60th International Congress of Meat Science and Technology, 17-22nd August 2014, Punta Del Este, Uruguay

OPTIMISING EATING QUALITY AND SHELF LIFE OF ENHANCED AND MARINATED PORK CHOPS USING THREE-GAS MAP

Mari Ann Tørngren[1*]
1 Department of Meat Quality, Danish Meat Research Institute, Taastrup, Denmark
*matn@dti.dk

Abstract – Fresh pork is packed in high oxygen modified atmosphere packaging (MAP) to preserve an attractive bloom colour on the surface of the meat and to extend the microbial shelf life. Unfortunately, the gas composition consisting of 70-80% oxygen (O_2) and 20-30% carbon dioxide (CO_2) results in less tender and less juicy meat with a more rancid flavour compared with wrapped or vacuum-packed pork. To establish whether three-gas MAP (O_2, CO_2 and N_2) with less oxygen, instead of two-gas MAP, would affect sensory attributes, shelf life and colour stability, enhanced and enhanced + marinated pork chops were packed in MAP with 0%, 40% or 80% O_2 and 20% or 40% CO_2 an N_2 as filler gas. However, it was not possible to optimise the eating quality and shelf life of enhanced pork chops without compromising the acceptance of the raw meat, as seen for fresh pork. By marinating enhanced pork chops, the acceptance limit was extended by two to seven days depending on the gas mixture, and differences in eating quality were equalised. It is recommended to pack enhanced pork chops and enhanced + marinated pork in an anoxic atmosphere (20% CO_2 + 80% N_2) to preserve the appearance, flavour and texture of the meat.

I. INTRODUCTION

Modified atmosphere packaging is widely used in the packaging of fresh and processed foods. Traditionally, red meat is packed in 70-80% oxygen (O_2) to obtain an attractive bloom colour and in 20-30% carbon dioxide (CO_2) to extend shelf life (Singh et al. 2011). Unfortunately, high oxygen MAP results in less tender and less juicy meat with a more rancid flavour and premature browning (PMB) of pork (Lund el al., 2007), beef (Tørngren, 2003, Lagerstedt, 2011, Kim et al. 2010) and chicken (Jongberg 2013). The reduction in eating quality is caused by oxidative changes of lipids and structural proteins (Lund el al., 2007, Jongberg 2011, Estevez, 2011).

The objective of this study was to investigate the effect of low oxygen three-gas MAP on shelf life and eating quality.

II. MATERIALS AND METHODS

Two retail meat products (1. Enhanced (brine-injected) loin chops, longissimus dorsi (LD), and 2. Enhanced (brine-injected) + marinated loin chops (LD)) were packed in five different gas compositions, stored at 5°C and analysed during storage.

For each cut, the experimental work was divided into two sub-trials – part 1: eating quality, and part 2: shelf life. For both sub-trials, all pigs were slaughtered on the same date. However, for Part 1 pigs were selected according to gender (female) and weight (79-87 kg), whereas random pigs were used for Part 2. The same slaughter process was used for both cuts: slaughtering on Monday, pH_{24}, cutting, deboning and injection (10% weight gain) on Tuesday, and slicing and MA-packing on Wednesday (day 0).

Table1. Experimental design

2 x cut	Enhanced pork chops (LD)		Enhanced, marinated pork chops (LD)		
5 x gas	-	40% O_2	40% O_2	40% O_2	80% O_2
	20% CO_2	20% CO_2	30% CO_2	40% CO_2	20% CO_2
	80% N_2	40% N_2	30% N_2	20% N_2	-

Packing: 3 x chops (20 mm) were MA-packed in five different gas compositions (Table 1) with a tray sealer (Multivac, T200, Denmark). Samples for Part 1 were stored for up to nine days at 5°C, and samples for Part 2 were stored for up to 13 days at 5°C.

Pigment: hemin (ppm) was measured spectro-photometrically at 640 nm.

Psychrotrophic count: samples (total surface) were diluted, surface-plated on PCA and incubated at 6.5°C for ten days.

Shelf life: shelf life was measured based on raw meat odour and colour and overall acceptance of bloomed and degassed meat 30 minutes after opening of the package using a 4-point scale, where 1 = no off-odour; 2 = slight off-odour, acceptable; 3 = off-odour, unacceptable; 4 = intense off-odour, unacceptable.

Sensory analysis: the meat was tempered at room temperature to 10-12°C and cooked on a frying pan at 170°C to a core temperature of 65-68°C. Samples were evaluated by eight trained assessors using a 15-point unstructured line scale anchored at the extremes (0 = low intensity and 15 = high intensity). The descriptive attributes were developed specifically for each meat product during training, with focus on flavour, texture, juiciness and appearance.

Statistical analysis: data were analysed using mixed models (SAS, 9.2, 2002-2008). The model included gas mixture interaction as fixed effects, and assessors, pig and interactions as random effects. Non-significant interactions were deleted from the model. Least squares (LSmeans) were calculated and separated using probability of difference. Levels of significance: $p > 0.05$ = non-significant (ns), $0.05 > p > 0.01$ = *, $0.01 > p > 0.001$ = **, $p < 0.0001$ = ***.

III. RESULTS AND DISCUSSION

Enhanced pork chops

Odour is the limiting factor for acceptance of MA-packed enhanced pork chops, regardless of the gas mixture (Table 2), although the meat will deteriorate at different times.

Table 2. Acceptance of enhanced pork (% acceptable samples/days for average score 2.5), MA-packed in different atmospheres ($O_2/CO_2/N_2$) stored for 6-7 days at 5°C (n=25).

	0/20/80	40/20/40	40/30/30	40/40/20	80/20/0
Day 2	100%	100%	100%	100%	100%
Day 5	84%	100%	100%	100%	100%
Day 7	0%	32%	84%	68%	92%
Day 9	0%	0%	0%	10%	50%
Day 13	0%	0%	0%	0%	4%
Colour limit	8 d	8-9 d	8-9 d	11 d	11 d
Odour limit	6 d	6-7 d	7-8 d	7-8 d	8-9 d

Odour limits for traditional MAP in 80% O_2 + 20% CO_2 and packing in 40% O_2 + 30-40% CO_2 are comparable. Fewer than 50% of the evaluated samples were unacceptable after approx. eight days of storage.

The appearance, texture and flavour of enhanced pork chops are affected by the gas mixture (Table 3). Packing of enhanced pork chops in 30-40% CO_2 increases the number of small holes in the cutting surface, although the level is generally very low.

Doneness is also affected by the gas mixture, and oxygen seems to be responsible for the changes, with doneness or PMB increasing in the following order: 0% O_2 < 40% O_2 < 80% O_2.

Texture is affected with respect to hardness of the first bite, which increases when packing in high oxygen MAP (80% O_2 + 20% CO_2) or in three-gas MAP with 40% O_2 + 30% CO_2 + 30% N_2 compared with MAP in 0-20% O_2 + 20% CO_2.

Rancid flavour and sour taste are related to the oxygen level in the pack and increase in the following order: 0% O_2 < 40% O_2 < 80% O_2. The significance level between gas 0/20/80 and gas 40/20/40 is as low as $p = 0.0619$, and between gas 40/40/20 and gas 80/20 $p = 0.0645$. These samples are therefore considered different.

Table 3. Sensory attributes (1-15) of enhanced pork chops, MA-packed in different atmospheres ($O_2/CO_2/N_2$) and stored for 6-7 days at 5°C (n=48)

	0/20/80	40/20/40	40/30/30	40/40/20	80/20/0	p
Small holes	0.5^{a}	0.6^{a}	1.1^{b}	0.9^{b}	0.6^{a}	**0.0017**
Doneness	7.0^{a}	8.5^{b}	8.7^{b}	8.8^{bc}	9.4^{c}	**< 0.0001**
Tenderness	8.3	8.2	7.6	7.8	7.5	Ns
Hardness	5.0^{a}	5.0^{a}	6.1^{c}	5.3^{ab}	5.8^{bc}	**0.0061**
Juiciness	7.9	7.6	7.2	6.9	7.6	Ns
Stale	2.9	4.0	4.1	4.1	4.5	Ns
Rancid	1.0^{a}	1.9^{ab}	1.7^{a}	1.8^{ab}	2.6^{b}	**0.0263**
Pork	5.3	4.7	4.6	4.5	4.5	Ns

Sour	1.7[a]	2.6[a]	2.5[a]	2.4[a]	3.6[b]	**0.0042**

In comparison with traditional MAP, two-gas MAP with an anoxic atmosphere (20% CO_2 + 80% N_2) optimises the appearance, texture and flavour of MA-packed enhanced pork (Table 3). Packing in three-gas MAP (40% O_2 + 40% CO_2 + 20% N_2) optimises appearance and flavour, but to a smaller degree.

In an earlier study by Tørngren et al. (2013), packing in three-gas MAP with 40% O_2 + 20% CO_2 + 40% N_2 was recommended for fresh pork chops. For enhanced pork, 40% CO_2 is needed to achieve an acceptable shelf life.

Enhanced + marinated pork chops

Odour is the limiting factor for acceptance of MA-packed enhanced + marinated pork chops (Table 4). In general, the marinade keeps the odour and the colour acceptable for longer compared with enhanced pork chops (Table 2), and the meat is perceived as acceptable for at least 13 days when packed in an anoxic atmosphere (20% CO_2 + 80% N_2).

Table 4. Acceptance of enhanced + marinated pork (% acceptable samples/days for average score 2.5), MA-packed in different atmospheres (O_2/CO_2/N_2) and stored for 6-7 days at 5°C (n=25).

	0/20/80	40/20/40	40/30/30	40/40/20	80/20/0
Day 2	100%	100%	100%	100%	100%
Day 5	100%	100%	100%	100%	100%
Day 7	100%	96%	100%	92%	100%
Day 9	72%	64%	80%	48%	92%
Day 13	100%	28%	52%	32%	56%
Colour limit	>13 d	>13 d	>13 d	>13 d	>13 d
Odour limit	>13 d	11 d	13 d	9 d	13 d

In contrast to enhanced pork (Table 3), only the appearance and flavour are affected by the MAP gas mixture, whereas texture remains unaffected when the marinade is added to the surface (Table 5).

With respect to appearance, the number of small holes increases when the gas mixture contains 40% CO_2 compared with 20% or 30% CO_2. Premature browning (PMB), measured by the attribute doneness, is reduced only when packing the meat in an anoxic atmosphere (20% CO_2 + 80% N_2).

Furthermore, the anoxic atmosphere decreases the stale flavour and increases the pork flavour of the meat.

The high level of acceptance of the enhanced + marinated pork chops could partly be due to the masking of the off-flavour and discolouration by the red and flavourful marinade. Nevertheless, colourful marinades can be a way to enhance consumer acceptance of meat packed in an anoxic atmosphere, as the red surface might look more attractive than the purple deoxymyglobin.

Table 5. Sensory attributes (1-15) of enhanced + marinated pork chops, MA-packed in different atmospheres (O_2/CO_2/N_2) and stored for 6-7 days at 5°C (n=48).

	0/20/80	40/20/40	40/30/30	40/40/20	80/20/0	p
Small holes	0.6[a]	0.7[a]	0.7[a]	1.1[b]	0.6[a]	**0.0202**
Doneness	5.9[a]	7.4[b]	8.3[b]	8.3[b]	8.1[b]	**0.0002**
Tenderness	9.0	8.3	8.3	8.1	8.7	Ns
Hardness	4.7	5.3	5.2	5.6	5.3	NS
Juiciness	7.7	7.7	7.6	8.1	8.2	Ns
Stale	1.8[a]	3.6[b]	3.6[b]	2.8[ab]	3.0[b]	**0.0136**
Rancid	0.4	1.1	1.2	0.7	0.9	Ns
Fried pork	3.0[b]	2.5[a]	2.5[a]	2.8[ab]	2.6[a]	**0.0357**
Sour	1.2	2.5	2.3	2.1	2.4	Ns

IV. CONCLUSION

Enhanced pork should be MA-packed in a two-gas anoxic atmosphere (20% CO_2 + 80% N_2) to optimise the appearance, flavour and texture of the meat. Unfortunately, it will shorten the shelf life by approx. two days at 5°C.

To maintain a shelf life comparable to high oxygen MAP, it is recommended to pack in a three-gas MAP (40% O_2 + 40% CO_2 + 20% N_2), although this gas mixture will optimise only appearance and flavour, and to a smaller degree.

It is recommended to MA-pack enhanced + marinated pork chops in an anoxic atmosphere (20% CO_2 + 80% N_2), since shelf life remains uncompromised, and appearance and flavour are optimised.

ACKNOWLEDGEMENTS

The author thanks the technicians at the Danish Meat Research Institute (DMRI), Roskilde, Denmark.

This work was financed by the Danish Pig Levy Fund, Nortura and HK Scan.

REFERENCES

1. Estévez, M. (2011). Protein carbonyls in meat systems: A review. Meat Science 89:259-279.
2. Lagerstedt, Å., Lundstrøm, K., & Lindahl, G. (2011). Influence of vacuum or high-oxygen modified atmosphere packaging on quality of beef M. longissimus dorsi steaks after different ageing times. Meat Science 87:101-106.
3. Lund, M. N., Lametsch, R., Hviid, M. S., Jensen, O. N., and Skibsted, L. H. (2007). High-oxygen packaging atmosphere influences protein oxidation and tenderness of porcine longissimus dorsi during chill storage. Meat Science 77:295-303.
4. Jongberg, S, Skov, S. H, Tørngren, M.A., Skibsted, L. H. and Lund, M. L. (2011). Effect of white grape extract and modified atmosphere packaging on lipid and protein oxidation in chill stored beef patties. Food Chemistry 218, 276-283.
5. Jongberg et al (2014). Effect of high-oxygen atmosphere packaging on oxidative stability and sensory quality of two chicken muscles during chill storage. Food Packaging and Shelf Life 1, 39-48.
6. Kim,Y.H. Huff-Lonergan,E., Sebranek, J.G., and Lonergan, S.M. 2010. High-oxygen modified atmosphere packaging system induces lipid and myoglobin oxidation and protein polymerization. Meat Science 85:759-767.
7. Singh, P., Wani, A., and Saengerlaub S. (2011). Understanding critical factors for the quality and shelf-life of MAP fresh meat. A review. Critical Reviews in Food Science and Nutrition 51:146-177.
8. Tørngren, M. A. (2003). Effect of packing method on colour and eating quality of beef loin steaks. 49th International 49th International Congress of Meat Science and Technology. Brazil, September. 495-496.
9. Tørngren, M. A., Darré, M. T. & Kristensen, L. (2013). Optimising the eating quality and shelf life of retail pork cuts using muscle-specific three-gas MA-packaging, 59th International Congress of Meat Science and Technology, Izmir, Turkey.