THE EFFECT OF STORAGE ON THE OXYGEN CONSUMPTION RATE OF BOVINE M. *LONGISSIMUS DORSI* AND M. *PSOAS MAJOR*

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Background

Colour is the most important factor determining acceptability of beef steaks. Consumers associate a bright cherry red colour with quality. The *longissimus dorsi* (LD) and *psoas major* (PM) muscles exhibit very different colour stabilities. The LD is considered to be a colour stable muscle with a colour shelf life of 4 - 5 days, while the PM has a colour shelf life of 1 - 1.5 days and is thus regarded as being very colour unstable (O'Keeffe and Hood, 1982; Isdell *et al.,* 1999). The oxygen consumption rate (OCR) influences colour stability by altering the depth at which the metmyoglobin (brown) layer forms. When the OCR is high, oxygen does not penetrate far into the meat, the metmyoglobin layer that forms at the limit of penetration will be near the surface, and colour deteriorates rapidly as this thickens and reaches the surface (Madhavi and Carpenter, 1993).

Objectives

The objective was to determine if time post mortem has an affect on the OCR of bovine LD and PM muscles. A secondary objective was to determine whether the OCR is affected by anatomical location within the muscle and whether there is variability within individual steaks.

Materials and methods

M. *longissimus dorsi* and M. *psoas major* (n=6) (pH 5.4 - 5.8) were excised from steers (≤ 36 months) at 48h post mortem at a commercial meat plant (Kepak Group, Clonee, Ireland). A steak (20 - 25mm thick) was cut from three areas of each muscle – posterior, centre and anterior to account for variability within muscle. The steaks were then placed in laminated retail polystyrene trays (Linpac 2-37 EPS) and overwrapped with a high oxygen permeable film (OTR: 20,000cm^3 m^{-2} $24hr^{-1}$ atm^{-1}). All steaks were stored in a cooled incubator (LMS, Davidson & Hardy Ltd, Ireland) at 4 ± 0.5ºC for 2 hours in the dark to allow them to bloom. The remaining portion of each muscle was vacuum packed (20/70 PA/PE; OTR: 40-50cm^3 m^{-2} $24hr^{-1}$ atm^{-1} at 23ºC, 75% RH) and stored at 0 ± 0.5ºC in a coldroom until 4, 7, 14 and 21 days post mortem. The temperature in the coldroom and incubator was recorded every 5 minutes using a Tinyview temperature logger (Gemini Data Loggers (UK) Ltd, Chichester, UK).

Bloomed steaks were vacuum packed (20/70 PA/PE; OTR: 40-50cm^3 m^{-2} $24hr^{-1}$ atm^{-1} at 23ºC, 75% RH). To account for any variability within the steaks, circles (3 for the LD and 2 for the PM) were marked on each pack and labelled 'a', 'b' and 'c' so that colour readings during storage could be taken at the same places. Reflectance spectra (360-750nm at 10nm intervals) were taken after 0, 10, 20, 30, 40, 50, 60 minutes in a vacuum pack using a HunterLab UltraScan™ XE spectrophotometer (Hunter Associates Laboratory, Inc. Reston, USA). During this time the samples were held in the incubator at 4 ± 1ºC in the dark, except while reflectance measurements were being taken. Reflectance values were used to determine the proportions of the three colour pigments (oxymyoglobin, myoglobin and metmyoglobin) present, using the method described by Kryzwicki (1979). Reflectance values at wavelengths not given by the instrument (473, 525 and 572nm) were calculated using linear interpolation. The OCR was determined by following the pigment changes that occur since oxygen, present as oxymyoglobin would be converted to myoglobin or metmyoglobin after vacuum packaging (Madhavi and Carpenter, 1993). The OCR was expressed as 'oxymyoglobin converted to myoglobin after 10 minutes in vacuum'.

Statistical analysis

At each storage time the effects of anatomical location and within steak location on the percentage of each form of myoglobin and on the OCR were tested using a tow-way ANOVA using SYSTAT (Systat Inc. Illinois, USA). For OCR, the difference between the two muscles was tested in a one-way ANOVA.

Results and discussion

There was no significant difference in oxygen consumption rate as a result of positional effects within the muscle or within the steak for the LD at each time post mortem. This is in agreement with Young, Priolo, Simmons and West (1999) who found no significant positional effects for bovine LD pieces. There was no significant difference within the PM steak ('a' and 'b'). However on days 7, 14 and 21 the posterior section was more susceptible to metmyoglobin formation than the centre and anterior sections ($P<0.01$).

The initial oxymyoglobin concentration increased with time post mortem from 58% to 66% on days 2 and 21 respectively. This trend was reflected in a decrease in the % myoglobin from 20% on day 2 to 14 % on day 21. The initial percentage metmyoglobin was consistent with respect to storage time at 20-22%. This increase in the % oxymyoglobin and decrease in the % myoglobin during storage would be expected to reflect a decline in the OCR of the LD with time post mortem.

The rate of conversion of oxymyoglobin to myoglobin for the LD was highest on day 2 post mortem, intermediate on days 4 and 7 and almost non-existant on days 14 and 21 post mortem (Figure 1). Oxymyoglobin was converted mainly to myoglobin and to a lesser extent to metmyoglobin on days 2, 4 and 7 post mortem. The metmyoglobin concentration remained constant on days 14 and 21, with a slight decline in oxymyoglobin and increase in myoglobin. This suggests that LD steaks are more susceptible to metmyoglobin formation in the first days post mortem.

PM oxymyoglobin concentration varied between 55% (day 2) and 66% (day 21) and decreased rapidly with time in vacuum at all days post mortem, the rate of decline being highest at day 2. As in the LD, storage time had no effect on the initial % metmyoglobin, but the % myoglobin ranged from 12% at days 7, 14 and 21 to 23% at day 2 post mortem. A concurrent increase in the myoglobin concentration occurred at each storage interval. Unlike the LD, the metmyoglobin concentration increased with time in vacuum for all storage times, indicating that the PM is susceptible to metmyoglobin formation up to 21 days post mortem.

The OCR of both muscles decreased with time post mortem (Figure 2), however there were differences between the muscles at each storage time. PM had a higher OCR than the LD at all times post mortem ($P<0.01$). The OCR of the LD was almost completely exhausted by day 7. The OCR has a direct influence on the colour stability of a muscle through its effect on the penetration depth of the oxygen; therefore the findings here are in agreement with O'Keeffe and Hood (1982) who found that the PM is the most colour unstable, has a high OCR and a colour shelf-life significantly shorter than that of any other muscle. On the other hand they found that the LD was the most colour stable. Madhavi and Carpenter (1993), when comparing the biochemical characteristics of LD and PM discovered that PM had a significantly higher OCR and lower NAD ($P<0.05$) than LD steaks up to day 7 post mortem. However, on days 14 and 21 they did not detect a significant difference between the LD and PM, which is not in agreement with the present work.

Conclusions

The OCR of the PM is higher than that of the LD, with the PM continuing to have an active OCR up to 21 days post mortem. The OCR of both the LD and PM stabilised from 7 days post mortem onwards. From this it can be concluded that the optimum storage time prior to anoxic packaging of beef steaks is on or after 7 days post mortem.

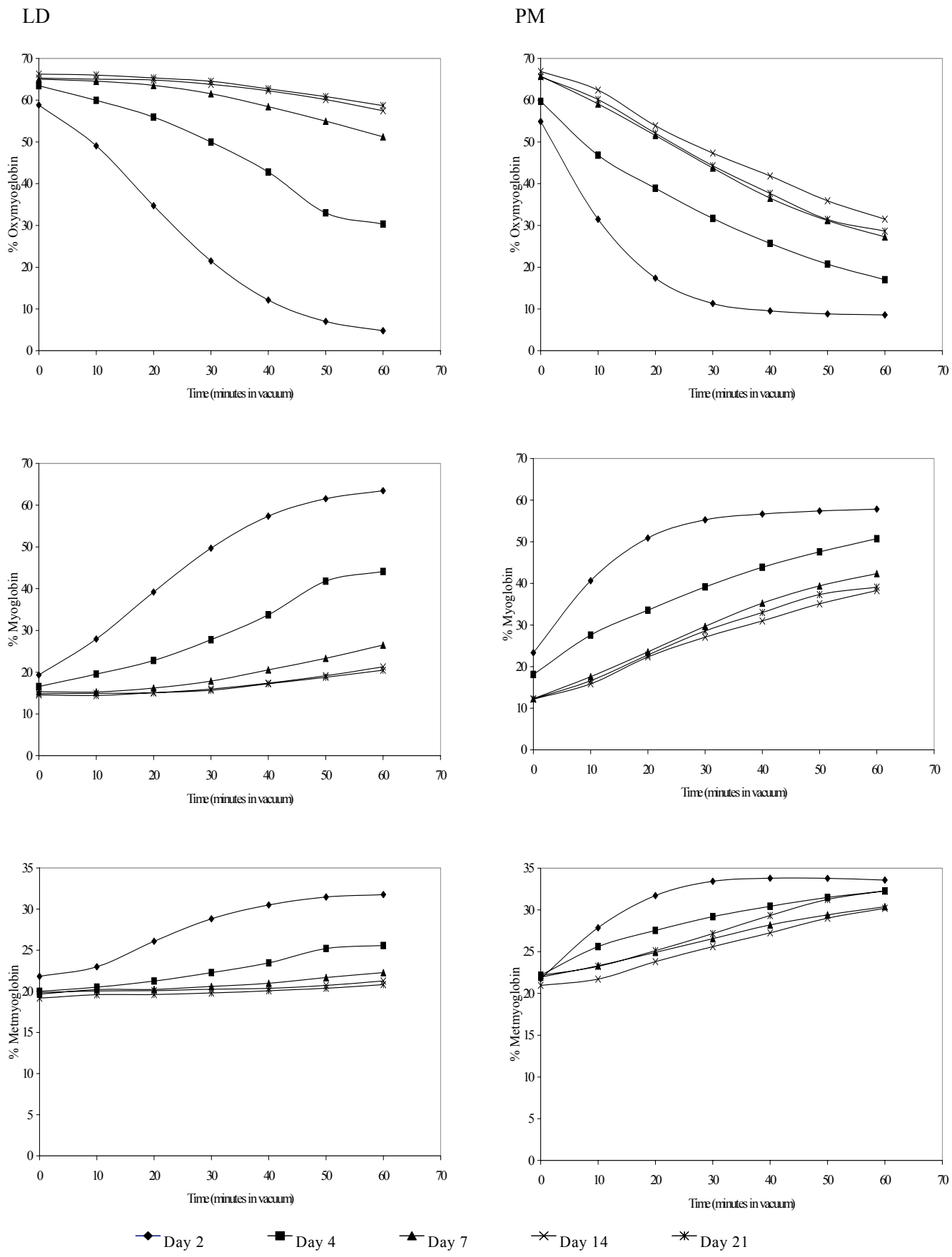

Figure 1: The concentration of the pigments oxymyoglobin, myoglobin and metmyoglobin over 60 minutes in vacuum in the LD and PM muscles.

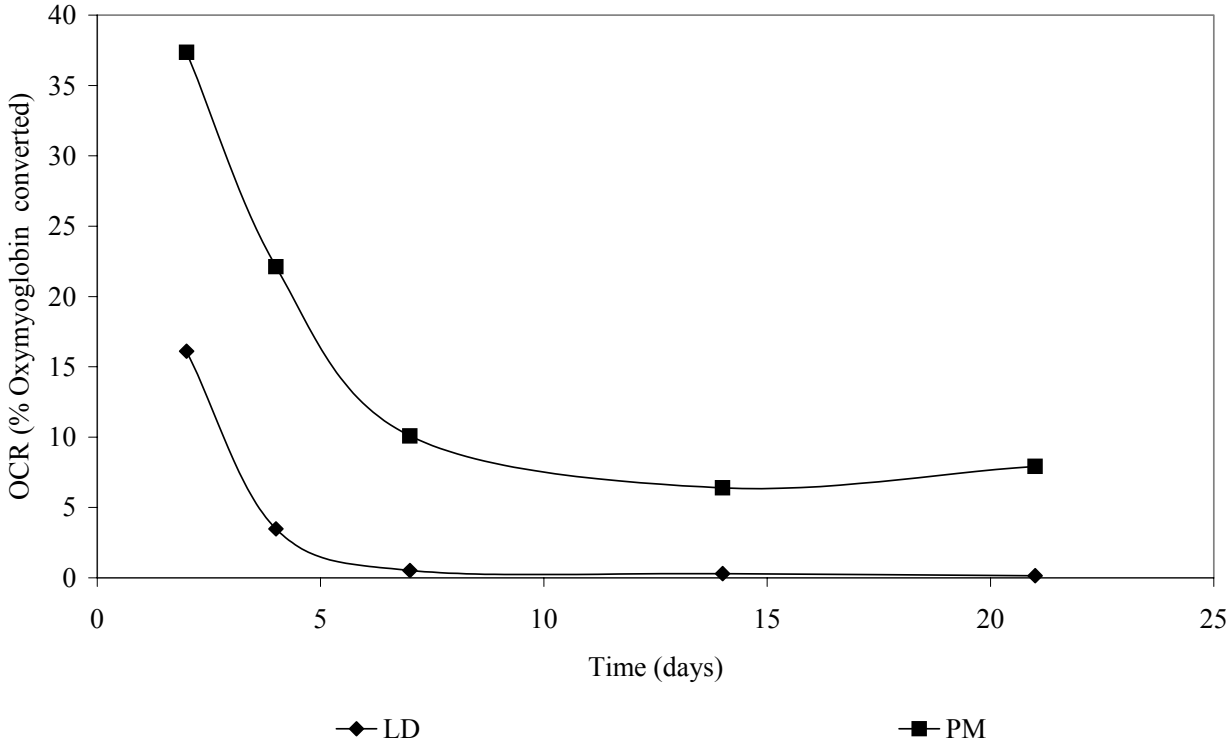

Figure 2: Effect of post mortem time on the oxygen consumption rate (% oxymyoglobin converted in the first 10 minutes in vacuum) of the LD and PM muscles.

References

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