DIFFERENT PACKAGING CONDITIONS TO IMPROVE THE SHELF-LIFE OF FRESH PORK SAUSAGES

L. Martínez, D. Djenane, J.A. Beltrán and P. Roncalés.
Dept. of Animal Production and Food Science. Laboratory of Food Technology. Faculty of Veterinary Science. University of Zaragoza. C/ Miguel Servet, 177, 50013. Zaragoza, Spain. E-mail: roncales@posta.unizar.es Tel.: +34-976-761582 Fax: +34-976-761612.

BACKGROUND AND OBJECTIVE. Fresh pork sausages are commonly presented for retail sale in over-wrapped trays. They usually contain colorants and additives (mainly sulfite) to preserve colour. Fresh meat colour is short-lived, so that meat discolouration is inevitable during storage (Zhu and Brewer, 1998b). Bradford *et al.* (1993) reported that colour acceptability of fresh pork sausages decreased with increasing refrigerated storage time. The oxygenated form of myoglobin (oxymyoglobin) is responsible for the bright-red colour while the oxidised form (metmyoglobin) is responsible for brown discolouration. Microbial growth is detrimental to colour, as it favours myoglobin oxidation. Lipid oxidation also occurs along storage, though it is usually not the major determinant of shelf life in over-wrapped packaging systems as air permeable films allow odour volatiles to escape from package. With modified atmosphere packaging (MAP), the volatile odour–causing products of lipid oxidation are retained within the package, thus allowing consumers perception of off-odours when packages with oxidised meat are opened. MAP of fresh meat normally uses mixtures of oxygen (O_2), carbon dioxide (CO_2) and nitrogen (N_2) to maintain the quality of fresh red meat, both from a microbiological and an organoleptic point of view. Besides this, the storage life of fresh meat can be greatly extended by vacuum packaging, although myoglobin is then in a purple-red deoxygenated state.
The objective of this work was to study the effect of different packaging conditions, without using colorants or aditives, on the storage life of fresh pork sausages.

MATERIALS AND METHODS

Preparation of samples. Four pork forelegs were obtained at 48 h postslaughter from a local supplier (MARBE, Zaragoza, Spain), trimmed of external fat, and ground using an industrial grinder machine. The ground meat was stuff into collagen casings, Colfan F (Viscofan S.A., Caseda, Spain), size 17 mm. The fresh sausages were placed on polypropilene trays and either overwrapped in polyethylene film or introduced in a pouch made of a polyethylene and polyamide and subject to vacuum or filling with gas mixtures (%O_2/%CO_2/%N_2): 0/20/80; 20/20/60; 40/20/40; 60/20/20; 80/20/0; 0/40/60; 0/60/40. They were stored in the dark 20 days at 1±1°C. **Meat colour and metmyoglobin analysis.** Meat colour was measured at the surface of fresh sausages using a reflectance spectrophotometer (Minolta CM-2002; Osaka, Japan), 30 min after packaging opening. CIE L*, a*, b* (CIE, 1978) parameters were recorded. The metmyoglobin percentage at the surface was estimated spectrophotometrically, according to Stewart et al. (1965), by measuring reflectance at 525 and 572 nm. The maximum value of the ratios of $(K/S)_{572}$ to $(K/S)_{525}$ at the beginning of the experiment was fixed as 0% metmyoglobin (MetMb). The value of 100% MetMb was obtained after oxidising a sample in a 1% (w/v) solution of potassium ferricyanid (Ledward, 1970). The average value for each fresh sausage was the mean of 30 determinations. **Lipid oxidation analysis.** Lipid oxidation was measured by the 2-thiobarbituric acid (TBA) method of Pfalzgraf (1995). TBARS values were expressed as mg malonaldehyde/kg sample. **Microbial analysis.** Counts of aerobic psychrotrophic flora were determined in Plate Count Agar (PCA; Merck; Darmstadt, Germany) after incubation at 10°C for 7 days (Elliott *et al.*, 1983). Counts were expressed as the $\log_{10}$ of colony forming units (cfu)/g. **Statistical analyses.** The significance of differences among samples at each day of storage was determined by analysis of variance using the least square difference method of the General Linear Model procedure of SPSS for Windows (1989-1997). Differences were considered significant at the $p<0.05$ level.

RESULTS AND DISCUSSION

Colour (a* values; Fig. 1). There was a relationship between the O_2 concentration and the a* value at the 4th day; fresh pork sausages stored in the highest O_2 concentration showed the highest a* value. The samples with 0% O_2 and variable concentrations of CO_2 decreased until an a* value of 5, with no significant differences among them ($p>0.05$). The concentration of residual O_2 was measured by gas chromatography, and the value was 0.5-1% O_2. Rousset & Renerre (1990) showed that 0.3-0.4% residual O_2 led to oxidation of myoglobin to metmyoglobin and thus to discolouration of meat. Over-wrap sausages showed the lowest a* value, near 3 at 4th day. Vacuum kept an acceptable a* value near 7 throughout all the storage period. All other atmospheres showed a* values of about 4 from day 8 of storage.
Metmyoglobin percentage (Fig. 2). The amount of metmyoglobin (MetMb) from day 8 of storage was lower ($p<0.05$) in vacuum, over-wrap, and 0% O_2 + 20% CO_2 + 80% N_2 samples, which maintained a highly acceptable level (below 40%) after 20 days of storage. Greene *et al.*, (1971) reported that 40% MetMb caused meat rejection by consumers. At day 4 of storage, MetMb percentage was lower the higher was the O_2 concentration.
Lipid oxidation (TBARS values; Fig. 3). Lipid oxidation increased rapidly starting from day 8 ($p<0.05$). As in the a* value, there was a relationship between the concentration of O_2 and TBARS; samples with higher oxygen were more oxidised throughout storage. Fresh sausage in 80% O_2 + 20% CO_2 showed the highest values ($p<0.05$). Samples in vacuum had the lowest values ($p<0.05$), followed by those subject to overwrapping and those without O_2.
Aerobic psychrothophic counts (Fig. 4). Counts of over-wrap sausages were the highest since day 8th of storage. All of those stored with O_2 had lower counts ($p<0.05$), showing no differences ($p>0.05$) among them. The higher was the CO_2 concentration the lower were microbial counts; samples stored in 60% CO_2 did not reach 10^7 cfu/g within the 20 days of storage. It is noteworthy that, even when spoiled, over-wrap sausages retained its red colour (Fig. 2). This phenomenon was also observed by Rousset & Renerre (1991).

CONCLUSIONS. Vacuum showed the lowest values of TBARS and metmyoglobin, and good values of a* and microbial counts. High concentrations of O_2 improved colour stability the first days of storage, although they enhanced lipid oxidation and microbial growth. High concentrations of CO_2 inhibited microbial growth; counts did not reach 10^7 cfu/g along storage. Over-wrapped sausages were rapidly spoiled, though they maintained red colour.

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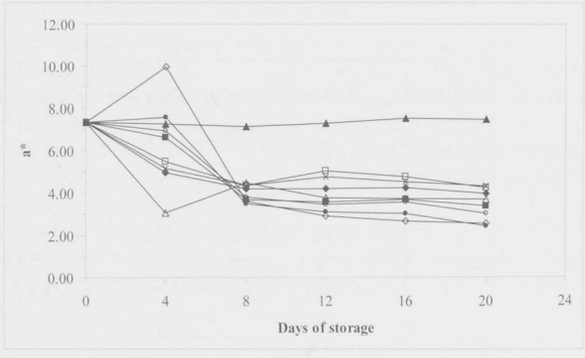

Fig. 1. Evolution of a* values.

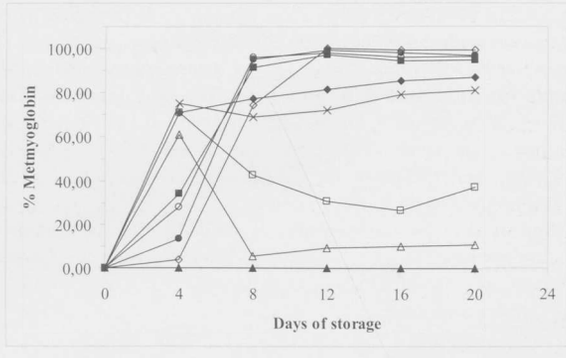

Fig. 2. Evolution of Metmyoglobin percentage.

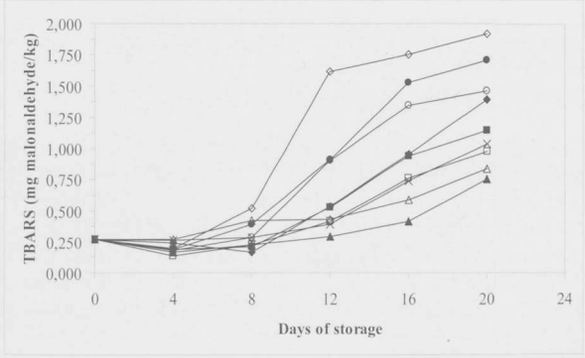

Fig. 3. Evolution of TBARS values.

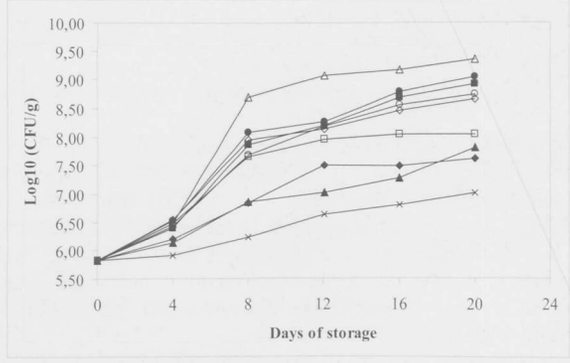

Fig. 4. Evolution of psychrotrophic aerobes counts.