EFFECT OF DIFFERENT DIETARY MAGNESIUM SUPPLEMENTS ON THE QUALITY OF MODIFIED ATMOSPHERE PORK MEAT

Verónica Alonso, Laura Provincial, Mario Gil, Elena Guillén, Luis M. Najes, José F. Jiménez, Paula Monge and José A. Beltrán*

Department of Animal Production and Food Science, University of Zaragoza, Miguel Servet 177, 50013 Zaragoza, Spain.

*Corresponding author (phone: +34-976-762738; fax: +34-976-761612; e-mail: jbeltran@unizar.es)

Abstract—**Forty crossbred (Pietrain x (Landrace x Large White)) female pigs were used to compare the effect of dietary supplementation with different sources of Magnesium (Mg oxide, Mg sulphate, Mg chelate) on pork meat quality during 13 days of storage under modified atmosphere conditions. The pH 24 h p.m. values were significantly higher in Control diet than dietary magnesium supplementation. There was only a slight difference for pH values of chops stored under MA conditions to be higher in Control diet compared to diets supplement with Mg until day 9 of storage. Dietary magnesium supplementation did not influence lightness parameter. Throughout display, L* values followed a similar significantly trend to increase for diets with Mg oxide and Mg sulphate. However, lightness of Mg chelate supplementation increased until day 4 and afterwards it was rather stable. Chops from pigs supplemented with Mg chelate had the lowest drip loss values and Control and Mg oxide the highest from day 7 of storage. However, Mg sulphate had a slight tendency to have intermediate values. The chops of pigs fed diets supplemented with Mg sulphate and Control had higher TBARS values than Mg oxide diet, while Mg chelate had intermediate values by the 9th day. Result suggest that supplementation of swine diets with Mg chelate for five days prior to slaughter may be effective in improving water holding capacity of chops during storage under modified atmosphere conditions.**

Index Terms—**Magnesium, Modified atmosphere packaging, Pork quality.**

I. INTRODUCTION

Improvements in pork quality can result in increased consumer demand, improved value of products, and, consequently, increased profit for all segments of the pork industry (Hamilton, Ellis, McKeith, & Eggert, 2003). Substantial fluid losses which result from various genetic anomalies (Halothane and rn gene status) resulting in aberrant postmortem pH decline, postmortem handling and other factors can diminish the juiciness of the meat (NPPC, 1994). A wide range of dietary supplements have been evaluated with the goal of enhancing meat quality (Swigert, McKeith, Carr, Brewer, & Culbertson, 2004).

Magnesium (Mg) helps to maintain osmotic pressure, acid–base balance, membrane potential, substrate transport, and enzymatic cofactors (Crenshaw, 1991). Beside, a number of studies have reported that feeding supra-nutritional levels of magnesium to pigs in the last few days prior to slaughter improves pork color and water-holding capacity (D'Souza, Warner, Dunshea, & Leury, 1999; Hamilton, Ellis, Hemann, McKeith, Miller & Purser, 2002 and Hamilton et al., 2003).

Ability of modified-atmosphere packaging (MAP) to extend the shelf life of foods has been recognized for many years. As far as we are aware, no studies have been devoted to the effect of dietary magnesium supplementation on pork meat packaged in modified atmosphere (MA). The aim of this study was to compare the effect of dietary supplementation with different sources of Magnesium (Mg oxide, Mg sulphate, Mg chelate) on pork meat quality during 13 days of storage under modified atmosphere conditions.

II. MATERIALS AND METHODS

A. Animals and sampling

The experiment was conducted with 40 female pigs, Pietrain (Dalland) as sire line and Landrace x Large White as dam line. During the experiment all pigs were subjected to the same feeding and management. At the beginning of the experiment the animals were divided into groups of 10 pigs and were randomly assigned to four dietary treatments with the individual animal as the experimental unit. The experiment consisted of four diet treatments for five days prior to loading for slaughter (1) control diet, (2) diet supplemented with magnesium oxide (5 g $pig^{-1}day^{-1}$ (50% Mg)), (3) diet supplemented with magnesium sulphate (12.5 g $pig^{-1}day^{-1}$ (20% Mg)) and (4) diet supplemented with magnesium chelate (11.7 g $pig^{-1}day^{-1}$ (21.4 % Mg)). The pigs were stunned using carbon dioxide and slaughtered at an abattoir at

approximately 107 kg live weight.

The loins were refrigerated at 4 ºC for 24 hours, after they sliced into 2 cm thick steaks and packaged in polystyrene tray sealed with a polyethylene and polyamide laminate film, using a packaging machine. The modified atmosphere used was 80 % O_2 and 20 % CO_2. All the packs were kept at 4°C±1°C and standard supermarket lighting conditions (14 h at day) during 13 days of storage time. Physical and chemical analyses were performed on day 1, 4, 7, 9, 11 and 13.

B. pH measurement

Muscle pH 24 h post-mortem (p.m.) in loin and pH of pork samples stored under MA conditions were measured using a pH meter equipped with a glass electrode. Each value was the mean of four measurements that were carried out on each sample.

C. Instrumental measurement of colour

A reflectance spectrophotometer (Minolta CM-2002; Osaka, Japan) was used to measure colour at the surface of a 2 cm-thick steak of *Longissimus lumborum* muscle after opening the trays and exposed to air for 2 h. The parameter registered was L* (lightness). Each value was the mean of 10 determinations per sample on the same slice.

D. Drip loss

Drip loss was measured as the weight decreased during the storage. The results were expressed as percent (%) of initial fillet weight.

E. Lipid oxidation

Lipid oxidation was measured by the 2-thiobarbituric acid (TBA) method (Pfalzgraf, Frigg, & Steinhart, 1995). TBA-reactive substances (TBARS) values were calculated from a standard curve of malondialdehyde and expressed as mg malondialdehyde per kg sample.

F. Statistical analysis

All data were statistically analyzed by the GLM procedure of SPSS, version 15.0 (SPSS, 2006). In the model, different diets were treated as a fixed effect and within each diet, days of storage were treated as a fixed effect. Mean values ($\bar{x}$) and standard errors (se) are reported in tables. Differences were considered significant if $p \leq 0.05$.

III. RESULTS AND DISCUSSION

The pH 24 h p.m. values were significantly higher in Control diet (5.65) than Mg oxide dietary supplementation (5.57), while Mg chelate (5.61) and Mg sulphate (5.61) had intermediate values. Those results disagree with several authors (D'Souza, et al., 1999; Hamilton et al., 2003) who found no differences in pH24 h between dietary Mg supplementation and the control diet. However, Swigert et al. (2004) reported an increase in ultimate pH for pigs supplemented with Mg. There was only a slight difference for pH values of chops stored under MA conditions to be higher in Control diet compared to diets supplement with Mg until day 9 of storage (Table 1). The ph values of Control diet kept constant during all storage time, while Mg chelate supplementation was too enough constant until day 11. The other two sources of magnesium had a gradual increase in pH values during storage.

Dietary magnesium supplementation did not influence lightness parameter (Table 2). The lack of definitive improvements in pork colour is in agreement with results of D´Souza et al. (1999) and Apple, Davis, Rakes, Maxwell, Stivarius and Pohlman (2001), who failed to find a significant difference in L* values in chops from pigs receiving supplemental Mg. In contrast, other authors (Hamilton et al., 2003, Swigert et al., 2004) have reported that pigs fed diets fortified with magnesium produced pork with lower lightness, indicating darker colored pork, in comparison to the controls. Throughout display, L* values followed a similar significantly trend to increase for diets with Mg oxide and Mg sulphate. From 1 to 7 day of display an increase in L* values was shown, rather stable from 7 to 11 day, and another increase in the values from 11 to 13 day. However, lightness of Mg chelate supplementation increased until day 4 and afterwards it was rather stable.

The average of drip loss values is shown in Figure 1. Chops from pigs supplemented with Mg chelate had the lowest drip loss values from day 7 of storage. No differences were found in the values of drip loss between Control and Mg oxide treatments. However, dietary Mg sulphate had a slight tendency to have intermediate values. This is consistent with the relationship between Mg sulphate supplementation and improvement of water holding capacity which has been previously described by D´Souza et al. (1999), Hamilton, et al. (2002) and Hamilton et al. (2003). On the other hand, these results are in disagreement with Frederick et al. (2004) and Swigert et al. (2004) who reported no effects on drip

loss when pigs were supplemented with Mg sulphate. Results showed that drip loss increases in agreement with the pass of time.

Lipid oxidation values are depicted in Figure 2. All treatments started with very low values of about 0.07 mg malonaldehyde/kg sample, which remained stable during the first 7 days of storage and showed no significant differences among samples. The chops of pigs fed diets supplemented with Mg sulphate and Control had higher TBARS values than Mg oxide diet, while Mg chelate had intermediate values by the 9th day. The observed reduction of TBARS, albeit small, from supplementing swine diets with Magnesium could be due to an association with Mg ions replacing manganese ions in the activation of superoxide dismutase or in scavenging free radicals (Apple et al., 2001). In general, oxidation increased with the length of the display.

IV. CONCLUSION

The supplementation with different magnesium sources for five days prior to slaughter have shown a tendency to produce a slight decrease for pH values, but no differences in lightness pork meat. On the other hand, results of this study suggest that supplementation of swine diets with Mg chelate may be effective in improving water holding capacity of chops during storage in MA conditions. Furthermore, supplementation with Mg oxide and Mg chelate may have a beneficial antioxidant effect.

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Table 1. Effect of dietary supplementation with different sources of Mg and display period on pH values of pork meat: mean ($\bar{x}$) and standard error (se).

Effect	*Display period*										
Diet supplementation	**4**		**7**		**9**		**11**		**13**		**Sign.**
	$\bar{x}$	**se**	$\bar{x}$	**se**	$\bar{x}$	**se**	$\bar{x}$	**se**	$\bar{x}$	**se**	
Mg Oxide	5.45ay	0.04	5.46ay	0.07	5.51abyz	0.07	5.54z	0.07	5.54z	0.11	*
Mg Chelate	5.46ay	0.04	5.48ay	0.05	5.52aby	0.06	5.54y	0.12	5.63z	0.13	***
Mg Sulphate	5.48aby	0.04	5.50abyz	0.05	5.49ay	0.05	5.55yz	0.08	5.60z	0.18	t
Control	5.51b	0.07	5.56b	0.11	5.58b	0.12	5.57	0.09	5.63	0.13	ns
Sign.	t		*		t		ns		ns		

Different letters in the same row (y, z) / column (a, b) indicate significant differences between means: ns = p>0.1; t = p≤0.1; * = p≤ 0.05; *** = p≤0.001.

Table 2. Effect of dietary supplementation with different sources of Mg and display period on L* values of pork meat: mean ($\bar{x}$) and standard error (se).

Effect	*Display period*												
Diet supplementation	**1**		**4**		**7**		**9**		**11**		**13**		**Sign.**
	$\bar{x}$	**se**	$\bar{x}$	**se**	$\bar{x}$	**se**	$\bar{x}$	**se**	$\bar{x}$	**se**	$\bar{x}$	**se**	
Mg Oxide	47.98x	2.01	50.90y	1.71	52.11yz	1.85	53.14yz	2.44	52.05yz	2.36	53.91z	3.27	***
Mg Chelate	46.84y	1.93	49.61z	2.35	51.09z	1.97	51.63z	1.66	50.19z	3.05	51.69z	4.47	**
Mg Sulphate	47.64x	1.76	50.99y	1.54	52.47yz	1.58	52.85yz	1.71	52.97yz	2.02	53.77z	3.54	***
Control	47.87y	2.84	50.6yz	2.46	51.82z	2.9	53.29z	2.31	51.28yz	2.88	53.39z	3.62	**
Sign.	ns		ns		ns		ns		ns		ns		

Different letters in the same row (x, y, z) indicate significant differences between means: ns = p>0.1; ** = p≤0.01; *** = p≤0.001.

Figure 1. Effect of dietary supplementation with different sources of Mg on drip loss values stored under modified atmosphere conditions.

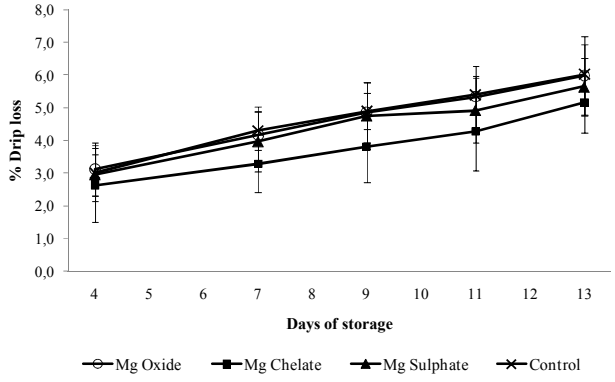

Figure 2. Effect of dietary supplementation with different sources of Mg on TBARS values stored under modified atmosphere conditions.