EFFECT OF PACKING METHOD ON COLOUR AND EATING QUALITY OF BEEF LOIN STEAKS.

Mari Ann Tørngren , Danish Meat Research Institute, Roskilde, Denmark (e-mail: mat@danishmeat.dk)

Background

For tenderising of fresh beef (ageing) primal cuts are usually stored anaerobically in vacuum bags at low temperatures. Subsequently fabrication of retail cuts and re-packaging to an oxygen-containing atmosphere are carried out in retail stores (air) or at centralised packaging factories in modified atmosphere (MA, usually in 70-80% O_2). Re-packing will allow the meat to bloom – and obtain the attractive red colour, but will also limit the shelf life and may cause a quality reduction in the course of a few days on retail display. This study examines the ability of different packaging methods to maintain good eating quality, prolong shelf life and eliminate re-packing.

Keywords: beef, colour, sensory, eating quality, modified atmosphere, high oxygen

Objectives

To examine the influence of different packaging methods on surface colour, sensory properties, and micro flora of beef loin steaks stored at 2°C for 16 days during ageing and 5°C for 2 days during retail display. Furthermore to evaluate the possibility of eliminating re-packing by ageing the beef cuts in the display packaging.

Material and Methods

Source of meat

Six animals (4 cows and 2 heifers) of the best Danish Friesian, Red Danish and Crossbreds approx. 2-4 years old, carcass weight (247-515 kg) were slaughtered at a Danish slaughterhouse, low voltage electrically-stimulated and chilled so no part of the carcass reached < 10°C in the course of 12 hours after stunning. The carcasses were selected according to pH (5.5-5.6) and stored at 2°C for 2 days before boning. *Longissimus dorsi* (LD) were then excised from each carcass half and separated for different packaging methods, Table 1.

Table 1. Package types and gas composition in headspace during ageing and display

Ageing conditions (2°C for 16 days)			Display conditions (5°C for 2 days)			Abbreviation
Cut	*Package type*	*Headspace*	*Cut*	*Package type*	*Headspace*	
loin	vacuum	none	steaks	wrap (PE)	air	Vac + PE
loin	vacuum	none	steaks	MA	80% O_2/ 20% O_2	Vac + MA_{O2}
steaks	MA	50% CO_2/ 50% N_2	steaks	wrap (PE)	air	$MA_{CO2/N2}$ + PE
steaks	MA	80% O_2/ 20% CO_2	steaks	MA	80% O_2/ 20% O_2	MA_{O2} + MA_{O2}

Air capacity: approx. 79% N_2, app. 21% O_2

Packaging and storage conditions

Left LDs were packed in vacuum bags (max. O_2 permeability: 30-44 cm^3/m^2/ x d x bar, NEMCO emballage A/S, Denmark) in a Multivac R7000 (5 mbar vacuum) and aged for 16 days at 2°C. After 16 days of vacuum ageing, left side loins were cut in two for display in aerobic conditions. Eight steaks 25 mm thick were cut from each half LD and placed in plastic trays. Half the trays were wrapped in a high O_2 permeable film (PE) and the other half were MA-packed at a commercial meat packaging plant (80%O_2/20%CO_2) using a CRYOVAC BDF packing machine. All retail packages were placed in display conditions for 2 days at 5°C and in light surroundings (1110-1249 lux). *Randomisation:* Half the loins were randomised before cutting and display, and steaks were randomised before colour measurements and sensory analyses.

Right LDs were cut in two for ageing, respectively in anaerobic MA (50% CO_2 and 50% N_2) and aerobic MA (80% O_2 and 20% CO_2). One steak from the middle of each LD was used for microbiological evaluation. Eight steaks 25mm thick were cut from each half and placed in plastic trays (non-transparent 4.5 x 15 x 20.5 cm, 78-50A FÆRCH Plast, Denmark). For aerobic MA, the trays were packed at a commercial plant in 80% O_2 and 20% CO_2 in a CRYOVAC BDF packing machine. For anaerobic MA the trays were wrapped in a high O_2 permeable film placed in a mother pack of low O_2 permeability (OTR: 40-45 cm^2/m^2/24h/23°C / 85% RH, 300x400 PA/PE 20/70, Waltenhofen, Germany). The mother pack contained one O_2 scavenger (GM-20, Ageless Mitsubishi Gas Chem. Co, Inc. Tokyo, Japan), and was filled with a gas atmosphere consisting of 50% CO_2 /50% N_2 and sealed using a Multivac A300/16 packing machine (100mbar vacuum, 750mbar filling). The steaks were subsequently aged for 16 days at 2°C. After ageing the mother pack was removed and the steaks were exposed to air through O_2 permeable film. All retail packages were moved to display conditions for 2 days at 5°C in light surroundings (1110-1249 lux). *Randomisation*: Half the loins were randomised before cutting and ageing and steaks were randomised before colour measurements and sensory analyses.

Analysis

Microbiological evaluations*:* Samples for initial microbiological characterisation were taken from the right LDs in connection with cutting steaks for MA packing and consisted of the following tests: total aerobic count (PCA, 20°C, 5 days), *Pseudomonas* sp. (CFC, 20°C, 5 days), lactic acid bacteria (ATP, 20°C, 5 days).

Surface colour: was measured with Minolta CR300 on the meat surface after blooming of the red colour (approx. 1½ h after exposure to oxygen) and 2 days at display conditions.

Cooking and sensory evaluation: Steaks equilibrated after storage at room temperature (approx. 20°C) to an internal temperature (T_i) of max. 15°C prior to cooking on a preheated frying-pan (155°C) turned every 2 minutes until an internal temperature of 63° had been reached. Steaks were cut and served in pieces of 2½ x 3 cm. Samples were evaluated by 8 trained assessors using a 15-point non-structured line anchored at the extremes (0=slight and 15= intense). The attributes were tenderness, juiciness, odour (meat-odour, off-odour), doneness (internal colour) and flavour (meat taste, Warmed Over Flavour (WOF), off-flavour)

Statistics

Data were analysed in an analysis of variance model (mixed procedure, SAS). Fixed effects in the model were main effects: packaging method and display time.

Sensory data: $Y_{ijk} = \mu + \text{package type}_i \text{ (fixed)} + \text{meat}_j \text{ (random)} + \text{package type*meat}_{ij} + \text{assessors}_k \text{ (random)} + e_{jk}$
Colour (a^*): $Y_{ijk} = \mu + \text{package type}_{i\ i} \text{ (fixed)} + \text{display time}_j \text{ (fixed)} + \text{package type}_i\text{*display time}_{ij} + \text{meat}_k \text{ (random)} + e_{jk}$

Results and Discussion

Microbiological evaluations

The beef loin presented higher initial counts than expected for total aerobic count (log 4.1-4.8 CFU/g) and *Pseudomonas* sp. (4.4-4.8 CFU/g) and the counts for lactic acid bacteria were 2.9-3.7 CFU/g. The micro flora was dominated by pseudomonads, which causes aerobic spoilage of meat at chill temperatures.

Surface colour

Significant differences in a^* values were detected between package method ($p>0.05$). Generally, ageing in vacuum resulted in higher a^*-values than ageing in MA, Table 2. Anaerobic modified atmosphere (50% CO_2 and 50% N_2) resulted in a^*-values significantly lower than that of all other package types and with a visual discolouration (brown-grey) of the surface. The discolouration may be a result of low O_2 concentrations (<1%) in package headspace which causes a rapid surface discolouration (Ledward, 1985).

Table 2. Surface colour (a^*-value) and sensory evaluation of odour, flavour, texture and doneness of cooked loin steak (T_i = 63°C, n=6), by 8 trained assessors using a non-structured line scale, anchored to the extremes (0=slight, 15=intense). Different letters in same row are significant different ($p \leq 0,05$).

Properties		Vac + PE	Vac + MA_{O2}	$MA_{CO2/N2}$ + PE	MA_{O2} + MA_{O2}
a^*-value	After ageing	27.5^c	28.1^c	12.5^a	21.2^b
	After display	24.3^c	25.4^c	14.4^a	20.3^b
Odour	Meat-odour	8.7^c	7.7^b	8.7^c	6.5^a
	Off-odour	0.1^a	0.4^a	0.5^a	2.3^b
Flavour	Meat-flavour	8.4^c	7.7^b	8.4^c	6.1^a
	Off-flavour	0.5^a	0.9^a	0.8^a	2.9^b
	WOF	0.1^a	1.1^b	0.2^a	5.4^c
Texture	Tenderness	9.3^c	7.6^b	8.5^c	6.5^a
	Juiciness	9.4^b	9.8^b	10.1^b	8.7^a
Doneness	Internal colour	7.0^a	11.3^b	6.4^a	13.4^c

Sensory evaluation

Meat odour decreased while off-odour increased in relation to the duration of storage in high O_2 concentration (Table 2). Likewise evaluation scores for flavour parameters showed decreasing scores in meat flavour and increasing scores in WOF and off-flavour related to the duration of storage in 80% O_2.

Tenderness and juiciness had significantly lower scores when stored in 80% O_2 as compared with anaerobic ageing and display in wrapped trays. The appearance of the internal surface of cooked steaks was highly affected by package type. Oxygen-containing atmosphere during ageing and display resulted in a very well-done appearance, and 80% oxygen in headspace during display resulted likewise in a well-done appearance with only a little rose colour in the centre of the steak. No significant differences were detected on internal colour between steaks stored in Vac + PE and $MA_{CO2/N2}$ + PE.

The differences in doneness related to package type may be explained by the phenomenon "premature browning" (PMB) resulting in well-done appearance at much lower temperatures than expected. In ground beef patties PMB was related to the oxidative state of the pigment (Warren *et al.*, 1996), and was detected when the pigment existed as oxymyoglobin and metmyoglobin and resulted in brown colour already at 55°C (Hunt *et al.*, 1999). In this study steaks stored in 80% oxygen appeared well-done when not expected. This observation may be related to PMB, because of oxygenation of the myoglobin throughout the steaks.

Conclusion

Storage in modified atmosphere with high content of oxygen (ageing or/and display) and Vac + PE resulted in a satisfactory appearance of the surface colour. Anaerobic ageing in modified atmosphere (CO_2/N_2) resulted in discoloured surface of the meat, probably because of the presence of residual O_2 in the headspace.

Sensory evaluation of internal colour after cooking was related to package type. Anaerobic ageing (vacuum/$MA_{CO2/N2}$) resulted in a satisfactory rose colour, while storage in 80% O_2 resulted in a well-done appearance.

Ageing of steaks in anaerobic modified atmosphere ($MA_{CO2/N2}$) resulted in sensory- and microbial quality corresponding to the traditionally ageing of wholesale cuts in vacuum. This package type however needs further developing because of the problems with surface discolouration. Surprisingly, storage of steaks in high oxygen (80%) resulted in poorer eating quality with respect to colour, tenderness, juiciness, flavour and odour. Storage in high oxygen during both ageing and display resulted in the quality becoming even poorer.

Perspective

These conclusions have to be considered with some reservations because of the small number of animals applied. Furthermore the high initial microbiological counts of pseudomonads may have an impact on the sensory quality, because of the differences of bacterial metabolism. Therefore, further work is in progress to verify the results of this study and to definitively establish the conclusions.

Acknowledgements

This study was supported by the Innovations law, The Danish Livestock and Meat Board and Swedish Meats.

References

Hunt, M. C., Sørheim, O. & Slinde, E. (1999). Colour and heat denaturation of myoglobin forms in ground beef. Journal of Food Science, 64 (5), 847-851.

Ledward, D. A. (1985). Post-slaughter influences on the formation of metmyoglobin in beef muscles. Meat Science, 15, 149-171.

Warren, K. E., Hunt, M. C., Kropf, D. H., Hague, M. A., Walder, C. L., Stroda, S. L. & Kastner, C. L. (1996). Chemical properties of ground beef patties exhibiting normal and premature brown internal cooked color. Journal of Muscle Foods, 7, 303-314.