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EFFECT OF HIGH-OXYGEN MODIFIED ATMOSPHERE PACKAGING ON SOME QUALITY TRAITS OF MEAT FROM IBERIAN PIGS REARED UNDER "MONTANERA" SYSTEM

Estrella PRIOR [1], Susana GARCÍA-TORRES [1], Adoración LÓPEZ-GAJARDO [1], María CABEZA DE VACA [1], David TEJERINA [2]

ABSTRACT

The Iberian pig is the most important autochthonous pig breed in the Mediterranean, both in population and economic importance. In addition there is an increasing demand for quality fresh meat from Iberian pigs reared under "*Montantera*" system, not only for the restaurants, also by gourmet consumers. So, the main aim of this work was to study the influence of high-oxygen modified atmosphere packaging during storage time (0, 6, 12, 18 and 24 days) on parameters related to meat quality of *Longissimus dorsi* muscle from Iberian pigs reared under "*Montanera*". Results showed that during refrigerated storage time under high-oxygen , the lipid oxidation, yellowness, water loss and pH had increased while redness index and water holding capacity (WHC) had decreased. As a consequence, the sensorial characteristics were significantly affected by refrigerated storage time under high-oxygen modified atmosphere packaging.

Key words: Iberian pigs / meat quality / modified atmosphere packaging / shelf life

1 INTRODUCTION

Meat products from Iberian pigs witness an important demand by national and international consumers, because of their extraordinary sensory characteristics, especially from free-range system. The main free-range production system of the South-West of Europe is "*Montanera*",a typical rearing system of the Iberian pig, taking place from November to January, and a feeding based on acorns and grass. Traditionally, Iberian pigs (IB) are mostly consumed as high-priced dry-cured products (ham, shoulder, loin), however, the consumption as fresh meat has recently increased in importance, especially "*lomo*" *(Longissimus dorsi*), "*presa*" (*Serratus ventralis*) but also "*solomillo*" (*Illiopsoas* + *psoas menor*) and "*secreto*" (*Latissimus dorsi*). This requires the search for conservation methods that increase shelf-life. In addition, new habits have led to an increase in demand for packaged fresh products (Nychas *et al.,* 2008). Actually, modified atmosphere packaging (MAP) is one of the most used methods, as it increases the shelf-life of the product and also improves their appearance. The bright red color maintenance, delayed oxidations and the microbial growth prevention, are the main factors of consumer acceptability. Thus, it is very important to select suitable conditions inside the package. It is well known that elevated levels of carbon dioxide inhibit microbial growth (Marshall *et al.,* 1991), whereas elevated levels of oxygen prolong colour stability color (the colour of meat is important in marketing, as it is the first quality attribute met by the consumer) (Bartkowski *et al.,* 1982). The gas composition normally used for modified atmosphere packaged in fresh meat present high proportion of O_2 (70–80%) (Blakistone, 1998). The main aim of this work was to determine the effects of refrigerated storage of 0, 6, 12, 18 and 24 days in high-oxygen modified atmosphere packaging (70% O_2 + 30% CO_2) on pH, instrumental colour, lipid oxidation index and water loss of *Longissimus dorsi* muscle of Iberian pigs (IB) reared under "*Montanera*" system.

1 Research Centre "Finca La Orden-Valdesequera". Animal Production Department. 06187-Guadajira (Badajoz), Spain
2 Corresponding author, e-mail: tejerinabarrado@yahoo.es

2 MATERIAL AND METHODS

2.1 ANIMALS AND EXPERIMENTAL DESIGN

Fifteen IB purebred males were randomly selected and reared according to "*Montanera*" system. After weaning, the pigs were fed with commercial feed mixture up to 90 ± 5 kg, and maintained on "*Dehesa*" (typical ecosystem of Southwestern Europe) during the last fattening phase for at least 70–80 days, or until a minimum weight gain of ~46 kg was attained. During this period, the animals were fed *ad libitum*, exclusively with natural resources from "*Dehesa*" (acorns and grass). Animals were slaughtered at 150 ± 10 kg live weight by electrical stunning and exsanguination at a local slaughterhouse and quartering was performed 4 h after the slaughter.

2.2 SAMPLE PREPARATION AND PACKAGING

After slaughter, a portion of the *Longissimus dorsi* muscle from the last lumbar vertebra to the first thoracic vertebra of the right half carcass was removed and tooled transversely into 5 portions for the different storage times: control (0), 6, 12, 18 and 24 days. Determinations on *Control* bath were performed at 24h *post-mortem*. The remaining samples (*Experimental* batches) were placed in polystyrene trays (300 mm of thickness) with an oxygen permeability rate of 3.2cm^3 m^{-2} day^{-1} atm^{-1} at 23 °C, and covered by a PE film for gas mixtures 74 mm thick (VIDUCA, Alicante, Spain) with transmission rates of 1cm^3 m^{-2} day^{-1} atm^{-1} for oxygen (23 °C; 50% RH); 5.5cm^3 m^{-2} day^{-1} for CO_2 (23 °C; 0% RH) and 2.2gm–2 day–1 for H_2O (25 °C; 90% RH) and packed under high-oxygen modified atmosphere (70% O_2 + 30% CO_2), using a packaging machine (ULMA ® Smart-300, Spain). Samples were kept in darkness at 4 ± 1 °C until analysed.

2.3 ANALYTICAL MEASUREMENT

- Water Holding Capacity (WHC) was determined as percentage of free water (24h) following the method proposed by Irie and Swatland (1992) with slight modifications; 1.5g of muscle was centrifuged at 7×10^3 g for 15 min. WHC was determined for each storage time of assay (day 0, 6, 12, 18 and 24), and expressed as the proportion of fluid retained in the sample. Results are presented as g water/100g muscle.
- Drip loss (DL) was measured following the method of Honikel (1998). The determinations were realised as the accumulated water loss between each storage period (0–6, 6–12, 12–18, 18–24 days) Results are presented as percentage between initial and final weight as g water loss/100g muscle.
- pH-value at 24h (control) using a puncture pH meter Crison mod. 507.
- Instrumental colour was measured according to the recommendations on colour determination of the American Meat Science Association (Hunt *et al.,* 1991). Colour parameters were expressed as lightness index (CIE L*), redness index (CIE a*), yellowness index (CIE b*) and were determined using a Minolta CR-300 colorimeter (Minolta Camera, Osaka, Japan) with illuminant D65. Additionally, the chroma (C*) defined as $C^* = (a^{*2} + b^{*2})^{0.5}$ was determined as an indicative of colour intensity and Hue angle (H°) as arctg (b*/a*).
- Lipid oxidation (TBARS) was assessed in duplicate by the 2-thiobarbituric (TBA) using the method proposed by Salih *et al.* (1987). The extract was obtained by homogenizing 2.5 g of sample with 7.5 ml of perchloric acid (3.86%) and 0.25 ml of BHT. The determinations were made spectrophotometrically at 532 nm in a spectrophotometer CARY Agilent Thecnologies®60. TBARS values were calculated from standard (1,1,3,3-tetraethoxypropane 97% (TEP) curve and expressed as mg of malondialdehyde (MDA) per kg muscle.

2.4 STATISTICAL ANALYSIS

The effect of refrigerated storage time was determined by the one-way analysis of variance (ANOVA) procedure of SPSS.PC+15.0 (SPSS, 2005) and HSD Tukey's test was used to compare means when main effects were significant. The relationships between water holding capacity and water loss was assessed by calculating Pearson`s correlation coefficients. Mean values and standard errors of the mean (SEM) are reported.

3 RESULTS AND DISCUSSION

pH value: pH values of *Longissimus dorsi* muscle (Table 1) showed no differences until the day 24, when a significant increase was observed ($P < 0.001$) reaching value 6.2, which according to Devine *et al.* (1993), might be a risk for microbial growth. This increase could be due to CO_2 as it is water and fat soluble (Gill, 1996) and can

Table 1: *Evolution of pH value, insturmental colour parameters and TBARS index during refrigerated storage time (4 °C) of Longissimus dorsi muscle packed under high-oxygen modified atmosphere*

	Storage time (days post-packing)						
	Control	6	12	18	24	SEM[1]	P-value[2]
pH	5.61^{b}	5.62^{b}	5.58^{b}	5.57^{b}	6.19^{a}	0.051	***
Instrumental colour							
CIE L*	34.23	37.67	38.42	37.18	37.61	0.574	ns
CIE a*	10.97^{a}	11.23^{a}	7.24^{b}	4.54^{c}	2.90^{c}	0.574	***
CIE b*	3.87^{b}	6.17^{a}	5.69^{a}	5.86^{a}	6.90^{a}	0.225	***
Hue (H°)	19.94^{c}	31.63^{bc}	45.29^{bc}	78.62^{b}	152.00^{a}	6.367	***
Chroma (C*)	11.64^{a}	12.82^{a}	9.23^{b}	7.46^{b}	7.54^{b}	0.418	***
TBARS (mg MDA/kg muscle)	0.02^{c}	0.15^{bc}	1.01^{b}	2.08^{a}	2.17^{a}	0.178	***

MDA – malondialdehyde; [1] SEM, standard error of the mean; [2] significance levels are given by ***($P \leq 0.001$), **($P \leq 0.01$), * ($P \leq 0.05$), ns (non significant, $P > 0.05$); [a, b, c] different letters in the same row indicate significant differences ($P \leq 0.05$) between days of post-packing storage

dissociate into hydrogen and bicarbonate (Dixon and Kell, 1989), increasing the final pH values.

Instrumental colour: no effect of storage time was observed for lightness (CIE L* value; $P > 0.05$), whereas the redness (CIE a* value) decreased with storage time (Table 1). This could be due to myoglobin oxidation into metmyoglobin, which has more brownish coloration (Gill and Penny, 1988). Keeping the red colour of the meat is very important for the sector of commercialization of packaged fresh meat, as it is one of the main attributes that the consumer values at the time of purchase. Regarding the yellowness (CIE b* value) it increased in first 6 days of storage ($P < 0.001$), thereafter it remained constant. As a consequence, hue increased and chroma decreased with storage time ($P < 0.001$).

Lipid oxidation: TBARS values obtained in this study are presented in Table 1 and show a progressive increase ($P < 0.001$) during refrigerated storage (+4 °C) in high-oxygen modified atmosphere. So, according to Campo *et al.* (2006), TBARS values close to 2 mg MDA/kg muscle indicate a limit for consumer acceptability, which means that according to our results, it corresponds to 18 days of storage. This could indicate that the use of atmospheres with high proportions of O_2 may be related to oxidation processes during cold preservation, despite having initially a good relationship antioxidant / prooxidant.

WHC and drip-loss: a significant effect of storage time (Fig. 1) was observed for WHC ($P < 0.001$) and drip-loss ($P < 0.001$). Furthermore, there was an inverse correlation ($r^2 = -0.640$, $P < 0.001$) between these two parameters, denoting that WHC decreased and drip-loss increased with storage time. The differences between storage times were significant only after 24 days of storage. According to Gill (1996) in previous studies using similar percentages of CO_2, this may cause some problems of water exudation in fresh meat, producing weight loss in the final product (Gill, 1996).

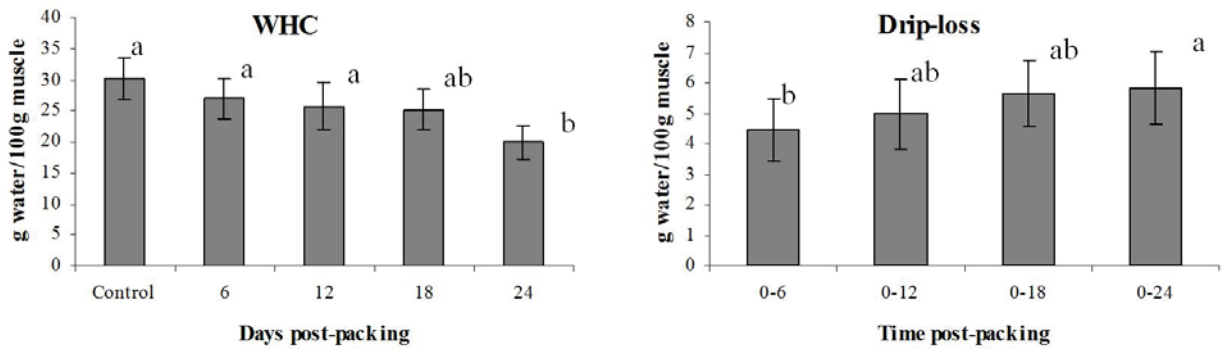

Figure 1: *WHC (g water/100g muscle) and drip-loss (g water/100 g muscle) evolution of Longissimus dorsi from Iberian pigs reared under "Montanera" system stored up to 24 days at 4 °C in modified atmosphere (70% O_2–30% CO_2)*

4 CONCLUSION

The use of high-oxygen modified atmosphere packaging could be an alternative conservation method for fresh meat from IB pigs reared under "*Montanera*" system. Results obtained show no adverse effect on colour or oxidation until 12 days of storage in high oxygen atmosphere (70% O_2–30% CO_2). On the other hand, water loss increased during storage time.

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6 REFERENCES

Bartkowski L., Dryden F.D., Marchello J.A. 1982. Quality changes of beef steaks stored in controlled gas atmosphere containing high or low levels of oxygen. Journal of Food Protection, 45:41–45

Blakistone B.A. 1998. Meats and poultry. In: Principles and applications of modified atmosphere packaging of foods (2nd ed). Blackie Academic & Professional, London, UK: 240–290

BOE. 2007. Real Decreto 1469/2007, de 2 de noviembre, por el que se aprueba la norma de calidad para la carne, el jamón, la paleta y la caña de lomo ibéricos. http://noticias.juridicas.com/base_datos/Admin/rd1469-2007.html (2. aug. 2013)

Campo M.M., Nute G.R., Hughes S.I., Enser M., Wood J.D., Richardson R.I. 2006. Flavour perception of oxidation in beef. Meat Science, 72: 303–311

Dixon N.M., Kell B.1989. A review. The inhibition by CO_2 of the growth and metabolism of micro-organisms. Journal of Applied Bacteriology, 67:109–136

Devine C.E., Graafhuis A.E., Muir P.D., Chrystal B.B. 1993. The effect of growth rate and ultimate pH on meat quality of lambs. Meat Science. 35: 63–77

Gill C.O. 1996. Extending the storage life of ray chilled meats. Meat Science, 43: S99–S109

Gill C.O., Penny N. 1988. The effect of the initial gas volume to meat ratio on the storage life of chilled beef packaged under carbon dioxide. Meat Science, 22: 53–57

Honikel K.O. 1998. Reference methods for the assessment of physical characteristics of meat. Meat Science, 49(4): 447–457

Hunt M.C., Acton J.C., Benedict R.C., Calkins C.R., Cornforth D.P., Jeremiah L.E., Olson D.G., Salm C.P., Savell J.W., Shivas S.D. 1991. AMSA guidelines for meat color evaluation. In: Proceedings of the 44th Annual Reciprocal Meat Conference, 9–12 July 1991, Kansas State University, Manhattan, KS: 3–17

Irie M., Swatland H.J. 1992. Relationships between Japanese pork color standards and optical properties of pork before and after frozen storage. Food Research, 25: 21–30

Marshall D.L., Wiese-Lehigh P.L., Wells J.H., Farr A.J. 1991. Comparative growth of listeria monocytogenes and pseudomonas fluorescans on precooked chicken nuggets stored under modified atmospheres. Journal of Food Protection, 54: 841–843

Nychas G.J.E., Skandamis P.N., Tassou C.C., Koutsoumanis K.P. 2008. Meat spoilage during distribution. Meat Science, 78:77–89

Salih A.M., Smith D.M., Price J.F., Dawson L.E. 1987. Modified extraction 2-thiobarbituric acid method for measuring lipid oxidation in poultry. Poultry Science.66: 1483–1489