Shelf life of veal calves from Holstein Friesian breed stored under vacuum-packaged and modified atmosphere

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Abstract- A total of eleven male veal calves from Holstein Friesian breed were used for this study. Samples were individually packed under vacuum and in modified atmosphere protective (MAP) conditions (M1 [70% CO_2-30% O_2]; M2 [80% O_2-20% CO_2]). pH, colour parameters, mioglobyn content, TBARS index and textural parameters were analyzed after 3, 7, 10 and 14 days of exposure time. pH, water-holding capacity and texture properties did not affect for packaging system and storage time. Meat luminosity (L*) increased during time storage but these increase was only significantly (P<0.01) in samples packaged under M1, whereas type of package affected all samples studied. Index of red (a*) decreased during display days except for samples vacuum-packaged. Storage time affected significantly (P<0.001) in samples packaged under M1 and M2, whereas vacuum-packaged samples did not affect TBAR´S values.

Keywords: **Shelf life, lipid oxidation, Vacuum-packaged, MAP**

I. INTRODUCTION

Packaging influences the extension of raw chilled meat shelf life (Renerre & Labadie, 1993). The properties of meat that are important in determining shelf life include water binding (or holding) capacity, colour, microbial quality, lipid stability, and palatability (Renere, & Labadie, 1993; Zhao, Wells, & McMillin, 1994). The variables that influence the shelf life properties of packaged fresh meat are the product, gas mixture, package and headspace, packaging equipment, storage temperature, and additives (Hotchkiss, 1989). Deteriorative changes during meat storage are affected by metabolic reactions from biological membrane disruption (Stanley, 1991) and biochemical oxidative processes (Xiong, & Decker, 1995). Deterioration of quality may include discoloration, off-flavor and off-odor development, nutrient loss, texture changes, pathogenicity, and progression of spoilage factors (Skibsted, Bertelsen, & Qvist, 1994). The purpose of MAP is to maintain the desired properties of meat for the desired period of storage and display.

Colour of prepackaged meat and its stability or discoloration are the most important quality attributes in shelf life (Renere, & Labadie, 1993). Meat purchasing decisions are influenced more by colour than any other quality factors (Mancini, & Hunt, 2005), with a strong relationship between colour preference and purchase intent by consumers who would discriminate against beef that was not red (Carpenter, Cornforth, & Whittier, 2001).

II. MATERIALS AND METHODS

II.1. Animals and treatment of the samples

Eleven male calves from Holstein Friesian breed were used for this study. Animals were castrated at seven months old and remained feeding only pasture until 7 months prior to slaughter, during this period animals were reared with a commercial concentrate "*ad libitum*". Animals were conventionally slaughtered at 18 months of age in a commercial abattoir. Carcasses were ageing during seven days at 4 ºC in a cold chamber. At this point, the *Longisimus thoracis* (LT) muscle was extracted from the left half of each carcass, between the first and the twelve ribs.

II.2. Preparation of samples and package conditions

Samples were taken immediately to the laboratory, under refrigerated conditions. LT was cut aseptically in 20 steaks of 1.5 cm of thickness with surface areas about 150 cm^2. Steaks were individually packaged under vacuum (98%) (V) and in modified atmosphere protective (MAP) conditions (M1 [70% CO_2-30% O_2]; M2 [80% O_2-20% CO_2). The trays (a transparent and thermo-sealing film of propylene and polyethylene 126 with a water vapour permeability of 10 g/m^2/24h/bar at 38°C and oxygen permeability of 110 ml/m2127 /24h/bar at 23 °C was used were displayed on a refrigerated chamber at 4 ºC, without light. Analyses were carried out for 3, 7, 10 and 14 days of exposure time. In each one of this point, pH, colour parameters, mioglobyn content, TBARS index and textural parameters were analyzed.

II.2. Analytical methods

II.2.1 pH and colour

The pH, colour and myoglobin analysis were measured as described by Franco, Bispo, González, Vázque, & Moreno (2009). Briefly, the pH of samples was measured using a digital pH-meter that was equipped with a penetration probe. A portable colorimeter Konica Minolta CR-400 was used to measure meat colour in the CIELAB space (CIE, 1976). Samples were allowed to bloom for 1 h before measuring directly in contact with air (Insausti, Beriaín, Purroy, Albertí, Lizaso, & Hernández 1999).

II.2.2. WHC and Texture analysis

Steaks were cooked placing vacuum package bags in a water bath with automatic temperature control until they reached an internal temperature of 70 ºC controlled by thermocouples. Samples were cooled at room temperature after cooking, placing vacuum package bags in a circulatory water bath set at 18 ºC for a 30 minutes period and percentage cooking loss was recorded. All samples were cut or compressed perpendicular to the muscle fibre direction at a 3.33 mm/s crosshead speed in a texture Analyzer TA.XT.plus of Stable Micro Systems. Maximum shear force (MØller, 1980), shear firmness (Brady, & Hunecke, 1985) and total necessary work performed to cut the sample were obtained.

II.2.3. Lipid oxidation analysis

Lipid stability was evaluated in the steaks using a small portion of 2 g. Lipid oxidation, measured by aldehydes generated in the process of polyunsaturated fatty acid oxidation, was determined by measuring 2-thiobarbituric acid reactive substances (TBARS) using the method proposed by Vyncke (1975). Results are expressed as (mg malonaldehyde/kg of fresh meat).

II.3. Statistical analysis

For the statistical analysis of the results, data were analyzed using the SPSS (version 15.0, USA). One-way analysis of variance (ANOVA) was used to analyze the effect of package type and displays days on meat quality traits studied in the work. The least squares mean (LSM) were separated using Duncan's t-test. All statistical test of LSM were performed for a significance level $\alpha<0.05$.

IV. RESULTS AND DISCUSSIONS

The results of this study are shown in Table 1. During display days, no significant differences ($P<0.05$) were observed for pH values, however, we found differences bewteen packaging system after 7 and 10 days of storage. In this period of time pH values were lower in samples under packaging M1 and are agree with reported previously (Juncher, Ronn, Mortensen, Henckel, Karlsson, & Skibsted, 2001; Jakobsen, & Bertelsen, 2004). This effect has been related to the absorption of CO_2 by meat, which results in the production of carbonic acid (Dixon, & Kell, 1989).

In our study there was no significant effect by packaging system and time of storage on heminic pigments ($P>0.05$), thus myoblobin content was not altered during storage.

Meat luminosity (L*) increased during time storage but these increase was only significantly ($P<0.01$) in samples packaged under M1, whereas type of package affected all samples studied. Index of red (a*) decreased during display days except for samples under vacuum packaging. This in agreement with results reported by Zakrys, Hogan, O'Sullivan, Allen, & Kerry (2008), who showed that instrumental a* values displayed a negative correlation with days, showing a decrease in red colour of beef steaks over time. Type of package also affected index of red showed higher values in samples pakage under M2. Index of yellow (b*) only increased significantly ($P<0.001$) during storage time in samples vacuum packaging. However, type of package affected significantly ($P<0.001$) in all sample points showed higher values in samples packaged under M2.

Water-holding capacity and textural properties were not affect by display days and packaging system. Shear force decreased during storage time reached lower values in samples under vacuum packaging. According to tenderness classification proposed by Belew, Brooks, McKenna, & Savell (2003) in bovine meat, our meat can be considered as "very tender" (WB shear force <3.2 kg) after 14 days of storage.

The level of lipid oxidation of meat was estimated on base of TBAR´S values. Storage time affected significantly ($P<0.001$) in samples packaged under M1 and M2, whereas vacuum packaged samples did not affect TBAR´S values. Exclusion or limiting of the oxygen in the vacuum pakaged limited oxidation and TBAR´S values remained constant during the whole display period. It has been established that atmosphere conditions with oxygen content enhance the lipid oxidation rate (Jayasing, Cornforth, Brennand, Carpenter, & Whittier, 2002) and continous exposure to light during 14 days of storage increase TBAR´S values in meats (Brewer, & Wu, 1993).

Table 1. *Changes in physico-chemical properties of veal calves from Holstein Friesian breed stored under vacuum-packaged and modified atmosphere*

	Storage time (days)					
	3	**7**	**10**	**14**	**SEM**	**SIG**
			pH			
Vacuum	5.68±0.12	5.73±0.13^{x}	5.71±0.06^{x}	5.69±0.12	0.16	n.s.
M1 70:30	5.60±0.06	5.59±0.08^{y}	5.62±0.04^{y}	5.60±0.05	0.01	n.s.
M2 80:20	5.63±0.06	5.63±0.09^{x}	5.67±0.04^{x}	5.63±0.04	0.01	n.s.
SIG	n.s.	*	**	n.s.		
			Colour Parameters			
Luminosity (L*)						
Vacuum	31.50±1.84^{x}	32.99±3.01^{x}	32.81±2.36^{x}	33.89±2.78^{x}	0.39	n.s.
M1 70:30	34.90±1.21^{ya}	35.60±2.00^{ya}	35.54±2.05^{ya}	37.93±2.73^{yb}	0.34	**
M2 80:20	34.94±1.72^{y}	36.70±2.35^{y}	35.38±2.42^{y}	36.15±1.70^{y}	0.31	n.s.
SIG	***	**	*	**		
Index of red (a*)						
Vacuum	21.25±0.93^{xa}	22.24±0.94^{xb}	22.95±1.26^{xbc}	23.36±0.99^{xc}	0.19	***
M1 70:30	27.26±1.71^{ya}	24.95±2.84^{yb}	22.26±2.22^{xbc}	14.60±6.09^{yc}	0.89	***
M2 80:20	28.46±2.04^{ya}	26.72±2.75^{yb}	25.25±2.53^{ybc}	21.90±5.34^{yc}	0.61	**
SIG	***	***	**	***		
Index of yellow (b*)						
Vacuum	1.37±1.11^{xa}	1.99±2.05^{xa}	3.34±1.23^{xb}	3.95±1.20^{xa}	0.26	***
M1 70:30	6.84±1.08^{y}	6.37±1.00^{y}	5.95±1.24^{y}	6.15±1.44^{y}	0.18	n.s.
M2 80:20	7.33±1.23^{y}	7.23±1.13^{y}	6.84±1.46^{y}	6.65±1.16^{y}	0.18	n.s.
SIG	***	***	***	***		
Mioglobyn						
Vacuum	4.71±1.02	5.09±0.68	5.38±0.63	5.26±0.72	0.12	n.s.
M1 70:30	4.75±0.84	5.09±0.65	5.06±0.68	4.99±0.73	0.10	n.s.
M2 80:20	4.65±0.70	5.19±0.67	5.37±0.65	5.06±0.59	0.10	n.s.
SIG	n.s.	n.s.	n.s.	n.s.		
			Water-holding capacity (%)			
Vacuum	19.96±4.39	17.09±3.74	18.50±3.44	18.34±4.13	0.59	n.s.
M1 70:30	18.44±3.04	18.79±3.40	18.37±2.60	17.20±2.93	0.44	n.s.
M2 80:20	16.44±2.79	19.09±4.47	20.15±8.63	17.64±3.54	3.54	n.s.
SIG	n.s.	n.s.	n.s.	n.s.		
			Textural properties			
Shear Firmness (kg/cm^2)						
Vacuum	0.81±0.27	0.80±0.21	0.75±0.18	0.69±0.18	0.03	n.s.
M1 70:30	0.79±0.26	0.87±0.21	0.72±0.16	0.72±0.20	0.03	n.s.
M2 80:20	0.78±0.23	0.86±0.20	0.74±0.30	0.69±0.22	0.03	n.s.
SIG	n.s.	n.s.	n.s.	n.s.		
Total work (kg*s)						
Vacuum	14.13±5.32	12.74±2.27	12.83±4.17	13.35±2.34	0.52	n.s.
M1 70:30	14.11±5.90	18.61±7.96	12.88±4.57	13.40±2.40	0.88	n.s.
M2 80:20	13.37±3.35	15.6±5.33	14.66±5.66	13.54±4.47	0.71	n.s.
SIG	n.s.	n.s.	n.s.	n.s.		
Shear Force (kg/cm^2)						
Vacuum	3.27±0.99	3.21±0.72	3.12±0.91	2.77±0.66	0.12	n.s.
M1 70:30	3.28±0.95^{a}	4.10±1.02^{a}	3.08±0.87^{a}	3.11±0.67^{b}	0.14	*
M2 80:20	3.34±0.93	3.84±1.09	3.37±1.14	2.90±0.83	0.15	n.s.
SIG	n.s.	n.s.	n.s.	n.s.		
			Lipid oxidation			
TBAR´S						
Vacuum	0.04±0.04^{x}	0.06±0.03^{x}	0.06±0.03^{x}	0.07±0.03^{x}	0.05	n.s.
M1 70:30	0.59±0.35^{ya}	1.33±0.46^{yb}	1.51±0.74^{yb}	2.89±1.13^{yc}	0.16	***
M2 80:20	0.53±0.30^{ya}	1.13±0.36^{yb}	1.58±0.43^{yb}	2.86±1.03^{yc}	0.15	***
SIG	***	***	***	***		

$^{x-y}$ Different letters in the same column show significant differences ($p<0.05$, Duncant test)
$^{a-c}$ Different letters in the same row show significant differences ($p<0.05$, Duncant test)

V. CONCLUSIONS

The results from this study indicated that increasing the oxygen level in MAP leads to a decrease in colour stability and an increase in lipid oxidation during display days, whereas pH, water-holding capacity and texture properties were not affect.

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