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Mineral and sensory profile of seasoned cracked olives packed in diverse salt mixtures

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ABSTRACT

This work studies the effect of packing cracked seasoned olives with NaCl, KCl, and $CaCl_2$ mixture brines on their mineral nutrients and sensory attributes, using RSM methodology. The Na, K, Ca, and residual natural Mn contents in flesh as well as saltiness, bitterness and fibrousness were significantly related to the initial concentrations of salts in the packing solution. This new process led to table olives with a significantly lower sodium content (about 31%) than the traditional product but fortified in K and Ca. High levels of Na and Ca in the flesh led to high scores of acidity and saltiness (the first descriptor) and bitterness (the second) while the K content was unrelated to any sensory descriptor. The new presentations using moderate proportions of alternative salts will therefore have improved nutritional value and healthier characteristics but only a slightly modified sensory profile.

1. Introduction

Fermentation has been an effective form of extending the shelf life of foods for centuries (Ross, Morgan, & Hill, 2002). Most of these processes are based on the use of salt as an additive for flavour and preservation. This is the case of table olives, with a world production of about 2,200,000 tonnes in the 2010/2011 season (IOOC, 2011). The most popular commercial presentation is Spanish green table olives. However, directly brined olives (processed without lye treatment) are gaining more and more acceptance in the market because of the current preference for natural and biological products. Under this processing, olives are usually placed in a 6–11% NaCl brine where they undergo a fermentation processes which depends on cultivar and conditions (Garrido Fernández, Fernández Díaz, & Adams, 1997). When packing, the fermentation brine is discarded and substituted with a fresh solution containing salt and other ingredients (lactic, ascorbic, acetic or citric acids in addition to eventual seasoning products). According to recent studies, the final sodium content in these olives is 16 g/kg flesh (López López, Cortes Delgado, & Garrido Fernández, 2010); for a serving size of 15 g, this means a contribution of 0.24 g to the daily intake of sodium.

The relationship between high sodium consumption and cardiovascular diseases is well established (INTERSALT Cooperative Group, 1988; MacGregor & Sever, 1996; Ortega et al., 2011). The daily intake of sodium has been established as 2500 mg/day by the Code of Federal Regulations (2003). The World Health Organization has recommended a maximum of 5 g salt per day (WHO/FAO, 2003). However, salt consumption still remains above such levels all over the world. In Spain, the current salt intake by the adult population has been found to be about 9.8 g salt/day (Ortega et al., 2011). The EU framework for National Salt Initiatives (Council of the European Union., 2010) has set the goal of reducing salt intake by 16% over 4 years in 12 food categories. Following this suggestion, the Spanish Agency for Food Safety and Nutrition (AESAN, 2010) has implemented plans for salt reduction in bread, meat products and pastries. No action regarding table olives has been taken but investigation into the safety and sensory repercussion of an eventual Na reduction/substitution in this product is advisable.

Potassium, magnesium and calcium have shown remarkable effects on micro-organisms related to table olives (Arroyo López, Bautista Gallego, Chiesa, Durán Quintana, & Garrido Fernández, 2009; Bautista-Gallego, Arroyo-López, Durán-Quintana, & Garrido-Fernández, 2008). Studies on the sensory effects of total or partial replacement of sodium with potassium in table olives have been carried out (Bautista Gallego, Arroyo-López, Durán-Quintana, & Garrido-Fernández, 2010; Bautista Gallego, Arroyo-López, López-López, & Garrido-Fernández, 2011; Marsilio, Campestre, Lanza, de Angelis, & Russi, 2002; Mulé, Fodale, Bati, Tucci, & di Pisa, 2000; Panagou, Hondrodimou, Mallouchos, & Nychas, 2011; Papoff, Agabbio, Vocredt, & Farris, 1996) but the relationship between mineral

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contents and sensory descriptors with the concentrations of the diverse chloride salts in the initial brines in seasoned table olives, using advanced statistical analysis, has not yet been reported.

The aim of this work was to study the effect of sodium, potassium and calcium chloride salts in the packing brine on the nutrient mineral content and on selected sensory attributes of seasoned olives, using Response Surface Methodology (RSM) based on a mixture design analysis. In addition, the research investigates the relationships among the diverse variables and treatments through the application of multivariate techniques. The results obtained in this olive matrix can be extended straightforward to other similar products and fermented vegetables.

2. Material and methods

2.1. Samples and experimental design

Fruits were fresh cracked Aloreña cv., 240/260 (fruits per kg) size, stored for 6 months in a 250 L plastic container, using a 110 g/L NaCl concentration brine. For packing, 400 g of olives were placed in 730 mL plastic containers with a 4% mixture of diced garlic, pepper strips, small pieces of fennel, and thyme. Then, 310 mL of different brines were added to the containers.

To prepare the various brines, a solution stock with the following composition was used: citric acid, 2.130 g/L; ascorbic acid, 0.640 g/L; and lactic acid, 1.500 g/L (Arroyo López, Durán Quintana, Romero, Rodríguez Gómez, & Garrido Fernández, 2007). From this brine, the fourteen brines required by the experimental design (Table 1) were generated by adding the appropriate amounts of NaCl, KCl, and $CaCl_2$. Basically, the experiment consisted of replacing a maximum of 50% of the NaCl in the packing brine with selected proportions of NaCl, KCl and $CaCl_2$, using appropriate designs to estimate the corresponding RS as a function of the three chloride salts in the initial brine. The design was generated by Design Expert 6.0.1. After completely filled, the containers were closed and kept at room temperature (20 ± 3 °C) for a period of time similar to that of the real shelf life (3 months). At the end of the storage period, the sensory profile and the mineral nutrient contents of the fruits packed in the diverse conditions were determined.

2.2. Sensory evaluation

The sensory analyses were carried out in individual booths by a trained panel of 9 experienced judges from the IG Food Biotechnology Department. Panellists were habitual consumers of table olives, have 3–10 years of experience on olive taste, and were familiar with their classification according to the Sensory Analysis of table olives issued by the IOOC (2010a, 2010b). After revision of literature and screening the opinion of panellists, those descriptors included in the Sensory Analysis of table olives (2010a) were selected for the Qualitative Descriptive Analysis (QDA). Then, panellists were subjected to a specific training session for this study so that each of them properly assimilated the objectives of the QDA and the descriptors evaluation. Such training is sufficient according to Stone and Sidel (2003) for panels consisting of experienced subjects. Olives were presented in the cups recommended in the Sensory Analysis of table olives (2010a), coded with three digits random numbers, and presented in a balanced, randomised order. Only 4 runs were tested in each session. Samples were analysed in duplicate. The olives were first evaluated for the perception of negative sensations and then for the descriptors. More details with respect to the methodology and panel performance have been described in Moreno-Baquero, Bautista-Gallego, Garrido-Fernández, and López-López (2012) and Bautista-Gallego, Moreno-Baquero, Garrido-Fernández, and López-López (2012). The scores given to the negative sensations were used for classification whereas those obtained for the gustative and kinaesthetic sensations were later used for performing a QDA (Stone & Sidel, 2003), which has successfully been applied for detailed descriptions of the aroma, flavour, and oral texture of foods and beverages (Chapman, Lawless, & Boor, 2001; Lee & Chambers, 2010; Nyambaka & Ryley, 2004). The centred average scores of each descriptor were obtained according to Hibbert (2009) and the data were then treated as responses for the mixture design and multivariate analyses.

Table 1
Simplex centroid mixture design used to study the effects of diverse mixtures of NaCl, KCl and $CaCl_2$ in the packing brine on the mineral and sensory profile of cracked "Aceituna Aloreña de Málaga" during shelf life. Concentrations of salts were constrained to: NaCl + KCl + $CaCl_2$ = 50 g/L. The ranges of the diverse salts were: NaCl, 25–50 g/L; KCl, 0–25 g/L; $CaCl_2$, 0–25 g/L.

Treatment	NaCl (g/L)	KCl (g/L)	$CaCl_2$ (g/L)
1[a]	50.00	0.00	0.00
2[a]	50.00	0.00	0.00
3[b]	25.00	0.00	25.00
4[b]	25.00	0.00	25.00
5	29.17	16.67	4.17
6[c]	25.00	12.50	12.50
7[d]	25.00	25.00	0.00
8	41.67	4.17	4.17
9	37.50	12.50	0.00
10	37.50	0.00	1.25
11	33.33	8.33	8.33
12[d]	25.00	25.00	0.00
13	29.17	4.17	16.67
14[c]	25.00	12.50	12.50
15[a]	50.00	0.00	0.00

Note: Runs followed by the same superscript were experimental replicates.

2.3. Mineral analysis in flesh

The procedure used was similar to that described elsewhere (López López, García García, & Garrido Fernández, 2008). Cu, Mn, Ca, Mg, Zn, Na and K were determined by atomic absorption spectrophotometry. A GBC model 932 AA (Victoria, Australia) atomic absorption spectrometer equipped with three hollow multi-element cathode lamps, (Cu and Mn) (GBC, Victoria, Australia), (Ca, Mg and Zn) (Photron, Victoria, Australia) and (Na and K) (Photron, Victoria, Australia) was used. An air acetylene flame was used. Instrumental conditions for each element were fixed according to the equipment manual (Anonymous, 1994). Measurements of phosphorus were made in a Cary UV/Visible spectrophotometer model IE (Varian Australia, Mulgrave, Victoria).

2.4. Effect of mixture composition on the sensory attribute scores and on the mineral contents in olives

Response Surface Methodology (RS) is a powerful tool to investigate the effect of several variables at the same time (Myers & Montgomery, 2002). In this work, RSM based on mixture designs was applied to model each studied variable (response) as a function of the initial NaCl, KCl and $CaCl_2$ concentrations in the initial brine, according to the following equation, expressed in the canonical (Sheffé) form:

$$R = \sum_{i=1}^{3}\beta_i x_i + \sum\sum_{i<j=2}^{3}\beta_{ij}x_i x_j + \sum\sum\sum_{i<j<k=2}^{3}\beta_{ijk}x_i x_j x_k + \varepsilon \quad (1)$$

where x stands for NaCl, KCl, and $CaCl_2$, R are the responses (any variable under study or their transformed values), and β are the coefficients to be estimated. The procedure for obtaining models and their interpretations can been found elsewhere (Bautista Gallego et al., 2011).