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Effect of different format-solvent rosemary extracts (*Rosmarinus officinalis*) on frozen chicken nuggets quality

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ABSTRACT

Three kinds of *Rosmarinus officinalis* extract (powder-acetone, liquid-methanol, liquid-acetone) were used to examine the effects of format-solvent on the active compounds extracted (total phenolic, carnosol and carnosic acid content) and antioxidant activity (FRAP, ABTS). The results showed that both, as the format but also the solvent used, had significant effect on the parameters analyzed ($p < 0.05$). The highest antioxidant activity was found for the powder-acetone extract followed by the liquid methanol and liquid acetone extracts ($p < 0.05$). The effect of the three different extracts on the physical–chemical and sensory quality of frozen chicken nuggets was evaluated. At the dose proposed by the European Union Directive 2010/69/EU for the carnosic and carnosol compounds [150 ppm (mg/kg fat basic)], the format-solvent combination of the rosemary extracts used did not modify the chicken nuggets quality characteristics (pH, colour, sensory quality) and still underlines the effectiveness of these extracts.

1. Introduction

Chicken-based foodstuffs are becoming increasingly popular mainly as "ready-to-eat" products, such as frozen chicken nuggets, because of the reduced preparation time, their good nutritional quality as a protein source and the low cost and longer shelf-life in frozen conditions (Magdelaine, Spiess, & Valceschini, 2008). The high polyunsaturated fatty acid profile of chicken meat, while nutritionally interesting, makes the product very susceptible to oxidative reactions, which may be intensified by deep-frying, the usual preparation way of this product. Moreover, these lipid oxidation reactions, which are considered the major deterioration form in stored muscle foods, may still occur during frozen storage (Soyer, Özalp, Dalmış, & Bilgin, 2010). Such changes could affect the physical–chemicals parameters and sensory attributes (odour, colour, and flavour) of the product, in addition to diminish the shelf-life (Selani et al., 2011).

Synthetic antioxidants have been successfully used to prevent lipid oxidation in chicken meat. However, increasing concerns over the safety of synthetic food additives have resulted in a trend towards "natural products". As a result, the industry faces a challenge to find effective antioxidants from natural sources to prevent deterioration in meat and meat products during processing and storage (Brannan, 2009). Among natural antioxidant sources, rosemary (*Rosmarinus officinalis L.*), a woody aromatic herb that is native to the Mediterranean countries, has recently been authorized by the European Union under Directive 95/2/EC and assigned E-392 as its E number (European Union Directives 2010/67/EU and 2010/69/EU) for use in meat product preservation. The addition of rosemary extract to poultry products has been shown to be effective in retarding lipid oxidation, and previous studies in chicken sausages (Liu, Tsau, Lin, Jan, & Tan, 2009) and patties (Naveena et al., 2013) have pointed to the protective effect of rosemary extract (500–1500 ppm) and leaves (22.5–130 ppm) in inhibiting lipid oxidation.

Rosemary antioxidant activity is related to components such as phenolic diterpenes, carnosol (CAS No. 5957-80-2) and carnosic acid (CAS No. 3650-09-7) (Rodriguez-Rojo, Visentin, Maestri, & Cocero, 2012). The antioxidant capacity of phenolic compounds is due to their ability to scavenge free radicals, donate hydrogen atoms and chelate metal cations (Shan, Cai, Sun, & Corke, 2005). Previous studies (Azmir et al., 2013; Wang, Wang, & Li, 2013) have reported that the yield of bioactive compounds can be changed or

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modified by using different extraction procedures, solvents, temperatures, pressures and times. In an earlier paper (Garrido, Auqui, Martí, & Linares, 2011) extraction systems to obtain red grape pomace extracts were studied, and the extraction process was seen to have a clear effect on the extract composition (antioxidant activity, total polyphenols and total anthocyanins) and on the inhibition of lipid oxidation in pork burgers.

Therefore, the aims of this study were (1) to characterize three different commercial rosemary extracts (*R. officinalis*) obtained in different ways (format-solvent combinations) and (2) to evaluate the effect of these rosemary extracts on the physical–chemical and sensory quality of frozen chicken nuggets during 9 months of storage.

2. Material and methods

2.1. Characterization of rosemary extracts

The rosemary extracts used in this study were elaborated by Natural Ingredients S.L. (Ingrenat S.L., Cartagena, Spain). The extracts were obtained from rosemary leaves by "*Liquid–Solid Extraction*" with methanol or acetone as principal extract and solvents. Both solvents are usually used for phenolic diterpene extraction due to their hydrogen-bonding ability that provides a high antioxidant yield (Erkan, Ayranci, & Ayranci, 2008). Both extraction processes (with acetone or methanol) were optimized by the company to improve the purity and deodorization of the extract, and are currently under patent. Two format types were considered: liquid and powders. Finally, the company obtained three types of extracts:

Powder-acetone: powdered rosemary extract obtained using acetone as solvent.
Liquid-methanol: liquid rosemary oil extract obtained using methanol as solvent.
Liquid-acetone: liquid rosemary oil extract obtained using acetone as solvent.

2.1.1. Concentration of carnosic acid and carnosol

Carnosol and carnosic acid were identified and quantified in the extract samples using high performance liquid chromatography (HPLC), as described by Okamura, Fujimoto, Kuwabara, and Yagi (1994). Extract samples were dissolved in acetone (1:10, w/v), and insoluble substances were removed by ultrasonic stirring and filtration through a 0.45 μm nylon mesh. The analysis was performed with an Agilent 1200 series HPLC instrument (Agilent Technologies, Waldbroon, Germany) equipped with an autosampler. The column was a HiChrom Hi-RPB 18 type with 0.46 × 250 mm with a 5 μm particle size diameter (Hichrom Ltd, Reading, United Kingdom). The mobile phase consisted ofacetonitrile HPLC (A) and purified water containing 1% acetic acid HPLC (B) applying the following gradient: 0–10 min 30% A, 70% B; 10–22.5 min 65% A, 35% B; 22.5–27.6 min 100% A, 0% B; 27.6 min 30% A, 70% B; stop 30 min. The flow rate was constant at 1.2 ml/min. The detector was equipped with a diode array detector (DAD) operating at 284 nm based on the standard solutions of carnosol and carnosic acid.

2.1.2. Antioxidant capacity

2.1.2.1. Total phenolic content. The total phenolic content (TPC) was determined by the Folin–Ciocalteu colorimetric technique (Rodríguez-Carpena, Morcuende, Andrade, Kylli, & Estevez, 2011).

2.1.2.2. Ferric reducing antioxidant power assay (FRAP). The total antioxidant capacity of the different extracts was determined using the ferric reducing antioxidant power (FRAP) assay by the method of Benzie and Strain (1996) with some modifications.

2.1.2.3. ABTS+ radical cation assay. Radical cation scavenging capacity was measured for the extract against ABTS + generated as described by Rodríguez-Carpena et al. (2011).

2.2. Chicken nuggets

2.2.1. Sample formulation, preparation and storage conditions

The nuggets were experimentally manufactured following commercial practices for pre-fried products. For this purpose deboned skinless chicken breasts (60%) were minced with ice (23%) in a chopper for 30 s. The usual additives for commercial nuggets, 15% potato flakes (McCain alimentarie S.A.S., Harnes, France); 1% salt (Salinas del Odiel S.L, Huelva, Spain) and 1% albumin (Huevos Guillén S.L., Valencia, España) were used. All components were thoroughly mixed to provide an uniform blend, and the chicken nugget samples were prepared in characteristic shapes of 5 × 3 × 1 cm, each weighing 25 g, and frozen at −18 °C. The pieces were dipped in the prepared batter (wheat flour 93.57%, salt 1.17% bicarbonate 0.24%, yeast 2.34% and xanthan gum 1.17%) for 15 s. Chicken nuggets were distributed into five different batches according to the following formulas: a control batch without any extract (1) and a batch with tocopherol extract (2) were used to check the rosemary extract effect. Tocopherol was selected because it is a commonly antioxidant used in food matrixes (McCarthy, Kerry, Kerry, Lynch, & Buckley, 2001). The doses of the three different rosemary extracts were selected to ensure 150 ppm of carnosic and carnosol expressed as fat basic in products according to European Union Directive 2010/69/EU on food additives. Given the differences in the composition and antioxidant capacity of the three of extracts, the following doses were used doses to reach 150 ppm carnosic acid and carnosol: 600 ppm powder-acetone (3), 900 ppm liquid-methanol (4) and 300 ppm liquid-acetone and liquid-tocopherol (5).

All the nugget batches were pre fried using a household fryer (Taurus S.L., Lérida, Spain) for 30 s at 165 °C in sunflower oil (Sovena España S.A., Sevilla, Spain). The pre-fried nuggets were then packaged in polyethylene bags and stored at −18 °C for 9 months. Physical–chemical (lipid oxidation, colour and pH) and sensory analysis were carried out in the samples after 0, 3, 6 and 9 month. Physical–chemical (Lipid oxidation, colour and pH) and sensory analyze were carried out in the samples after 0, 3, 6 and 9 month. A total of 480 chicken nuggets were used, 200 for the physical–chemical analysis (5 nuggets * 5 batch * 4 time) by duplicated and 280 for the sensorial analysis (7 nuggets * 5 batch * 4 time) by duplicated.

2.2.2. Lipid oxidation

Thiobarbituric acid reactive substances (TBARS) were measured according to the method of Targladis, Watts, Younathan, and Duggan (1960). The analysis was repeated by triplicate.

2.2.3. Colour coordinates (L^*, a^*, b^*)

Colour was measured using a Minolta CR400 colorimeter standardized using a white calibration plate (Minolta Camera Co., Osaka, Japan) (8-mm-diameter aperture, d/0 illumination system, D65 illuminant and a 2° standard observer angle) by triplicate. Lightness (L^*), green–red chromacity (a^*) and blue–yellow chromacity (b^*) were measured according to the CIELab system.

2.2.4. pH measurement

The pH of the nugget samples was measured by triplicate using Crison GLP21 equipment (Crison Instruments S.A., Barcelona, Spain) (ISO 2917:1999).