive flesh serving size).

1. Introduction

Table olives are the main fermented vegetable with a 2,200,000 tonnes/year production (IOOC, 2010a). The "Aceituna Aloreña de Málaga" (Protected Denomination of Origin) is prepared from cracked olives seasoned with garlic, pepper, fennel and thyme and a brine containing citric acid, lactic acid and potassium sorbate; however, the product has a relatively short shelf life (Arroyo López & Garrido Fernández, 2010) because of yeast growth (Arroyo-López et al., 2009). Recently, zinc salts have proven to provide a remarkable antifungal activity in table olives (Bautista-Gallego et al., 2010) and pathogens (Jin, Su, Zhang, & Sue, 2009). The addition of Zn salts in "Aceituna Aloreña de Málaga" could simultaneously reduce yeast growth and produce a Zn fortified presentation; however, its application still requires research into the effect of Zn presence on the physicochemical properties, Zn content in flesh and sensory profile of the nobel product.

Adequate zinc nutrition is essential for human health because of zinc's role in multiple enzyme systems related to the metabolism of protein, carbohydrates, fat and alcohol (Hess, Lönnerdal, Hotz, Rivera, & Brown, 2009). A zinc deficiency particularly affects the growth of children growth and the risk and severity of a variety of infections. A meta-analysis showed a statistically significant reduction (9%) in overall mortality among young children who received zinc supplementation (Hess et al., 2009). WHO and UNICEF recommend zinc (10–20 mg/day) supplemented foods as a component in diarrhoea treatment regimens (World Health Organization/UNICEF, 2004). Zinc fortification is also increasingly recognized as an effective strategy to improve dietary Zn intake and total daily absorption (Hess & Brown, 2009). In the USA, zinc acetate, chloride, citrate, gluconate, lactate, oxide, carbonate and sulphate are considered as GRAS and authorized for the fortification of foods (FDA, 2011; Office of Dietary Supplements, 2011). They can be used in the European Union for the same purpose (Directive, 2002/46/CE).

Zinc forms green colour complexes with chlorophyll derivatives. Technology has been recently applied to retaining green pigments in thermally processed, peels-on, green pears (Ngo & Zhao, 2005).

The aim of this work was to develop a novel Zn fortified product from fresh seasoned cracked table olives, characterizing its physicochemical properties, zinc content in flesh and sensory profile. An estimation of the potential contributions to the daily Zn intake from the novel products is also hypothesized. The results obtained in this model matrix could be applied to other table olive preparations and fermented vegetables in general.

2. Material and methods

2.1. Samples and experimental design

The olives of fresh Aloreña cv., 240/260 (fruits per kg) size were washed, cracked and brined for three days before packing. The

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fruits were then placed in plastic containers (400 g olives and 310 mL brine) together with the seasoning material (a 40 g/kg proportion of a mixture of garlic dices, pepper strips and small pieces of fennel and thyme), and covered with four different brines: a) the brine habitually used for packing in the industry; b) brine with 0.50 g/L zinc chloride; c) brine with 0.75 g/L zinc chloride; and d) brine with 1.00 g/L zinc chloride, making a total of four treatments. The composition of the usual packing brine, in addition to 50 g NaCl/L, had (per 1000 L) the following ingredients: potassium sorbate, 1200 g; citric acid, 2130 g; ascorbic acid, 640 g; lactic acid, 1200 g. The brines added with zinc chloride were similar but without potassium sorbate. Once they were completely filled, the containers were closed and maintained at room temperature (20 ± 3 °C) for a period of time similar to the commercial shelf life of the habitual presentation ($\sim$90 days). At the end of this period, the containers were removed and analysed.

2.2. Physicochemical analysis

Analyses of the brines for pH, NaCl concentration, titratable acidity and combined acidity were carried out using the standard methods for table olives (Garrido Fernández, Fernández Díez, & Adams, 1997).

Firmness, related to the mastication (chewing) effort required for eating the product, was measured using a Kramer shear compression cell coupled to an Instron Universal Testing Machine (Canton, MA, USA). Each determination was performed on one weighed, de-stoned cracked fruit placed on the bottom of the cell. Then, the lid was put on the cell and the head of the Instron lowered, following the guides, until the blades went through the olive. The cross-head speed was 200 mm/min. The firmness of the olives was expressed as the mean of 20 measurements. Shear compression force was expressed as kN/kg pitted olives (or flesh).

Olive surface colour analyses were performed using a BYK-Gardner Model 9000 Colour-view spectrophotometer, equipped with computer software to calculate the CIE coordinates. The values of hue (h_{ab}) and chroma (C^*) were also estimated. This methodology has been described elsewhere (Bautista-Gallego, Arroyo-López, López-López, & Garrido-Fernández, 2011). The colour index (CI) was calculated according to Sánchez, Rejano, and Montaño (1985), using the following equation:

$$\mathrm{CI} = \frac{-2R_{560} + R_{590} + 4R_{635}}{3}$$

where *Rs* stand for the reflectance at 560, 590 and 635 nm, respectively.

Subsequently, changes in a^*, $h_{ab,}$ and $-a^*/b^*$ parameters during shelf life were modelled. After checking different models (Taoukis, Labuza, & Saguy, 1997), the following first order formation and decay kinetic equations were chosen because of their good fit:

$$\text{Formation,} \quad P^* = P_0 + a\left(1 - e^{-k_c \cdot t}\right)$$

$$\text{Decay,} \quad P^* = P_0 + a \cdot e^{-k_c \cdot t}$$

where P_0 was the intercept constant (parameter value for t_0), a was a specific value for each fit (parameter estimated change), k_c was the constant rate, units h^{-1} and t the time (in h). The time required to reach a 50% decrease (t_{50}) in a particular parameter, i.e. the loss of 50% green (or 50% red formation) was estimated according to (Taoukis et al., 1997):

$$t_{50\%} = \frac{\ln 2}{k_c}$$

2.3. Sensory analysis

The olives were first evaluated for the perception of negative sensations and then for the descriptors mentioned in the Method of Sensory Analysis of Table Olives by the IOOC (2010b, 2010c). The scores for such descriptors were later used for performing a Qualitative Descriptive Analysis. The details with respect to the methodology and test performance have been described elsewhere (Moreno-Baquero, Bautista-Gallego, Garrido-Fernández, & López-López, 2012).

2.4. Mineral analysis in flesh

Zn was determined by atomic absorption spectrophotometry, using an air acetylene flame. The measurements were made in a GBC model 932 AA (Victoria, Australia) atomic absorption spectrometer equipped with a hollow multi-element cathode lamp (Zn, Mg, Ca and Cu) (Photron, Victoria, Australia). Instrumental conditions were fixed according to the equipment manual.

All reagents were of analytical purity (Panreac, Barcelona, Spain). A hydrochloric acid (6 N) solution was obtained through the dilution of concentrated HCl (Fluka, Buchs, Switzerland). The stock solution of Zn was obtained from Sigma–Aldrich (St. Louis, USA). The standard solutions were obtained through the dilution of the stock solution and the addition of HCl in a concentration similar to that obtained in the sample solutions. A detailed description of the sample ashing and solubilization can be obtained elsewhere (López-López, García-García, & Garrido-Fernández, 2008).

2.5. Chemometric analysis

Before chemometric analysis, Zn content data were autoscaled (Kowalski & Bender, 1972) while sensory scores were centred (Hibbert, 2009).

2.5.1. Principal component analysis (PCA)

PCA is a standard tool in chemometrics whose objective is to find trends in both variables and treatments (Jackson, 1991). For the selection of the number of PCAs, the Kaiser criterion (Jolliffe, 1986) was followed and only principal components with eigenvalues higher than 1 were retained (Donadini & Fumi, 2010). Then, the loadings of the original variables were projected onto the planes of the first and second components.

2.5.2. Partial least square (PLS) analysis

PLS analysis is useful for studying the relationship between product characteristics and sensory judgements (Tenenhaus, Pagés, Ambroisini, & Guinot, 2005). Usually, the products (n) are described by a set (p) of characteristics (X table, dimensions n and q) and are the subject of q sensory judgements (Y table, dimensions n and q). A space representing the variability of the product characteristics along with the sensory judgements was chosen and a multiple factor analysis on the juxtaposed tables was (X,Y) made. Following the representation space proposed by Tenenhaus et al. (2005), the principal components were replaced by the PLS components coming from the PLS regression of Y on X. In this way, the analysis summarizes the characteristics of the product X in terms of components which simultaneously explain the product characteristics and the sensory judgements. The products are also represented by using the correlations between the product dummy variables and the principal or PLS components.

2.6. Statistical data analysis

Statistica software version 7.0 (Statsoft Inc, Tulsa, USA), Design Expert v6.06 (Stat-Easy Inc, Minneapolis, USA), and XLSTAT version