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Influence of short-term pre-aging in vacuum on physicochemical characteristics and consumer acceptability of modified atmosphere packed beef steaks

Joanna Łopacka*, Katarzyna Żontała, Jacek Pietras, Andrzej Półtorak, Agnieszka Wierzbicka

Division of Engineering in Nutrition, Faculty of Human Nutrition and Consumer Sciences, Warsaw University of Life Sciences, 159C Nowoursynowska St., Poland

Abstract

The objective of this study was to investigate the physiochemical changes and consumer acceptability of meat packed in high oxygen modified atmosphere during 12 days of storage with and without pre-aging in vacuum for 7 days. Steak samples from forequarter muscles *Infraspinatus* and *Supraspinatus* were stored at 2°C and tested for colour, Warner–Bratzler shear force (WBSF), storage/cooking loss, and consumer acceptability. Overall consumer acceptability at the beginning of modified atmosphere display was higher for aged *Infraspinatus* samples, however at the end of display samples from both treatments were equally rated by consumers. No impact of aging was observed in terms of storage loss, while cooking loss was slightly affected by aging, resulting in higher losses in aged samples at the end of modified atmosphere storage. Inclusion of an aging process prior to modified atmosphere display improved the tenderness of *Infraspinatus* muscle at the 8th day of display and led to a considerable increase in redness of both muscles.

Keywords

Beef • Modified atmosphere packaging • Meat aging • Meat colour • Sensory analysis

Introduction

The aging process of fresh meat involves storage at low temperatures for sufficient time to enhance its palatability – increase of tenderness and development of flavors (Sitz *et al.* 2006). Vacuum aging, also called wet aging, is widely used in the meat industry, mainly due to convenience in storage and transport, and high production yield (Warren and Kastner 1992). Removal of air from the meat environment within a package can also eliminate the oxidizing effect of oxygen, and delay oxidation processes (Franco *et al*. 2009; Jiang *et al*. 2010). On the other hand, oxygen is crucial for myoglobin oxygenation, and its removal may lead to unattractive color of meat due to formation of purple deoxymyoglobin (Troy and Kerry 2010).

Modified atmosphere packaging (MAP) with 70-80% of oxygen is one of the most popular packaging systems for fresh beef steaks, due to stable well developed red meat colour, which is attractive to consumers (McMillin 2008). The main disadvantage of this system is increased oxidation which negatively affects meat quality traits such as flavour and tenderness (Madsen and Clausen 2006; Zakrys *et al*. 2009; Kim *et al*. 2010). Many authors also reported that high oxygen modified packaging can reduce tenderness of beef (Clausen *et al*. 2009; Grobbel *et al*. 2008; Sorheim *et al*. 2004).

Since post mortem aging allows desirable structural and sensory changes in meat it is recommended to sell beef after 14 days post-mortem (Dunne, Monahan and Moloney 2010). Consumers prefer bright red beef, but long storage under MAP conditions may result in some undesirable changes in beef quality. A combination of vacuum aging and MAP packaging may be considered a solution for this problem.

Limited literature is available on the combined effect of vacuum aging and storage under modified atmosphere on beef quality characteristics (Lindahl 2011; Vitale *et al.* 2014). However, none has considered the muscles of the forequarter, like *M. infraspinatus* (IS) and *M. supraspinatus* (SS). Nortje and Shaw (1989) reported a reduction in the shelf life of beef stored in MAP after three weeks of ageing compared to one week, suggesting that a longer aging time may not be appropriate for meat displayed afterwards in MAP.

M. infraspinatus is one of the chuck muscles of the beef carcass. Several authors reported that it may be more tender than sirloin steak (Hildrum *et al.* 2009) or even tenderloin (Rhee *et al*. 2004), whilst SS as one of the round muscles is generally considered tough. The IS muscle was the first successful value-added chuck cut and in recent years is

*Corresponding author: Joanna Łopacka

E-mail: joanna_lopacka@sggw.pl

more often sold under the name of flat-iron steak. Thus, it is important to look for other muscles that may be used for upgrading purposes. Improved quality of low-value cuts may contribute to an improved sustainability of the beef sector (Almli *et al*. 2013).

One of the most important goals of research on this topic is to find the compromise between improvement in meat tenderness through vacuum storage and bright colour retention using MAP. Available literature shows that aging times of 14 or 21 days may result in higher improvements in tenderness than aging for 6 days but meat shelf life is reduced due to poorer colour stability at the end of display in MAP (Vitale *et al*. 2014).

The aim of this study was to investigate whether pre-aging of whole cuts in vacuum for 7 days has any positive impact on physicochemical characteristics and consumer acceptability of raw IS and SS steaks stored in MAP for 4, 8 and 12 days.

Materials and methods

Animals, samples, and packaging

Animals (six steers, aged in the range of 14-22 months) were slaughtered according to standard routines at a local slaughter plant. All animals came from one farm and had the same feeding regime, ad libitum access to grass silage and oats. After 48h postmortem the meat was trimmed and the IS and SS muscles were removed from the both sides of the carcasses, labelled, packed in vacuum bags (polyamide/polyethylene bags) and stored at 4°C until required for MAP. Then the muscles from the left side of the carcasses were removed from bags, trimmed free of fat and cut across the length of the muscle into steaks 2.5 cm each, packed in modified atmosphere with 80%/20% oxygen/carbon dioxide in polypropylene/EVOH/polyethylene packages with oxygen transmission rate of 2 cm3/m2/24 h at STP and stored under illumination by a standard fluorescent lamp at 2°C for up to 12 days. Muscles from the right side of the carcass were left in vacuum for 7 days and then repackaged in MAP and stored up to 12 days. Six steaks per each of four storage days in MAP (0, 4, 8 and 12 days) for each treatment were evaluated. Zero time measurements were performed on the cross-section of meat directly after cutting. Samples were divided into treatments according to the side of the carcass to minimize the effect of sample location within a muscle on physicochemical parameters.

Near infrared spectroscopy analysis (NIR) and pH - sample characterisation

Near infrared spectroscopy analysis was performed using a NIRFlex Solids N-500 spectrophotometer (BUCHI Labortechnik GmbH, Germany) to examine the chemical composition of samples. Results were expressed as percentage of protein, fat, water, connective tissue and ash. Samples (100 g) of meat were homogenized (Buchi B-400 homogeniser, BUCHI Labortechnik GmbH, Germany), placed into a Petri plate and scanned in a triplicate. All three scans of each sample were examined for consistency and then averaged. pH was measured a with Testo pH-meter (Testo Inc., Germany) to eliminate meat with pH > 5.8.

Instrumental measurement of colour

The surface colour of beef steaks was measured by assessing L*, a* and b* values using a Minolta CR 400 colorimeter (Minolta Camera Co. Ltd., Osaka, Japan). The chromameter was calibrated using a white tile (Minolta calibration plate). Ten readings were taken per sample on each measurement day, directly after opening the package to obtain colour similar to that seen by consumers at the point of sale. In addition, the general distance between colours (parameter showing overall difference in colour between samples) was evaluated as $\Delta E = [(L1 - L2)^2 + (a1 - a2)^2 + (b1 - b2)^2]^{1/2}$.

Water loss

Water loss was estimated by weighing the meat on day 0 (M_0) and after removal from package on the appropriate day of measurement (M_n). All samples were gently blotted with tissue paper prior to weighting. Water loss was expressed as a percentage of the initial weight of the meat:

$$\%\,water\ loss = \frac{M0 - Mn}{M0} \times 100$$

Sensory analysis

Sensory analysis of raw meat was performed with consumers in the age range 19-56 years old. They were recruited from workers and students of the Faculty of Human Nutrition (Warsaw University of Life Sciences) on the basis that they consume and purchase beef. Consumers were asked to evaluate the following descriptors: odour attractiveness (OA), odour intensity (OI), colour attractiveness (CA) and overall acceptability (OAc) of meat removed from a package. Consumer assessment was performed within 20 minutes from the removal of the package to reduce the impact of oxygen air on colour and, on the other hand, to obtain odour evaluation of meat itself without an impact of gas phase odour from the package. Evaluation of the meat was performed in sessions on every measurement day with 30 consumers per session. For each piece of meat, consumers were asked to indicate their degree of liking on a 10 cm line scale ranging from 0 ('extremely dislike') to 10 ('extremely like'). Steaks were placed into 12 plates. Plates was randomly combined into 6 sets, each containing one IS sample and one SS sample. Each consumer was presented with one set for approximately 3 minutes, then samples were mixed and given to the next consumer.

Warner–Bratzler shear force and cooking loss

Shear force measurements were performed according to the method by Shackelford *et al.* (1991) with slight modifications. Steaks were weighted, placed in individual plastic bags and cooked in a convection oven (100% humidity) (KEG 010K, Küppersbusch Großküchentechnik GmbH, Germany) at 85°C to an internal temperature of 75°C, cooled down in tap water and stored overnight at 4°C. Internal temperature was measured with an oven thermocouple in one randomly chosen sample during cooking. After removal from bags steaks were weighted to estimate cooking loss. Subsequently ten cores (1.27 cm diameter) were cut out from each of the steaks, parallel to the muscle fibre direction. Cores were sheared perpendicular to the muscle fibres using a Warner-Bratzler V-shaped blade attached to a 5 kN load cell of an Instron Universal Testing Machine (Model 5965, Instron Corp., Canton, MA) with a crosshead speed of 200 mm/min. Peak shear force was recorded in newtons. From the ten cores measured, six values nearest to the mean were used to obtain the mean value for the sample, as recommended (Wheeler *et al.* 1997). Cooking loss was expressed as a percentage of the initial weight of the meat (Mr – raw meat, Mc – cooked meat):

$$\%\ cooking\ loss = \frac{Mr - Mc}{Mr} \times 100$$

Statistical analysis

The data were subjected to analysis of variance to determine the effect of aging and storage time on each variable. The model used as appropriate for a strip plot design with repeated measures using Statistica 10 (StatSoft Inc., Tulsa, OK). The muscle type, aging time and MAP storage were the factors and the animals were treated as blocks. The Tukey HSD test was used to describe the likely size of the difference needed to be statistically significant. Correlation coefficients were generated using Pearson's correlation coefficient option of the correlation procedures.

Results and discussion

Sample characterisation

As shown in Figure 1, the composition of SS and IS differs only in terms of fat content. No differences in other components were observed between muscles. The pH ranged between 5.51 and 5.73.

Colour

Whole beef cuts are typically aged under vacuum, cut into commercial cuts or steaks and then repackaged in high-oxygen MAP to achieve the bright red colour of oxygenated myoglobin (Lindahl 2011). Meat colour is one of the most relevant parameters determining consumer purchase decision at the place of sale (Troy and Kerry 2010). Comparison of the means for muscles (Table 1) shows that values of all colour coordinates were higher in SS ($p<0.05$). However, the ΔE distance between colours of these muscles was 1.65 and such difference may be noticeable by experienced observers but not by average consumers (Upton 2006).

Beef colour coordinates were not negatively affected by aging. Redness (a*) of IS was highest on the fourth day of display in MAP, both in aged and non-aged samples (Table 2). Significantly higher a* values ($p<0.05$) were obtained in aged samples on D0 for IS and on D4 for SS. These results are in agreement with Picouet *et al*. (2014) and Lindahl *et al.* (2010) and confirm that aging may preserve beef colour (Hood 1980). However, in IS the increase in a* value after four days of storage in MAP was higher in non-aged samples than in samples aged for 7 days. Both IS and SS had comparable

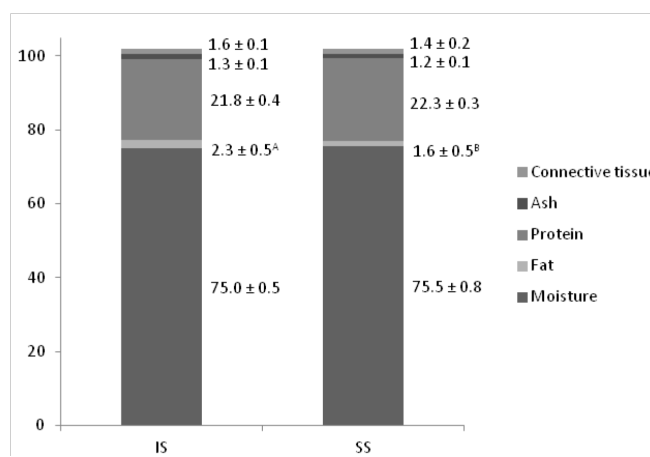

Figure 1. *Basic chemical composition – NIR analysis of IS and SS samples (mean ±SD). Mean values bearing different superscripts (A, B) differs significantly (P<0.05).*

Table 1. *Mean values for colour traits of* M.infraspinatus *(IS) and* M.supraspinatus *(SS) steaks.*

Colour traits	IS	SS	SEM
L*	41.63[a]	42.85[b]	0.29
a*	26.52[a]	27.39[b]	0.05
b*	12.45[a]	13.14[b]	0.05
C*	29.30[a]	30.39[b]	0.05
Hue	25.18[a]	25.61[b]	0.08

[a–b] mean values with different superscripts are significantly different (p<0.05).

Table 2. ***Means for the interaction of*** *time of storage in MAP x muscle x aging* ***for colour parameters of*** *M.infraspinatus* ***(IS) and*** *M.supraspinatus* ***(SS) steaks stored up to 12 days in MAP with or without previous aging in vacuum.***

Days in MAP	Muscle	Aging time	L*	a*	b*	C*	Hue
0	IS	7	40.43	26.40[b]	12.01	29.01[b]	24.43
4	IS	7	42.23	29.77[c]	13.69	32.77[c]	24.72
8	IS	7	42.14	26.87[b]	12.44	29.62[b]	24.84
12	IS	7	43.46	25.22[ab]	12.28	28.06[ab]	26.00
0	IS	1	39.65	24.76[a]	11.47	27.31[a]	24.84
4	IS	1	41.59	29.12[c]	13.53	32.11[c]	24.91
8	IS	1	41.15	25.57[ab]	12.33	28.40[ab]	25.74
12	IS	1	42.45	24.42[a]	11.88	27.16[a]	25.94
0	SS	7	39.71	26.93[b]	11.84	29.42[ab]	23.71
4	SS	7	44.66	30.41[d]	14.85	33.84[d]	26.03
8	SS	7	42.27	27.12[b]	13.20	30.16[b]	25.95
12	SS	7	43.73	26.33[ab]	13.37	29.53[ab]	26.93
0	SS	1	40.33	26.76[b]	12.15	29.39[ab]	24.41
4	SS	1	44.23	28.97[c]	14.10	32.22[c]	25.96
8	SS	1	42.50	27.30[b]	13.24	30.34[b]	25.85
12	SS	1	45.37	25.32[a]	12.40	28.20[a]	26.10
HSD[A]			NS	2.36	NS	1.47	NS
SEM[B]			0.403	0.279	0.055	0.074	0.095
F test for interaction				*		*	
Significance of other interactions							
aging x muscle			*	***	NS	**	NS
time of storage in MAP x aging			NS	NS	NS	NS	NS
time of storage in MAP x muscle			NS	NS	NS	NS	NS

[a–d] ***mean values with different superscripts are significantly different***
[A] ***Honest significant difference***
[B] ***Standard error of mean***

lightness L* and yellowness b* during storage and no difference between aged and non-aged samples was observed, which shows that neither aging time nor time of storage in MAP significantly influenced these parameters. As stated by Picouet *et al*. (2014) differences in lightness are considerable only in meat aged for more than 7 days. In general, redness showed a tendency to decrease with increased storage time, with a slight increase just after packing, consistent with Lagerstedt, Lundström and Lindahl (2011), who observed similar changes in *M. longissimus dorsi.* Vitale et al. (2014) observed that six days of aging in vacuum prior to MAP resulted in the highest redness and chroma values with improved colour stability at 9 days of display in MAP.

Water loss

No differences between treatments were observed in water loss (Table 3). A general increase was observed in both treatments during storage, however differences were not significant. The results differ from other authors, who observed significantly higher drip loss with increased storage time in MAP (Sekar *et al*. 2006; Lindahl *et al.* 2011). Aged samples were repacked, which might have increased total loss due to the additional handling, however aging was applied to whole muscles and aging loss is not included in this comparison. Generally in previous studies purge losses were lower in MAP packages compared to vacuum (Sebranek and Houser 2006).

Sensory analysis

Aging of fresh meat is used to enhance its palatability. It has been proved that aging can increase meat tenderness; however, its effect on other attributes is still not clear (Jiang *et al.* 2010), especially in terms of raw meat attractiveness. Storage under high-oxygen MAP causes oxidation of polyunsaturated fatty acids, resulting in meat rancidity, which in turn may affect the colour and flavor of packaged meat (Zakrys-Waliwander *et al*. 2011).

In the present study, no differences between aged and non-aged samples stored in MAP were observed for OA or OI (Table 4), hence it might be concluded that inclusion of aging does not influence consumers' ratings in terms of these

Table 3. ***Means for the interaction of*** *time of storage in MAP x muscle x aging* ***for water loss, WSBF and cooking loss of*** *M.infraspinatus* ***(IS) and*** *M.supraspinatus* ***(SS) steaks stored up to 12 days in MAP with or without previous aging in vacuum***

Days in MAP	Muscle	Aging time	Water loss [%]	WBSF [N]	Cooking loss [%]
0	IS	7		31.94^{b}	26.04^{a}
4	IS	7	1.51	28.28^{ab}	26.24^{a}
8	IS	7	1.88	29.75^{ab}	26.19^{a}
12	IS	7	1.90	36.77^{c}	29.97^{b}
0	IS	1		31.23^{ab}	25.73^{a}
4	IS	1	1.72	27.73^{a}	27.20^{a}
8	IS	1	2.08	36.87^{c}	27.04^{a}
12	IS	1	1.98	36.60^{c}	27.30^{a}
0	SS	7		41.71^{ab}	31.92^{a}
4	SS	7	1.77	40.71^{a}	35.41^{b}
8	SS	7	1.87	41.50^{ab}	35.34^{b}
12	SS	7	2.03	41.83^{ab}	38.33^{c}
0	SS	1		41.68^{ab}	35.05^{b}
4	SS	1	2.10	41.06^{a}	36.43^{bc}
8	SS	1	2.13	40.98^{a}	36.83^{bc}
12	SS	1	2.15	44.96^{b}	36.87^{bc}
HSD[A]			NS	3.76	1.93
SEM[B]			0.012	0.190	0.084
F test for interaction				***	*
Significance of other interactions					
aging x muscle			NS	NS	*
time of storage in MAP x aging			***	NS	***
time of storage in MAP x muscle			***	***	**

[a–c] ***mean values with different superscripts are significantly different***
[A] ***Honest significant difference***
[B] ***Standard error of mean***

quality traits. Brewer and Novakofski (2008) observed that aging had no impact on flavour of wet-aged loin steaks after thermal treatment. Some slight differences were observed for OA and OI in aged IS samples with increased MAP storage time, however this relationship was not linear. Quite opposite results were obtained for SS samples whereby OA decreased and OI increased during storage in both treatments (P<0.01). Similar results were obtained by Campo *et al.* (2006), who noted that the consumer overall acceptability of the taste of meat decreased with storage time in MAP (0, 4, 9 days).

The CA of IS increased (P<0.01) within storage time in non-aged meat, while in aged samples CA decreased (P<0.05). Consumers preferred the colour of aged IS samples and non-aged SS samples before packing and at the beginning of display in MAP (D0 and D4), while results on further display days were not different in both cases. Vitale *et al.* (2014) observed that meat aged for 6 days did not differ significantly (P <0.05) in the assessment of color attractiveness from meat which has not been aged. They also found that with increased storage time in MAP attractiveness of colour decreased.

In SS, scores for CA and OAc decreased during ageing time with a higher rate for non-aged samples. Higher initial scores (on D0 and D4; P <0.05) were observed in CA and OAc for non-aged SS steaks compared to aged steaks, while no differences between treatments were observed at the end of storage. The high correlation between CA and OAc shows that colour is the most important factor influencing consumer acceptability of meat, for both muscles (r=0.77 for IS and 0.76 for SS, Table 5), and this relationship is well-documented in the literature (Grunert 1997; Killinger *et al.* 2004; Lawrence 2010). In studies performed on other muscles, Zakrys *et al*. (2009) and Zakrys-Waliwander *et al.* (2011) found that storage in MAP adversely affects meat flavour and overall acceptability and with time all samples became less acceptable for consumers.

Warner-Bratzler shear force and cooking loss

It has been previously shown that consumer ratings are consistent with the Warner-Bratzler shear force data and that values below 4.1 kg (40.2 N) will ensure consumer satisfaction (Huffman *et al.* 1996). However some authors found that

Table 4. *Means for the interaction of* time of storage in MAP x muscle x aging *sensory consumer evaluation of* M.infraspinatus *(IS) and* M.supraspinatus *(SS) steaks stored up to 12 days in MAP with or without previous aging in vacuum*

Days in MAP	Muscle	Aging time	Odour attractiveness	Odour intensity	Colour attractiveness	Overall acceptability
0	IS	7	5.9	3.8	7.6^{a}	7.5^{a}
4	IS	7	4.4	4.5	7.0^{a}	7.1^{a}
8	IS	7	5.1	3.2	6.4^{abc}	6.9^{ab}
12	IS	7	5.8	4.4	6.3^{bcd}	5.1^{bc}
0	IS	1	5.3	3.6	4.6^{d}	4.6^{c}
4	IS	1	4.9	4.2	6.0^{abcd}	5.2^{bc}
8	IS	1	5.1	3.9	6.0^{abcd}	5.3^{bc}
12	IS	1	5.8	4.4	6.6^{abc}	6.3^{abc}
0	SS	7	6.0	3.3	6.0^{abcd}	6.0^{abc}
4	SS	7	6.4	4.3	6.7^{abc}	7.2^{a}
8	SS	7	5.1	5.2	6.0^{abcd}	6.1^{abc}
12	SS	7	4.9	6.2	5.1^{cd}	5.2^{bc}
0	SS	1	6.0	3.0	7.5^{a}	7.5^{a}
4	SS	1	6.5	4.3	7.4^{ab}	6.8^{ab}
8	SS	1	6.3	5.2	6.6^{abc}	6.2^{abc}
12	SS	1	5.5	6.2	5.3^{abcd}	6.7^{ab}
HSD[A]			NS	NS	1.80	1.78
SEM[B]			0.106	0.120	0.098	0.100
F test for interaction					***	***
Significance of other interactions						
aging x muscle			NS	NS	***	***
time of storage in MAP x aging			***	***	**	***
time of storage in MAP x muscle			NS	NS	NS	NS

[a–d] ***mean values with different superscripts are significantly different***
[A] ***Honest significant difference***
[B] ***Standard error of mean***

consumer evaluation of toughness does not fully correspond with WBSF. There were significant differences in toughness assessed by consumers, while no differences in WBSF values were detected (Zakrys *et al.* 2009). A decrease in WBSF values, caused by aging is well documented (Wicklund *et al.* 2006; Lagerstedt *et al.* 2011). On the other hand it has been shown that storage in MAP containing more than 70% oxygen can negatively affect beef tenderness (Clausen *et al.* 2009; Lagestedt *et al.* 2011).

Table 5. *Correlation coefficients (r) between sensory traits and overall acceptability of* M.infraspinatus *(IS) and* M.supraspinatus *(SS) muscles.*

	M.Infraspinatus	*M.supraspinatus*
Odour attractiveness	0.51^{***}	0.45^{***}
Odour intensity	0.16^{*}	0.13^{*}
Colour attractiveness	0.77^{***}	0.76^{***}

As is shown in Table 3 susceptibility to tenderisation through aging was different for the two muscles. Differences between treatments were more visible for IS, however only on day 8 were differences statistically significant. The lowest WBSF values were observed on day 4 for both treatments, while the rate of WBSF increase during storage time was higher in non-aged samples. This resulted in significantly higher values in non-aged compared to aged IS on D8. In general, SS WBSF values were significantly lower than those of IS (Table 6). Clausen *et al*. (2009) reported that storage of beef in high-oxygen modified atmosphere can increase protein oxidation. Meat tenderisation which occurs *postmortem* is the result of enzyme systems degrading the myofibrillar structure (Campo *et al*. 2000), so delayed oxidation both of myofibrillar and enzyme proteins can result in increased tenderness of product. In the case of SS, significantly higher WBSF values were observed in non-aged samples at the end of MAP storage, while values for samples aged for 7 days remained generally constant through the whole MAP storage. Vitale *et al.* (2014) observed that aging for 8 or 14 days caused significantly increased tenderness of *M. longissimus thoracis et lumborum* from mature cows, while WBSF values of samples aged for 6 days were not different from samples stored in MAP without aging in vacuum. In addition, Lagerstedt *et al.* (2011) observed that steaks stored in vacuum and then repackaged to MAP represented higher WBSF values than those stored only in vacuum during the same time.

Table 6. *Mean values for water loss, WBSF and cooking loss of* M.infraspinatus *(IS) and* M.supraspinatus *(SS) steaks.*

Parameter	IS	SS	SEM[A]
Water loss [%]	1.85[a]	2.01[b]	0.024
WBSF [N]	32.39[a]	41.80[b]	0.164
Cooking loss [%]	27.00[a]	35.77[b]	0.150

[a–b] mean values with different superscripts are significantly different (p<0.05).
[A] Standard error of mean

Belew *et al.* (2003) showed that IS is the second most tender muscle and it is even more tender than *M. psoas major* (WBSF 2.29kg and 2.96kg, respectively). The same study evaluated WBSF of SS and results are quite similar to those obtained in the present study, showing that it is about 70% more tough than IS. However, this difference in toughness in the present study is lower (approx. 30%).

During thermal treatment meat can lose part of its mass due to purge of meat juice. About ninety percent of this juice is water, which determines technological yield of the cooking process and affects sensory acceptability related to juiciness and tenderness (Oiliic *et al.* 2011). In present study IS steaks showed lower cooking loss than SS steaks (P<0.05) representing a higher ability to retain water during cooking. Differences between cooking losses for treatments were observed on every measurement day with higher values for non-aged samples, however only on D12 were differences in cooking loss for IS significant. A similar trend was observed for SS, however the rate of cooking loss increase was less evident.

Conclusions

The major goal of this study was to determine whether ageing in vacuum for 7 days prior to MAP display would improve physical and sensory quality of IS and SS steaks stored up to 12 days. Colour attractiveness and overall acceptability can be positively influenced by ageing. No impact of short-term pre-aging in vacuum on meat odour and tenderness was observed, while some slight differences were noticable at the end of display in MAP with lower WBSF values for aged steaks. The general conclusion is that aging for 7 days prior to 12days display in MAP may not be sufficient to improve tenderness, however it may positively affect visual quality of meat. Thus, short-time aging may be convenient in retail display, where visual attributes are the most valuable for consumers, however it may not be adequate for foodservice, where tenderness plays the most important role in consumer perception.

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