THE EFFECT OF A RANGE OF CO CONCENTRATIONS AND EXPOSURE TIMES ON THE COLOUR STABILTY OF VACUUM PACKAGED BEEF STEAKS

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Abstract –The effect of a range of CO concentrations and exposure times on the colour stability of vacuum packaged *Longissimus thoracis et lumborum* (LTL) beef steaks was investigated. Steaks were exposed to four CO concentrations (5% CO, 60% CO_2 and 35% N; 3% CO, 60% CO_2 and 37% N; 1% CO, 60% CO_2 and 39% N; 0.4% CO, 60% CO_2 and 39.6% N) or a control (60% CO_2 and 40% N_2)) for 5, 7 or 24 h and stored at 2 °C. A CO gas concentration and exposure time of 1 % for 5 h was optimal as it gave a desirable initial colour which discoloured to reach unacceptable levels (a* = 12, C* = 16) by the use-by-date (28 days).

Key Words – Carbon monoxide, *K/S* ratios, packaging

I. INTRODUCTION

Carbon monoxide (CO) used as a pretreatment, prior to vacuum packaging can provide added-value to meat quality through improved colour and tenderness. Van Rooyen, *et al.* [1], showed that exposure to 5% CO for 5 h prior to vacuum packaging enhanced meat colour while allowing discoloration to occur by day 28 before spoilage occurred, without having any adverse effects on microbiological safety or quality attributes. This study addressed previous consumer safety concerns that CO may be used to mask meat spoilage. However, further reducing the CO-pretreatment gas concentration may result in safer handling conditions for workers, while a reduced exposure time would decrease processing time. The combination of CO concentration and exposure time determines the colour stability and a prolonged exposure time even at a low CO concentration may mask spoilage. Therefore, more research is required to determine the appropriate exposure time tailored to a reduced concentration of CO, if CO pretreatments were to be implemented within the meat industry. The objective of this study was to investigate a range of CO concentrations and exposure times on the colour stability of vacuum packaged beef steaks.

II. MATERIALS AND METHODS

A bovine LTL muscle (n = 1) from a Charolais-cross (CHX) heifer (aged between 21-29 months) was obtained from a commercial meat producer. Steaks were cut (n = 15) (25 mm thick, 285.2g – 388.0g) at 6-8 days post-mortem and randomised. Steaks were vacuum packaged as a reducing step prior to pretreatment. Samples were assigned to five treatment groups of a range of gas concentrations (**5% CO**, 60% CO_2 and 35% N; **3% CO**, 60% CO_2 and 37% N; **1% CO**, 60% CO_2 and 39% N; **0.4% CO**, 60% CO_2 and 39.6% N; or a **control** (60% CO_2 and 40% N_2)) for 5, 7 or 24 h and stored at 2 °C. Steaks were then removed from the pretreatment pouches, individually vacuum packed and randomised before being placed in an open front-display cabinet at 2 °C for 28 days under continuous fluorescent lighting (2115 lux) to simulate retail conditions. Surface colour readings, reflectance and absorbance measurements were performed using a HunterLab UltraScan Pro (Hunter Associates Laboratory., Inc., Reston, VA) using a viewing port of 25 mm and illuminant D_{65}, 10°. CIE a* (redness) and b* (yellowness) measurements were used to calculate Chroma ($C^* = (a^{*2} + b^{*2})^{1/2}$) values. Surface reflectance readings (n=3) were determined from 400 to 700 nm (5 nm interval) and values at 474, 525, 572 nm were calculated via linear interpolation. The Kubelka-Munk equation $((1-R)^2 \div 2R)$ was used to calculate *K/S* ratios for Carboxymyoglobin (COMb) ($(K/S_{610})/(K/S_{525})$) and myoglobin redox forms [2]. Reference standards for 100% COMb were prepared [2]. Colour stability was measured at 0, 2, 10, 21 and 28 days. Data were analysed using Repeated measures ANOVA (rANOVA) with F-protected LSD (GenStat (Release 14.1 Copyright 2011)). Significance was defined as P<0.05. Three replicates were carried out.

III. RESULTS AND DISCUSSION

A gas concentration × day interaction and an exposure time × day interaction were observed for a* and C* values (P<0.001), with the difference between gas concentrations and exposure times decreasing over storage time (Fig 1.A

& B). Increased CO concentration and longer exposure time both increased redness ($P<0.05$). The combinations of gas concentration and exposure time that induced the desirable colour while allowing discoloration to reach an unacceptable level by use-by-date (a* = 12, C* = 16) were 5% CO/5 h, 3% CO/5 h, 3% CO/7 h, 1 % CO/5 h and 1% CO/7 h Van Rooyen, *et al.* [1] found that the 5% CO/5 h treatment achieved the objective of discolouring by 28 days, however the present study demonstrates that the gas concentration can be reduced to 1% with the same exposure time while still achieving this objective. This is desirable as it would be safer for workers while not increasing processing times. For COMb *K/S* ratios a gas concentration × day interaction and an exposure time × day interaction occurred ($P<0.01$) with the differences between treatments decreasing with display time (Fig.1 C). COMb *K/S* ratios increased with display time representing decreased redness and corresponding to the trends for a* and C* values. The increase in *K/S* ratios values for COMb towards the 0% COMb reference standard (0.52) by day 28 indicates that very little COMb was present on the surface at the end of storage, confirming that meat spoilage was not masked by the CO-pretreatments and addressing consumer concerns.

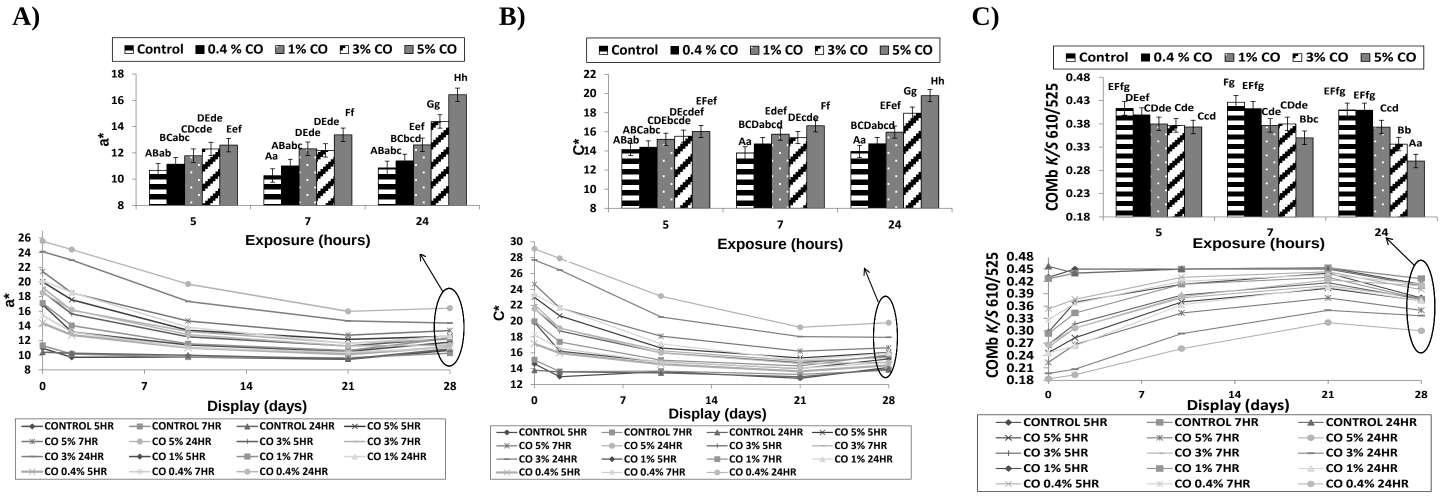

Figure 1. Mean values of CO pre-treatments (0.4%- 5% CO) and exposure times (5-24 h) over 28 days storage for A) a* and B) C*values & C) COMb *K/S* ratios. Different uppercase (A-H) indicates significant differences by exposure*day. Different lowercase (a-h) indicates significant differences by gas concentration*day. Statistical significance: ($P<0.05$).

IV. CONCLUSION

The CO concentration used in pretreating beef steaks can be reduced from 5% to 1% with the same exposure time of 5 h, to achieve acceptable colour stability while allowing discoloration by 28 days so as to not mask spoilage. This could result in safer handling conditions for workers while processing times would not be increased.

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