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The effects of high pressure treatment and of storage periods on the quality of vacuum-packed "salchichón" made of raw material enriched in monounsaturated and polyunsaturated fatty acids

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Abstract

This study investigates the effects of high-pressure processing on the microbiological, physico-chemical and sensory properties of 3 fermented Spanish dry sausages (salchichón), all high in unsaturated fatty acids. The products, manufactured from the sausage meat and back fat of pigs fed on high-oleic and high-linoleic diets and a control diet, were vacuum-packed prior to high hydrostatic pressure (HPP) treatment (500 MPa, 5 min), and storage at 6 °C for up to 210 days. High-pressure treatment slightly inhibited certain microorganisms, especially yeasts and moulds, and psychotrophic and anaerobic bacteria. Consequentially, microbial counts fell, although injured microorganisms recovered during storage except in the case of the high-linoleic salchichón, in which they remained inactive causing it to register the lowest counts. High-pressure treatment had no noticeable effect on the physico-chemical and sensory properties of the three samples suggesting that it improves the food safety of salchichón with no detrimental effects on organoleptic properties.

Keywords: Vacuum packaging; High-pressure processing; Fermented sausage; Salchichón; Meat products

Industrial relevance: The problem of safe preservation is increasingly complex for the meat industry as today's products require longer shelf lives and greater assurance of protection from microbial spoilage. High pressure processing is finding increased use in products such as sliced cured meats, where microbial contamination can occur during the slicing process and develop over storage. This study evaluates the microbiological, physicochemical and sensory characteristics of vacuum-packed slices of dry fermented sausage – control (CO), high oleic (HO), and high linoleic (HL) *salchichón* samples – following high pressure treatment and subsequent chilled storage, contributing thereby to the growing body of knowledge on this new food preservation technology, which produces microbiologically safe food products with long shelf lives, whilst retaining high nutritional and sensory qualities.

1. Introduction

Dry-cured sausages enjoy an international reputation as popular Mediterranean products, of which the most widely-consumed in Spain are salchichón and chorizo (Ruiz Pérez-Cacho, Galán-Soldevilla, León-Crespo, & Molina-Recio, 2005). Salchichón, in particular, is a dry fermented sausage manufactured from a mixture of chopped meats (pork and/or beef), lard, salt, spices, additives (nitrate, nitrite, and antioxidants) and starter cultures (optional). Consumption of these traditional meat products marketed after slicing has increased over recent years, despite concerns over their high content of animal fats. The meat industry is trying to address this problem through modification of the lipid fraction, by increasing the percentages of monounsaturated (MUFA) and polyunsaturated (PUFA) fatty acids and by decreasing cholesterol. A further problem is contamination immediately prior to packaging. Packaged products require longer shelf lives, and should be resistant to microbial spoilage, which has led to ongoing research into new technologies to preserve the products high nutritional and sensory qualities and their comparability with similar untreated products, whilst assuring microbiological safety over a long

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shelf life. High-Pressure Processing (HPP) is one of the most promising technologies in the treatment of sliced cured meat products (Hugas, Garriga, & Monfort, 2002), and there is great interest in applying this new technology to products such as cured meat, which risk contamination with *Listeria monocytogenes* during the chopping and slicing processes (Sanz, 2003).

Many studies exist as to the efficacy of HPP in the preservation of fresh (Carlez, Rosec, Richard, & Cheftel, 1993, 1994; Carlez, Veciana-Nogues, & Cheftel, 1995; Hoover, Metrick, Papineau, Farkas, & Knorr, 1989; Jung, Ghoul, & Lamballerie-Anton, 2003; Ma & Ledward, 2004; Moss, Johnston, Graham, & Stewart, 2004; Yuste, Mor-Mur, Capellas, & Pla, 1999; Yuste, Pla, Capellas & Mor-Mur, 2002) and cooked meat products (Díez, Santos, Jaime, & Rovira, 2005; Garriga, Aymerich, & Hugas, 2002; Mor-Mur & Yuste, 2003) and dry cured products (Andrés-Nieto, Møller, Adamsen, Ruiz, & Skibsted, 2004; Cava, González, Ladero, & Carrasco, 2005; Rubio, Martínez, García-Cachán, Rovira, & Jaime, 2006; Saccani, Parolari, Tanzi, & Barbuti, 2004). In relation to dry fermented sausages, Martín (2005) found that HPP improved the hygienic and sanitary properties of the slightly fermented sausages. However, to the best of our knowledge, there are no research articles that describe the effect of HPP on the organoleptic properties of these products.

This work aims to study the effects of high-pressure treatment on the microbiological, physicochemical and sensory properties of three types of sausages, each with differing compositions of fats (control, high oleic and high linoleic salchichóns), and their evolution over 210 days of storage under refrigeration.

2. Materials and methods

2.1. Raw material

Raw meat was taken from pigs bred at the *Centro de Pruebas de Porcino* (*Instituto Tecnológico Agrario de Castilla y León*, *Hontalbilla,* Spain). Pigs of the genetic strain (Large White × Pietrain) × (Large White × Landrace) were fed a conventional pig diet while growing in live weight from 19 to 70 kg. They were then divided into three groups that corresponded to the three experimental diets which were formulated with the same ingredients except for the source of fats:

(1) Control (CO): principally maize, barley, wheat, and soybean.
(2) High oleic (HO): maize, barley, wheat, soybean and sunflower oil.
(3) High linoleic (HL): maize, barley, wheat, soybean and soya oil.

All pigs were fed *ad libitum* with the experimental diets, and were stunned and slaughtered at a local slaughterhouse after having reached a live weight of 125 kg. After overnight chilling at 1 ± 1 °C, the meat and back fat were taken from the carcasses and the raw material (lean and fat) stored separately at −20 °C until it was made up into 3 batches (CO, HO and HL) of sausages.

2.2. Sausage formulation and processing

All the sausages were manufactured on the same day, using the same technology and according to the same traditional formulation (75% pork meat and 25% pork back fat). Lean pork meat and pork back fat were minced with a grinder (P-32 FUERPLA, Valencia, Spain) to a particle size of about 8 mm. The mince was subsequently mixed in a vacuum mixer (A-85 FUERPLA, Valencia, Spain) with the following ingredients added to each kilogram of meat mixture: 25 g sodium chloride, 5 g dextrose, 4 g white wine, 3 g ground black pepper, 1.5 g sucrose, 1 g GDL (Glucono D-Lactone), 1 g polyphosphates, 1 g ground white pepper, 1 g nutmeg, 0.45 g sodium ascorbate, 0.15 g sodium nitrite, 0.10 g potassium nitrate. The sausage mixture was stuffed into natural casings (62–65 mm diameter) and the sausages were then fermented in a drying chamber (Hermekit, Cenfrio, Spain) at 15 °C, and at 90–100% relative humidity (RH) for 18 h, and then at 22–23 °C and 90% RH for 48 h, and at 14–15 °C and 80–90% RH for a further 10 days. RH was then slowly reduced to 75% until the end of the ripening process (a total of 28 days) when the sausages were packed and stored at 6 °C.

2.3. Slicing and packaging

Two of the sausages selected at random from each batch (CO, HO, HL), were sliced at thicknesses of 1 mm and 100 g of the slices were placed in polystyrene trays. In addition, 2 slices of salchichón, each 1.5 cm thick, were placed on trays to perform instrumental colour measurements.

The trays with the sliced salchichón were individually placed in commercial plastic bags (polyamide/polyethylene with an oxygen transmission rate of 30/40 cm^3/m^2/24 h/bar at 23 °C and 50% RH and a water vapour transmission rate of 2.5 g/m^2/24 h at 23 °C and 50% RH, supplied by W. K. Thomas España S.L., Rubí, Spain), and passed through a vacuum packer (model: EVT-7-TD Tecnotrip, Barcelona, Spain).

Following vacuum packing, the samples were treated under high pressure, except for one group from each batch (CO, HO, LO) that remained untreated, and placed in storage at 6 °C for up to 210 days.

2.4. HPP

HPP was performed at an industrial hydrostatic pressure unit (Wave 6000/135. NC Hyperbaric, Burgos, Spain) equipped with a 135 l volume high-pressure vessel using additive-free water as the pressure transmitting fluid. The pressure level was set at 500 MPa, treatment time at 5 min and the initial water temperature at 18 °C. Treatment pressure was reached in approximately 4 min and decompression was instantaneous.

2.5. Sample storage

Following HPP, the samples treated with high pressure (HP) and the untreated samples (UT) were stored at 6 °C for up to 210 days. Microbiological, physicochemical and sensory