Meat Science 80 (2008) 1182–1187

Contents lists available at ScienceDirect

Meat Science

journal homepage: www.elsevier.com/locate/meatsci

Effect of the packaging method and the storage time on lipid oxidation and colour stability on dry fermented sausage *salchichón* manufactured with raw material with a high level of mono and polyunsaturated fatty acids

Begoña Rubio [a,*], Beatriz Martínez [a], Mª Dolores García-Cachán [a], Jordi Rovira [b], Isabel Jaime [b]

[a] Estación Tecnológica de la Carne, Instituto Tecnológico Agrario de Castilla y León, C/Filiberto Villalobos s/n, Aptdo. 58, 37770 Guijuelo (Salamanca), Spain
[b] Departamento de Biotecnología y Ciencia de los Alimentos, Facultad de Ciencias, Universidad de Burgos, Plaza Misael Bañuelos s/n, 09001 Burgos, Spain

ARTICLE INFO

Article history:
Received 20 July 2007
Received in revised form 12 May 2008
Accepted 15 May 2008

Keywords:
Vacuum packaging
Gas packaging
Fermented sausage
Salchichón
Fatty acid composition
TBA
Colour

ABSTRACT

The effects of fatty acid composition, two packaging methods (vacuum and 20% CO_2/80% N_2) and storage under refrigeration for 210 days were evaluated on a dry fermented sausage (*salchichón*), manufactured with raw material enriched in monounsaturated or polyunsaturated fatty acids. Fatty acid composition was determined on sausage mixtures and on ripened sausages and lipid oxidation and colour stability was determined on ripened sausage at different times during storage. The modification of fatty acid composition of the sausages raised the nutritional quality, slightly affecting the colour properties. Dry fermented sausages enriched in polyunsaturated and monounsaturated fatty acids presented higher lipid oxidation values than the control ones. Both packaging methods (vacuum and 20% CO_2/80% N_2) during 210 days of chilled storage had minor effects on the colour and the lipid oxidation stability.

1. Introduction

Dry-cured sausages are very popular Mediterranean products, well known internationally. In Spain, one of the most widely consumed types is *salchichón*. *Salchichón* is a manufactured product obtained from a mixture of chopped meat (pork, beef/pork or beef), lard, salt, spices, additives (nitrate, nitrite, and antioxidants) and starter cultures (optional).

From the nutritional point of view, sausages are an important source of proteins of high biological value (Beriain, Chasco, & Lizaso, 2000); however, these traditional meat products show some negative aspects as a consequence of their high animal fat content. The relatively high cholesterol level and low polyunsaturated/saturated fatty acids ratio (PUFA/SFA) are enhancing factors for some pathologies like coronary heart diseases (Muguerza, Gimeno, Ansorena, Bloukas, & Astiasarán, 2001).

Nowadays, the meat industry tries to offer the consumer healthy products obtained by different strategies, improving the nutritional quality of food by the modification of the lipid fraction: increasing monounsaturated fatty acids (MUFA) and PUFA fractions. Moreover, high percentage of MUFA and PUFA makes these products highly sensitive to oxidation. The ability of unsaturated fatty acids, especially PUFA, to oxidise rapidly, is important in regulating the shelf life of meat or meat products (Sheard et al., 2000). Lipid oxidation can damage sensory properties of food products, since fat contributes to flavour, texture, mouth feel, juiciness and overall sensation of lubricity of the product (Muguerza, Fista, Ansorena, Astiasarán, & Bloukas, 2002; Navarro, Nadal, Izquierdo, & Flores, 1997). Besides, oxidation can affect the nutritional value of food by decomposition of vitamins, unsaturated essential fatty acids or can even give rise to toxic compounds (Ansorena & Astiasarán, 2004).

Packaging in modified atmospheres (vacuum and gas packaging) is being introduced as a commercial way for the retail selling of dry fermented sausages. These packaging methods allow increases in the shelf life as well as attractive commercialization formats such as sliced meat products. Authors such as Fernández-Fernández, Romero-Rodríguez, and Vázquez-Odériz (2001), von Holy, Cloete, and Holzapfel (1991), Summo, Caponio, and Pasqualone (2006) and Wang (2000) have studied the effect of vacuum packaging on microbiological, physicochemical and organoleptic aspects of different sausages. The effect of packaging type has also been studied in fresh pork sausage (Guerrero Legarreta, Usborne, & Ashton, 1988), Chinese-style sausage (Wang, Jiang, & Lin, 1995), Greek taverna sausage (Samelis & Georgiadou, 2000), Milano-type sausages (Zanardi, Dorigoni, Badiani, & Chizzolini, 2002) and Galician *chorizo* sausage (Fernández-Fernández, Vázquez-Odériz, &

* Corresponding author. Tel.: +34 923580688; fax: +34 923580353.
E-mail address: rubherbe@itacyl.es (B. Rubio).

0309-1740/$ - see front matter © 2008 Published by Elsevier Ltd.
doi:10.1016/j.meatsci.2008.05.012

Romero-Rodríguez, 2002). However, little is known about the effect of the modification of the lipid fraction on meat products packed under different systems. Ansorena and Astiasarán (2004) have studied the effect of packaging storage in dry fermented sausages manufactured with a partial substitution of pork backfat with pre-emulsified olive oil and Valencia, Ansorena, and Astiasarán (2006a) have studied the effect of different storage conditions on the lipid fraction in dry fermented sausages manufactured with a partial substitution of pork backfat by linseed oil and antioxidants. In a previous study (Rubio et al., 2007), we studied the shelf life of *salchichón* made from raw material enriched in monounsaturated and polyunsaturated fatty acids and stored under modified atmospheres. In this work, the aim was to observe the effect of the different storage conditions (vacuum and gas mixture packaging) and the storage time on lipid oxidation and colour stability in sliced *salchichón*, manufactured from raw meat with different fatty acid composition, and stored for a long period (210 days) at 6 °C.

2. Materials and methods

2.1. 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. The meat and backfat were obtained from pigs fed with different diets (control diet-CO, high oleic diet-HO and high linoleic diet-HL).

Lean pork meat and pork backfat used to prepare each batch of sausage 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, 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.

2.2. 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 on trays. Besides, 2 slices of 1.5 cm thick *salchichón* were put on the trays for colour measurement. Then, the trays were packed under:

(a) Vacuum: trays were introduced in 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 WK Thomas España S.L., Rubí, Spain) which were subjected to vacuum and sealed. The vacuum pump has an efficiency of 21 m^3/H and vacuum was controlled by a sensor to 99%. (Packing machine, mod. EVT-7-TD Tecnotrip, Barcelona, Spain).

(b) Gas mixture: trays were evacuated and flushed with a selected gas mixture, 20% CO_2/80% N_2, (Carburos Metálicos S.A., Barcelona, Spain). Then, they were heat sealed with a packer (mod. TSB-100 Tecnotrip, Barcelona, Spain) in a high barrier film with an oxygen transmission rate of 5 cm^3/m^2/24 h/bar at 23 °C and 50% RH and a water vapour transmission rate of 19 g/m^2/24 h at 23 °C and 90% RH supplied by BEMIS EUROPE (L'Hospitalet de Llobregat, Spain). Packages had a headspace volume ratio of 1:1 (MØller et al., 2003). The gas content of each pack and the residual O_2 were controlled using a 1450 B3 Servomex gas analyzer (Aries, Madrid, Spain).

All trays were stored in darkness at 6 °C until analysis. The packs were opened for subsequent analysis after 0, 15, 30, 60, 90, 150 and 210 days of storage.

The whole experiment was replicated twice and three measurements were carried out for each parameter studied in each replica.

2.3. Chemical composition

Moisture, total nitrogen and total fat were determined according to the ISO methods 1442:1997 (ISO, 1997), 937:1978 (ISO, 1978), 1443:1973 (ISO, 1973). The nitrogen to protein conversion factor used was 6.25.

2.4. pH and a_w analyses

pH was measured by blending 10 g of product with 10 ml of distilled water for 2 min. A 507 pH meter (Crison, Barcelona, Spain) equipped with a glass electrode was used for this measurement. Water activity (a_w) was measured by CX2 AQUA LAB equipment (Decagon, Washington, USA).

2.5. Determination of fatty acids

Fatty acids were determined on the lipid extract from the sausage mixture before stuffing and from ripened sausages for each packaging method and after each storage time.

The Bligh and Dyer (1959) method was used for lipid extraction. The fatty acid composition was determined by gas chromatography. Boron trifluoride/methanol was used for the preparation of fatty acid methyl esters (Morrison & Smith, 1964). A Perkin–Elmer Autosystem XL gas chromatograph fitted with a capillary column Omegawax 320 (30 m × 0.32 mm i.d. and 0.25 μm film thickness) and flame ionization detection was used. The temperature of both the injection port and the detector was 260 °C. The carrier gas was helium, 11 psi. The sample volume was 0.5 μl. Fatty acids methyl esters were identified by comparison with standards previously run, alone or together with samples. Fatty acids methyl esters were quantified as percentage of total methyl esters.

2.6. Lipid oxidation analysis

TBA (2-thiobarbituric acid) measurements were done using the Maraschiello, Sárraga, and García-Regueiro (1999) method, and the TBA values were expressed as milligrams of malonaldehyde per kg of sample.

The peroxide index was evaluated according to (AOCS, 1993, cd 8–53) Official method, and peroxide values were expressed as milliequivalents (mEq) of active oxygen per kg of fat.

2.7. Instrumental colour measurement

Objective measurements of colour were performed on the *salchichón* surface using a reflectance spectrophotometer (Minolta CM-2002; Osaka, Japan). The illuminant used was D65 (colour temperature of 6504 K) and the standard observer position was 10°. Colour coordinates were determined by the CIE-LAB system and