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The effects of olive oil emulsified alginate on the physico-chemical, sensory, microbial, and fatty acid profiles of low-salt, inulin-enriched sausages

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ABSTRACT

This paper examines variations in the quality of low-salt, inulin enriched Pamplona-style chorizo, in which some of the pork back fat was replaced with olive oil. Four different sausage formulations were prepared in which 50% of the pork back fat was replaced with olive oil emulsified with alginate and 58% of the sodium chloride was replaced with 20% potassium chloride and 38% calcium chloride. Four lots were prepared, three with 3%, 6% and 10% proportions of added inulin were labeled O–I 3%, O–I 6% and O–I 10%, respectively; while one, lot O, was without inulin. These four formulations were compared with a control manufactured according to the traditional formula using pork back fat. The various lots were tested for proximate analysis, pH, processing loss, water activity, lactic acid bacteria, *Salmonella* and *Listeria monocytogenes*, physico-chemical composition, instrumental colour (CIE L*a*b*), texture profile and fatty acid composition during mixing and at days 3, 10, 17, 24 and 31 of the drying process. A sensory evaluation was also performed by a seven-member trained panel, to obtain a descriptive analysis of the taste, texture and appearance of the product. The addition of olive oil alginate emulsion and inulin, O–I 6%, resulted in a low-salt, reduced-fat product (20% less fat than traditional sausage), richer in monounsaturated fatty acids (10%), while retaining sensory notes similar to those of the traditional chorizo used as a control and achieved a good acceptability rating.

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1. Introduction

The creation of a new cured raw sausage with health properties requires compliance with the dietary recommendations of several different organizations and scientific committees for nutrition (Aranceta & Serra-Majem, 2001; Deparment of Health, 1994), and a reduction in salt content to meet the latest recommendations published by NAOS (Agencia de seguridad Alimentaria, 2005).

Various authors have conducted research on sausage-making where animal fat is replaced with vegetable oils from soya (Muguerza, Ansorena, & Astiasarán, 2003), linseed (Ansorena & Astiasarán, 2004a, 2004b; Valencia, Ansorena & Astiasarán, 2006a, 2006b) emulsified olive oil (Ansorena & Astiasarán, 2004a, 2004b; Bloukas, Paneras, & Fournitzis, 1997; Muguerza, Ansorena, & Astiasarán, 2002; Muguerza, Gimeno, Ansorena, Bloukas, & Astiasarán, 2001; Severini, De Pilli, & Baiano, 2003), and sea weed (Lee et al., 2006; Valencia, Ansorena, & Astiasarán, 2007). Fish oil has also been used for this purpose (Muguerza, Ansorena, & Astiasarán, 2004). Other modifications studied are the addition of dietary fibre obtained from cereals (wheat and oats) and fruit (peaches, apples and oranges) (García, Domínguez, Gálvez, Casas, & Selgas, 2002), inulin (Mendoza, García, Casas, & Selgas, 2001); and also the partial substitution of salt (Gelabert, Gou, Guerrero, & Arnau, 2003; Gimeno, Astiasarán, & Bello, 1999; Gimeno, Astiasarán, & Bello, 2001; Guàrdia, Guerrero, Gelabert, Gou, & Arnau, 2008). However, these changes in formulation had some negative impact on the quality and palatability of the Pamplona-style chorizo. For this study, different lots of chorizo were prepared, taking into account nutritional recommendations by replacing pork back fat with olive oil pre-emulsified using sodium alginate as a gelling agent, and substituting sodium chloride with other salts in quantities in accord with nutritional recommendations. In addition, different quantities of inulin were added to improve the nutritional quality of the product and to determine whether the presence of inulin improves the sensory properties by preventing reduction of the fat content causing hardening (Mendoza et al., 2001).

The purpose was thus to examine the effect of substituting pork back fat with olive oil emulsified with alginate and adding inulin to improve the quality of raw cured sausages with reduced NaCl (low salt content).

2. Material and methods

2.1. Preparation of dry fermented sausages

Three batches of five different dry fermented Pamplona-style chorizos (16 kg of meat batter for each batch) were manufactured and prepared according to the formulations shown in Table 1. The pork

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Table 1
Experimental design and formulations.

Formulation		C	O	O–I 3%	O–I 6%	O–I 10%
Lean pork		53.9	53.9	53.9	53.9	53.9
Pork backfat level (%)		26.8	13.4	13.4	13.4	13.4
Alginate emulsion (*AE) replacing level (%)		–	13.4	13.4	13.4	13.4
Salt level (%)	NaCl	2.4	1.01	1.01	1.01	1.01
	KCl	–	0.48	0.48	0.48	0.48
	$CaCl_2$		0.91	0.91	0.91	0.91
Inulin level (%)		–	–	3	6	10
Sodium ascorbate		0.5	0.5	0.5	0.5	0.5
Sodium nitrite		0.015	0.015	0.015	0.015	0.015
Potassium nitrate		0.015	0.015	0.015	0.015	0.015
Sodium caseinate		4	4	4	4	4
Lactose		2	2	2	2	2
Glucose		0.5	0.5	0.5	0.5	0.5
Dextrin		0.5	0.5	0.5	0.5	0.5
Flavouring		0.081	0.081	0.081	0.081	0.081
Red pepper		2.4	2.4	2.4	2.4	2.4
Soya		5	5	5	5	5

Formulations: C, Control; O, 50% of the pork back fat was replaced with an olive oil emulsion; O–I 3%, O–I 6%; O–I 10% containing 3%, 6% and 10% of inulin, respectively.
* AE: alginate emulsion: 64% water; 30% olive oil; and 6% ADROGEL GR (alginate).

meat and pork back fat used were obtained from a local producer (Navarra, Spain).Except in the Control, 50% of pork back fat was replaced with an emulsion prepared with 64% water, 30% olive oil, 6% alginate (Adroer GR España), inulin was supplied by (Cargill, USA). Commercial extra-virgin olive oil (13% saturated fatty acid, SFAs; 79% monounsaturated fatty acid, MUFAs and 8% polyunsaturated fatty acid, PUFAs) was obtained from a local producer (Navarra, Spain). The other additives (g/kg) used were sodium chloride (20.4) (total salt amount depending on the formulation were sodium chloride, potassium chloride, and calcium chloride), sodium ascorbate (0.5), sodium nitrite (0.15) and potassium nitrate (0.15), sodium caseinate (40), lactose (20), glucose (5), dextrin (5) flavoring (0.81, Gewüerzmüeller, GmbH, Münchingen, Germany), soya (5) and red pepper (24). Similar contents of additives were added to all formulations (Table 1).

The standard chorizo formulation used a control (Control, C) was made from a mixture of lean pork and pork back fat as follows: frozen pieces of lean pork were mixed with salts, spices and starter culture in a cutter. Frozen pork fat was added after being minced in a 3 mm diameter mincer. The mixture was vacuum minced and stored at 4 °C for 20 h. It was then stuffed into a 50 mm diameter sausage cellulose casing (Fibran, S.A., Gerona, España) (Mainca, Barcelona, España) the final weight of each sausage was 800 g. Approximately 20 sausages were made in each batch. The sausages were fermented for 3 days (25 °C, 90% RH) and dried for 4 weeks (15–18 °C, 75–80% RH). Temperature and RH of the ripening chambers (Mainca, Barcelona, España) were continuously recorded. In order to control the ripening process, three sausages from each treatment were weighed at each stage to control weight losses, expressed as a percentage of initial weight.

The rest of the formulations were prepared as for the Control but with the following changes: formulation (O) in which 50% of the pork back fat was replaced with an olive oil emulsion (64% water, 30% olive oil, 6% calcium alginate (Adrogel GR)), the sodium chloride content was reduced by 58% by replacing it with 20% potassium chloride and 38% calcium chloride (O); and formulations O–I 3%, O–I 6% and O–I 10% to which 3%, 6% and 10% of inulin (commercial brand) was added, respectively (Table 1).

From each batch (C, O, O–I 3%, O–I 6% and O–I 10%), 300 g of the minced meat mixture (M) were collected and at days 3 (fermentation stage, F), 10, 17, 24 and 31, three sausages from each batch were randomly chosen to study the effect of ripening time and formulation. A 200 g portion of the sample was minced and used for moisture, water activity, pH, colour measurement and microbiological tests that at the mixing and filling stage and each week of the drying process (mixture, fermentation, and drying 10, 17, 24 and 31 days). Texture values were obtained at 3 days (fermentation stage, F), and drying 10, 17, 24 and 31 days. The remaining minced sample was vacuum packed and frozen at −20 °C for subsequent analyses (total lipids, protein, and fatty acid composition). All results were expressed as the mean of three replicates at each sampling time. Finally, at 31 days of drying three sausages from each batch were taken for sensory profile analysis, when the product was considered finished. Three replicates were made in each batch for the studied parameters.

2.2. Proximate composition and pH values

The protein (ISO 937-1978), total fat (ISO 1443, 1973) and moisture content (ISO 1442, 1973) and pH levels of the mixture after mixing and in the finished product were measured using an Orion Research Potentiometer for solid samples (ISO R2917, 1974).

2.3. Processing loss and water activity

Weight loss during the drying process was calculated as the weight loss (expressed as % of initial sample weight) after each week of drying. Water activity (a_w) was determined using an Aqualab CX2 instrument (Decagon Devices, Inc., Canada).

2.4. Microbiological analysis

Samples were taken by cutting along the perimeter of the sausage with a sterile scalpel and using sterile forceps to aseptically separate the casing from the sausage. Two 10 ± 0.1 g cores were aseptically removed from each sample and blended with a 90 ml of 1% tryptone solution (w/v) for 60 s in a Stomacher (Lab Blender 400; Seward Medical, London, UK). Additional dilutions were made in 1% tryptone (w/v). 1 ml of the undiluted homogenate and of each dilution was then spread on duplicate plates. Counts were determined from plates bearing 30–300 colonies. Counts were obtained as follows: Lactic acid bacteria on *Lactobacilli* MRS Broth (Difco®) + Bacto Agar (Difco®) and glacial acetic acid (Panreac), on MRS agar 30 °C for 48 h in a Heraeus BBD 6220 CO_2 incubator (Thermo Scientific, Barcelona, España) with 5% CO_2. VIDAS IC *Salmonella* for salmonella, and VIDAS LMO for *Listeria monocytogenes* sp (Anonymous, 1996). The results are expressed as logarithms of colony-forming units per gram (Log cfu/g).

2.5. Colour

The colour of the sausages was taken in quintuplicate using a Minolta CM 2002 (Konica Minolta Business Technologies Inc., Tokyo, Japan). L* (lightness), a* (redness) and b* (yellowness) were measured on an (internal) cross-section immediately after cutting.

2.6. Texture profile analysis

Texture profile analysis (TPA) was performed using a TA-XT2i Texture Analyzer (England) as described by Bourne (1978). Five samples per dry cured sausage (diameter 18.0 mm and length 2.0 cm) were compressed to 50% of their original height. Force–time deformation curves were derived with a 250 N load cell at a constant crosshead speed of 2.0 mm/s. Textural measurements were: hardness (Hd) = peak force (N) required for first compression; cohesiveness (Ch) = ratio (dimensionless) of active work done under the second compression curve to that done under the first compression curve; springiness (Sp) = distance (mm) of sample recovery after the first compression and chewiness (Cw) = Hd × Ch × Sp (N mm). Measurement was carried out at 20 °C (room temperature).