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EFFECTS OF VACUUM STORAGE AND SUBSEQUENT DISPLAY ON SENSORY AND MICROBIOLOGICAL QUALITY OF FOUR BEEF MUSCLES

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This research was partly financed by the Product Boards for Livestock, Meat and Eggs

Background

During ageing, a gradual improvement in meat tenderness and water-holding capacity is generally observed whereas colour stability and microbiological quality are negatively affected. The influence of ageing has been extensively studied on meat sensory properties (Ouali, 1990; Smulders *et al.*, 1991) and microbiological quality (Lambert *et al.*, 1991; Sofos, 1994). However, the combined effects of different vacuum and display storage times on both sensory and microbiological characteristics were not systematically evaluated in the previously mentioned studies. As a consequence, comparison of results from the literature is difficult due to the different processing, sampling and packaging conditions, storage temperature and muscles used to study the effect of ageing on meat quality parameters.

Objectives

The objective of this study was to investigate changes in shear force, water-holding capacity, colour stability and microbiological quality of 4 beef muscles during display, following different vacuum storage periods.

Methods

From 30 Belgian Blue bulls (age 1.5 years) slaughtered at a commercial plant, 12 carcasses (mean carcass weight 386 kg) were selected on the basis of average conformation and fat cover scores (EUROP classification). pH and temperature (T,°C) values in the *longissimus lumborum* were: $pH_{3\,h}$ 5.90 ± 0.12 and $T_{3\,h}$ 29.3 ± 1.2 and $pH_{48\,h}$ 5.43 ± 0.03 and $T_{48\,h}$ 3.0 ± 0.4.

At 62 hours p.m., *Mm longissimus* (LO), *semimembranosus* (SM), *triceps brachii* (TB) and *supraspinatus* (SS) were excised, divided in 4 parts and vacuum packaged. One part of each muscle was randomly assigned to a 1, 3, 7 or 14 day-ageing period (0-2 °C). At the end of each vacuum storage period, packages (± 1 kg) were opened and muscles were cut into steaks (± 250 g and ± 150 g for sensory and microbiological analyses, respectively). The steaks were repackaged in individual polystyrene trays, overwrapped with oxygen-permeable (PVDC) film and displayed under continuous illumination at 4 °C for 7 d.

Meat quality parameters: At the beginning (d 0) and at the end of the display period (d 7) Warner Bratzler shear force (SF) was assessed on samples heated in polyethylene bags in a waterbath at 70°C for 1 h. Ten rectangular samples of 1 cm^2 cross section, parallel to the muscle fibre direction were prepared for SF measurements. Drip loss was assessed after each vacuum storage period and after 7 d of display. Drip loss percentage was determined as weight loss relative to the initial weight. Muscle surface colour was measured with a Minolta Chroma Meter (L*, a* and b* values). Colour stability was determined by repeating the measurements during display (at 0, 1, 3 and 7 d).

Microbiological analysis: At 1, 3, 7 and 14 d of vacuum storage and at 0, 3 and 7 d of display, steaks were sampled according to a destructive method described by Snijders and Gerats (1977). Muscle surface samples (3 x 5 cm^2) were taken for the enumeration of 4 groups of meat spoilage micro-organisms: lactic acid bacteria (MRS; pH 5.7; spread plates; anaerobically incubated for 4 d at 25 °C), *Pseudomonas spp.* (*Pseudomonas* Agar Base with CFC supplement; spread plates; incubated for 3 d at 20 °C), psychrotrophic (APHA; spread plates; incubated for 4 d at 20 °C) and Gram negative bacteria (Olson agar; spread plates; incubated for 3 d at 20 °C).

Statistical analysis: Data were analysed with an analysis of variance model (GLM procedure, SPSS 7.0). Fixed effects in the model were main effects: vacuum storage time, display time, muscle and their interactions. Tukey's honestly significant difference-test was used to separate means.

Results and Discussion

As the main effects and their interactions had significant effects ($P < 0.05$) on meat quality traits and microbiological counts, overall conclusions could not be drawn and data were further analysed separately. Conclusions were only drawn from comparisons made between different storage periods (vacuum or display) per muscle or between different muscles per storage period.

The relatively low initial SF values (Table 1) obtained in this experiment might be attributed to the quite extended time muscles were left on the carcasses. The beneficial effect of a delayed boning (e.g. 48 hours p.m. vs 24 hours p.m.) on tenderness has already been described for beef (Butcher, 1972). The decrease in SF values was more pronounced under display (4°C) than under vacuum storage (0-2°C) conditions. This result is likely explained by a temperature effect, higher storage temperatures are promoting a higher ageing rate. Short storage times including 7 d of display were more beneficial for the decrease in SF values than longer vacuum storage times without display.

During the vacuum storage period, drip loss significantly increased and the rate of drip production decreased (Table 2). Red muscles (SS and TB) had significantly lower drip loss than white muscles (LO and SM). However, after an extended vacuum storage period followed by 7 d of display, differences between muscles disappeared. Drip loss during display (Table 3) was higher than under vacuum storage (Table 2). O'Keeffe and Hood (1980-81) reported that a rise in storage temperature from 0 to 10 °C causes an appreciable increase in drip loss from beef steaks. The combined effects of an extended storage under vacuum and a higher storage temperature during display improved the water-holding capacity of the meat by reducing the rate of drip production (Table 3).

Den Hertog-Meischke *et al.* (1998) suggested that the effect of storage temperature on the total loss of drip at a fixed storage time may be determined by the effect of drip viscosity and the coinciding improvement of WHC induced by ageing at higher temperatures. In our experiment, and especially for the SM muscle for which the extent of vacuum storage did not significantly affect SF values, an ageing effect has been observed during display. It is therefore tempting to speculate that the positive effect of storage under display on drip loss of the SM muscle was due to a higher ageing rate.

The colour coordinates (L*, a* and b* values) were valuable tools to detect changes in colour occuring during storage (results not shown). However, the main differences between muscles were detected with the a* value, indicating the degree of meat redness. White muscles were more colour stable than red muscles. During display, the colour shelf-life, determined in the present experiment by a significant decrease in meat redness, was found to be lower for the SS muscle (1 d) than the TB and SM muscles (3 d) and the LO muscle (3 to 7 d). Colour can be negatively affected by a high bacterial number. An amount of bacteria above 10^6 CFU/cm^2 have been shown to influence significantly colour (Satterlee and Hansmeyer, 1974). According to our microbiological results (results not shown), such levels were reached for the SS and TB muscles at 7 d of display.These results suggest that the bacterial contamination probably had no significant effect on the discoloration rate of the meat.

Significant growth of the 4 groups of micro-organisms studied was not observed during the first 7 d of vacuum storage. However, slight increases of the numbers of CFU were observed between 7 and 14 d. Steaks stored for 1, 3 and 7 d under vacuum did not reach during display the generally for beef recognised spoilage level of 10^7 CFU/cm^2 (Gill and Jones, 1994). The highest levels were recorded on the SS muscle under vacuum storage (d14) and during display. It is not clear whether a specific muscle effect (Boers, 1992) or an unknown effect inherent to the slaughtering and excision operational procedures of the commercial meat plant was involved. Overall, a pre-display vacuum period with a duration of 3 d showed the best results with respect to the microbiological quality during subsequent retail display, which is in agreement with the literature (Bell et al., 1996; Greer and Jones, 1991).

Conclusions

Our study emphasizes the fact that meat quality attributes depend on the muscle type and the extent of the storage period under vacuum and display. An acceptable meat quality may be obtained using a standard storage period applied to different muscles. However, an optimal consumption time should be formulated per muscle and processing conditions.

References

Bell *et al.* (1996) Meat Sci., 42, 165. **Boers R.H.** (1992) PhD thesis, Utrecht University, NL. **Butcher L.** (1972) Proc.Meat Res.Inst.Symp., no 2, Pp 4.51. **den Hertog-Meischke** *et al.*(1998) J. Sci. Food Agric., 78, 522. **Gill C.O. and Jones T.** (1994) Meat Sci., 38, 385. **Greer and Jones** (1991) Can. Inst. Sci. Technol. J., 24, 161. **Lambert** *et al.* (1991) Food Microbiol., 8, 267. **O'Keeffe M. and Hood D.E.** (1980-81) Meat Sci.,5, 267. **Ouali A.** (1990) J. Muscle Foods, 1, 129. **Satterlee D.L. and Hansmeyer M.** (1974) Food Technol., 39, 305. **Smulders** *et al.* (1991) In: The European meat industry in the 1990's. Smulders (Ed.), 121. **Snijders J.M.A. and Gerats G.E.** (1977) Fleischwirtschaft 57, 2216. **Sofos J.N.** (1994) Adv. Meat Res., 9, 359.

Table 1: Shear force values (kg/cm^2) during display, following 1, 3, 7 and 14 d of vacuum storage. Means and standard deviations (n= 12).

After 1,3, 7 and 14 days of vacuum storage		display (days)			
		0		7	
Muscle		mean	SD	mean	SD
SM	V1	**4.46**^{b}	0.6	**3.91**^{a}	0.6
	V3	**4.71**^{a}	0.5	**4.28**^{a}	0.7
	V7	**4.48**^{a}	0.9	**4.29**^{a}	0.6
	V14	**4.52**^{a}	0.6	**4.29**^{a}	0.5
TB	V1	**4.96**^{b}	0.5	**3.74**^{a}	0.3
	V3	**4.55**^{a}	0.6	**4.19**^{a}	0.5
	V7	**4.34**^{a}	0.6	**4.64**^{a}	0.5
	V14	**4.25**^{a}	0.5	**4.05**^{a}	0.5
LO	V1	**4.64**^{b}	1.8	**3.24**^{a}	0.6
	V3	**4.08**^{b}	0.6	**3.19**^{a}	0.5
	V7	**3.59**^{b}	0.9	**2.94**^{a}	0.3
	V14	**3.20**^{a}	0.4	**3.04**^{a}	0.5
SS	V1	**5.56**^{b}	0.4	**4.77**^{a}	0.4
	V3	**5.05**^{a}	0.5	**4.88**^{a}	0.3
	V7	**5.28**^{b}	0.5	**4.88**^{a}	0.3
	V14	**5.08**^{b}	0.5	**4.49**^{a}	0.5

^{a,b} within rows, means with superscripts not containing a common letter differ significantly (P<0.05).

Table 2: Drip loss (%) during vacuum storage. Means and standard deviations (n=12).

	Vacuum storage period (days)							
	1		3		7		14	
DL (%)	mean	SD	mean	SD	mean	SD	mean	SD
SM	**1.02**^{a}	0.4	**1.94**^{b}	0.4	**2.61**^{c}	0.5	**3.47**^{d}	0.8
TB	**0.42**^{a}	0.2	**0.84**^{a,b}	0.4	**1.33**^{b,c}	0.5	**1.45**^{c}	0.7
LO	**0.63**^{a}	0.3	**1.25**^{b}	0.3	**1.83**^{c}	0.4	**2.24**^{c}	0.6
SS	**0.23**^{a}	0.2	**0.42**^{a}	0.1	**0.67**^{a,b}	0.4	**0.97**^{b}	0.9

^{a,b,c,d} within rows, means with superscripts not containing a common letter differ significantly (P<0.05)

Table 3: Drip loss (%) during display (7 d) following 1, 3, 7 and 14 d of vacuum storage.

	pre-retail vacuum storage period (days)							
	1		3		7		14	
DL, display d0-7 (%)	mean	SD	mean	SD	mean	SD	mean	SD
SM	**3.11**^{b}	0.4	**3.18**^{b}	0.6	**2.86**^{a,b}	0.5	**2.29**^{a}	0.6
TB	**1.78**^{a}	0.3	**1.61**^{a}	0.5	**2.36**^{a}	1.2	**2.14**^{a}	0.5
LO	**2.41**^{a}	0.6	**3.08**^{b}	0.5	**3.05**^{b}	0.6	**2.27**^{a}	0.4
SS	**1.99**^{a}	0.3	**2.21**^{a}	0.5	**2.40**^{a}	0.4	**2.03**^{a}	0.5

^{a,b} within rows, means with superscripts not containing a common letter differ significantly (P<0.05)