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# Study of the shelf life of a dry fermented sausage "salchichon" made from raw material enriched in monounsaturated and polyunsaturated fatty acids and stored under modified atmospheres

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**Abstract**

The microbiological, physico-chemical and sensory properties of salchichon with high unsaturated fat content, packed under vacuum and 20/80% $CO_2/N_2$ modified atmosphere, were evaluated to determine its quality changes during storage under refrigeration. These sausages were manufactured with pork meat and pork backfat obtained from pigs fed with three different diets (control diet-CO, high oleic diet-HO and high linoleic diet-HL). In general, few significant differences were found in counts of different groups of microorganism between the three types of sausages and no difference between the packaging methods. A reduction in pH values was observed during storage and no great differences were determined by storage period on water activity ($a_w$). Both parameters (pH and $a_w$) presented similar results to those found in different Spanish sausages and other European dry fermented products. The sensory results denoted that sensory quality gradually decreased during storage under both packaging conditions (vacuum and 20/80% $CO_2/N_2$), so it is not advisable to store longer than 150 days. On the other hand, fermented sausages with high content of unsaturated fatty acids had similar sensory properties to those of conventional sausages, and even a comparable sensory stability. In conclusion, the results showed healthier salchichons (HO and HL) similar to the traditional (CO) one could be manufactured and stored under refrigeration after slicing for a reasonable period, but the advantage of the gas mixture packaging (20/80% $CO_2/N_2$) versus vacuum packaging was not clear.


*Keywords:* Vacuum packaging; Gas packaging; Fermented sausage; Salchichon; Fatty acid composition; Instrumental texture; Shelf life

## 1. Introduction

Salchichon is one of the most important dry-cured sausages produced in Spain. The basic ingredients of salchichon are lean pork, pork backfat, salt and spices. After manufacturing, the salchichon is subjected to a preservation treatment with the aim of increasing its shelf life and avoiding problems such as contamination, decolouration and rancidity. Nowadays, due to recent changes in shopping and consuming habits, packaged sliced meat products are an important retail selling method. Therefore, the problem of safe preservation in the meat industry has become more complex as today's products require longer shelf life and greater assurance of protection from microbial spoilage.

Moreover, pork meat has often been blamed for being too high in fat, especially in saturated fat. Saturated fatty acids are well known to raise total and low-density lipoprotein (LDL) cholesterol. Changes in meat fat composition, mainly a reduction of saturated fatty acids together with an increase of mono and polyunsaturated fatty acids, have been persistently recommended by nutritionists for the positive effects that such changes appear to have on the serum balance

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between low and high density lipoproteins and on blood cholesterol levels. The interest in improving the nutritional quality of food by means of manipulation of the fatty acid composition of animal feeds has also been used to improve the fatty acid profile of carcass fat in pigs (Morgan, Noble, Cocchi, & McCartney, 1992; Vanoeckel & Boucque, 1992) and of meat products (Bosi et al., 2000; Hoz, D'Arrigo, Cambero, & Ordóñez, 2004). Besides, it is possible to increase the proportion of unsaturated fats by incorporation of vegetable oils into the meat product (Bloukas, Paneras, & Fournitzis, 1996; Muguerza, Gimeno, Ansorena, Bloukas, & Astiasarán, 2001). However, a relatively highly unsaturated fat in dry fermented sausages can increase lipid oxidation process. In order to prevent it, the sausages would need to be packed under anaerobic conditions. Therefore, industry tries to extend the shelf life of this type of products by storage practices such as modified atmospheres packaging (vacuum and gas mixtures packaging).

Microbiological, chemical and sensory characteristics of typical Mediterranean dry sausages have been extensively studied (Baldini et al., 2000; Comi et al., 2005; Coppola, Mauriello, Aponte, Moschetti, & Villani, 2000; Drosinos et al., 2005; González & Díez, 2002; Lizaso, Chasco, & Beriain, 1999; Moretti et al., 2004; Ruiz Pérez-Cacho, Galán-Soldevilla, León Crespo, & Molina Recio, 2005). Also, studies on the effect of packaging conditions on these characteristics have been carried out (Fernández-Fernández, Rozas-Barrero, Romero-Rodríguez, & Vázquez-Odériz, 1997; Fernández-Fernández, Romero-Rodríguez, & Vázquez-Odériz, 2001; Fernández-Fernández, Vázquez-Odériz, & Romero-Rodríguez, 2002; Yen, Brown, Dick, & Acton, 1988; Zanardi, Dorigoni, Badiani, & Chizzolini, 2002). Moreover, all recent publications about the modification of sausage lipid composition are primarily focused on the nutritional and chemical aspects throughout production and ripening of these meat products (Bryhni, Kjos, Ofstad, & Hunt, 2002; Muguerza, Fista, Ansorena, Astiasarán, & Bloukas, 2002; Severini, De Pilli, & Baiano, 2003; Valencia, Ansorena, & Astiasarán, 2006a; Warnants, Van Oeckel, & Boucqué, 1998) and a limited number of papers have dealt with the link between fatty acid modifications and product shelf life (Ansorena & Astiasarán, 2004; Harms, Fuhrmann, Nowak, Wenzel, & Sallmann, 2003; Sheard et al., 2000; Valencia, Ansorena, & Astiasarán, 2006b).

The aim of the present work was to determine the influence of a high content of unsaturated fatty acids on salchichon characteristics and to establish the advisable period of storage under refrigeration when the sausage was sliced and packed under vacuum and 20% $CO_2$/80% $N_2$ modified atmosphere for retail sale.

## 2. Materials and methods

### 2.1. Raw material

The raw meat was obtained from pigs growing in the "Centro de Pruebas de Porcino" (Instituto Tecnológico Agrario de Castilla y León, Hontalbilla, Spain). Pigs (Large White × Pietrain) × (Large White × Landrace) were fed with a conventional pig diet from 19 to 70 kg live weight. Then, pigs were divided into three groups for providing the experimental diets. The three diets were formulated with the same ingredients except for the fat source:

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

The ingredients, chemical composition and fatty acid profile of these experimental diets are shown in Table 1 (data provided by "Centro de Pruebas de Porcino"). All pigs were fed *ad libitum* with the experimental diets. Animals, having reached a live weight of 125 kg, were stunned and slaughtered at a local slaughterhouse. The meat and backfat were obtained from carcases, after chilling overnight at 1 ± 1 °C. The backfat and the meat from pigs fed with different diets were used to prepare each batch of sausage. Raw material (lean and fat) used for the three batches (CO, HO and HL) was stored separately at −20 °C until they were used for making sausages.

### 2.2. Sausage formulation and processing

All the sausages were manufactured the same day, using the same technology and according to a traditional formulation, which consisted of 75% pork meat and 25% pork backfat. Lean pork meat and pork backfat were minced (P-32 FUERPLA, Valencia, Spain) to a particle size of about 8 mm and subsequently mixed in a vacuum mixer (A-85 FUERPLA, Valencia, Spain) with the following common ingredients per 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. This sausage mixture was stuffed into natural casings (62–65 mm ∅). The sausages were fermented in a drying chamber (Hermekit, Cenfrio, Spain) at 15 °C and 90–100% relative humidity (RH) for 18 h, 22–23 °C and 90% RH for 48 h, at 14–15 °C and 80–90% RH for 10 days. Then the RH was slowly reduced to 75% until the end of the ripening process (a total of 28 days). At that time, sausages were packed and stored at 6 °C as indicated below.

### 2.3. Packaging and storage of samples

Manufactured sausages, two pieces randomly selected for each batch, were sliced at 1 mm thickness and 100 g of slices were placed in polystyrene trays. Besides, two slices of salchichon, 1.5 cm thick were put on trays to carry out