The Use of Carbon Monoxide as a pre-packaging treatment in Beef

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Abstract— **Consumers choose beef primarily based on colour and associate a bright red colour with freshness and wholesomeness. Packaging must preserve and present the meat in a pleasing manner. Vacuum packaging serves to preserve the product well but causes the meat to become much darker than consumers prefer. Alternative packaging systems such as Modified Atmosphere Packaging (MAP) which include oxygen cause the meat to exhibit a bright cherry-red colour but are not as effective in product preservation and may give rise to other problems such as lipid oxidation and loss of meat tenderness. Carbon monoxide (CO) as a MAP gas also induces the cherry-red colour. The colour is more long-lasting than that induced by oxygen. For the purposes of this research CO was not used as a packaging gas but as a pre-treatment before packaging. A gas mixture of CO, Carbon dioxide and Nitrogen was used at 5, 60 and 35% respectively. The gas was then removed and the samples were vacuum packed. LD muscles were pre-treated at 4°C for a range of times varying from 30 minutes to 72 hours and then assayed over a 21 day period for colour, pH, tenderness, cooking-loss, lipid oxidation and microbial counts. Some consumers are concerned that the prolonged red colour could be used to market meat beyond its sell-by-date. The shorter exposure times in this pre-treatment regime cause the beef colour to return to the normal vacuum induced dark colour before the product reaches its use-by-date thus allaying consumer concerns.**

Keywords— **MAP, Carbon monoxide, packaging.**

I. INTRODUCTION

Colour is regarded as the primary characteristic by which a consumer is attracted to beef [1]. Redness is associated with freshness and wholesomeness. After this other factors such as price, country of origin and fat content become important in their decision. It is therefore important that the type of packaging used should adequately display the meat colour and act to preserve the meat quality.

In Modified Atmosphere Packaging (MAP) meat is packaged under a gas atmosphere. The gases most routinely used are Carbon dioxide, Nitrogen and Oxygen. Oxygen induces a cherry-red bloom, due to the formation of oxymyoglobin in the meat, which consumers like. The inclusion of Oxygen in MAP packaging has some disadvantages such as limiting the shelf-life of the product, (due to the possible growth of aerobic micro-organisms), inducing off-odours due to lipid oxidation and reducing meat tenderness [2,3].

Vacuum packaging is better for preserving meat, due to the absence of oxygen, and has the added advantages of better physical protection of the product and reduced pack size for storage, transport and display. A disadvantage of vacuum packing is that beef has a much darker colour, due to the formation of deoxymyoglobin, which consumers do not find so acceptable.

Carbon monoxide (CO) also induces a cherry-red colour due to the formation of carboxymyoglobin which is more stable than the oxymyoglobin produced in the presence of oxygen [1].

CO had been used as a MAP gas for over twenty years in Norway, is a component of the smoking process of a range of products and is routinely used as a packaging gas in the US. Some US consumer groups have expressed concerns that the more stable CO induced bloom might be used to market beef beyond its recommended sell-by-date.

The premise of the work presented here is to develop a range of CO pre-treatments for beef to induce the cherry-red bloom, remove the gas mixture and then package the product under vacuum. The final product exhibits the colour normally associated with oxygen MAP and with the additional benefits normally associated with vacuum packed products. Pre-treatment regimes were chosen so that the red bloom would dissipate as the product shelf-life is reached. Reported here are the preliminary results from the trials.

II. MATERIALS AND METHODS

A. Sample Preparation

Two *Longissimus dorsi* (LD) muscles from a Charolais-cross animal were used for each replicate. 2.5cm steaks were cut and randomised to avoid a muscle-position or animal-side effect. All steaks were

vacuum packed, to provide a reducing step before pre-treatment. Pre-treatment involved exposure to the gas mixture (CO, Carbon dioxide and Nitrogen at 5, 60 and 35% respectively) for a range of times from 30 minutes to 72 hours, before the steaks were rapidly transferred to a fresh vacuum pouch and vacuum packed. All operations were carried out at 4°C. Steaks were stored in display cabinets under continuous illumination in order to simulate retail display conditions. Samples were assayed weekly for colour, pH, lipid oxidation, tenderness, cooking loss and sensory panel acceptance.

B. Sample analysis

Lipid-oxidation was analysed using the TBAR method of Pfalzgraf *et al* [4]. Colour was analysed using the HunterLab UltraScan PRO using the CIELAB scale. Standard microbiological methods were used to assay surface counts (colony forming units per cm^2). Surface swabs were taken from the entire surface of the treated steaks. Dilutions were inoculated onto selective media and grown at selective temperatures for the relevant time. Duplicate samples were grown under aerobic and anaerobic conditions.

III. RESULTS AND DISCUSSION

A. CO Penetration depth

Initial CO pre-treatment trials showed that the induced cherry-red bloom was a surface effect alone.

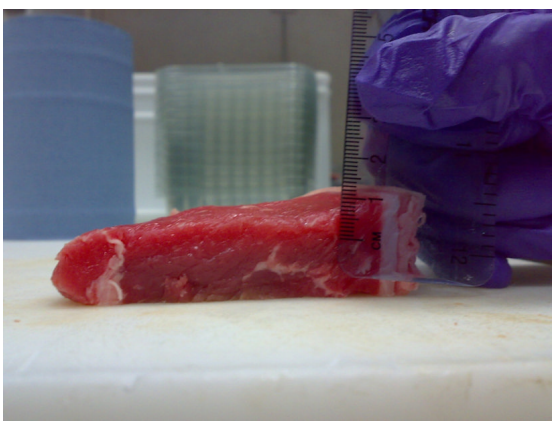

Figure 1. Surface carboxymyoglobin penetration layer in LD steaks

The lighter–coloured Carboxymyoglobin layer (Figure 1) was 3 to 4mm in thickness with pre-treatment exposure times of 30 minutes to 5 hours. Layers greater than 4.5mm were seen with longer pre-treatments. A pre-treatment time of 72 hours caused the carboxymyoglobin layer to permeate throughout the steaks. When steaks were removed from subsequent vacuum-packaging and exposed to the normal atmosphere they exhibited the same bloom as seen in non-pre-treated meat.

B. Lipid-oxidation

Figure 2 shows the levels of lipid-oxidation observed in CO pre-treated and control samples. As expected for vacuum packed beef the lipid-oxidation levels are very low. Pre-treatment with the CO gas mixture had no significant effect ($P<0.05$) on lipid-oxidation.

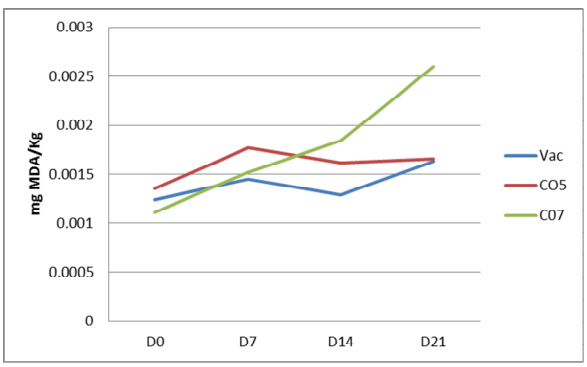

Figure 2. TBAR analysis of control, vacuum packed and 5 (CO5) and 7 hour CO gas mixture pre-treatment.

C. Microbial analysis

As the CO pre-treatment colour response is primarily a surface effect, surface-swabs were used to sample the steaks. As expected, due to the low temperature (4°C) under which the samples were stored the psychrophile counts showed an increase over time under both aerobic and anaerobic conditions. These, and all other groups of bacteria tested were well below two logs. (Figure 3). No Enterobacteriaceae were detected.

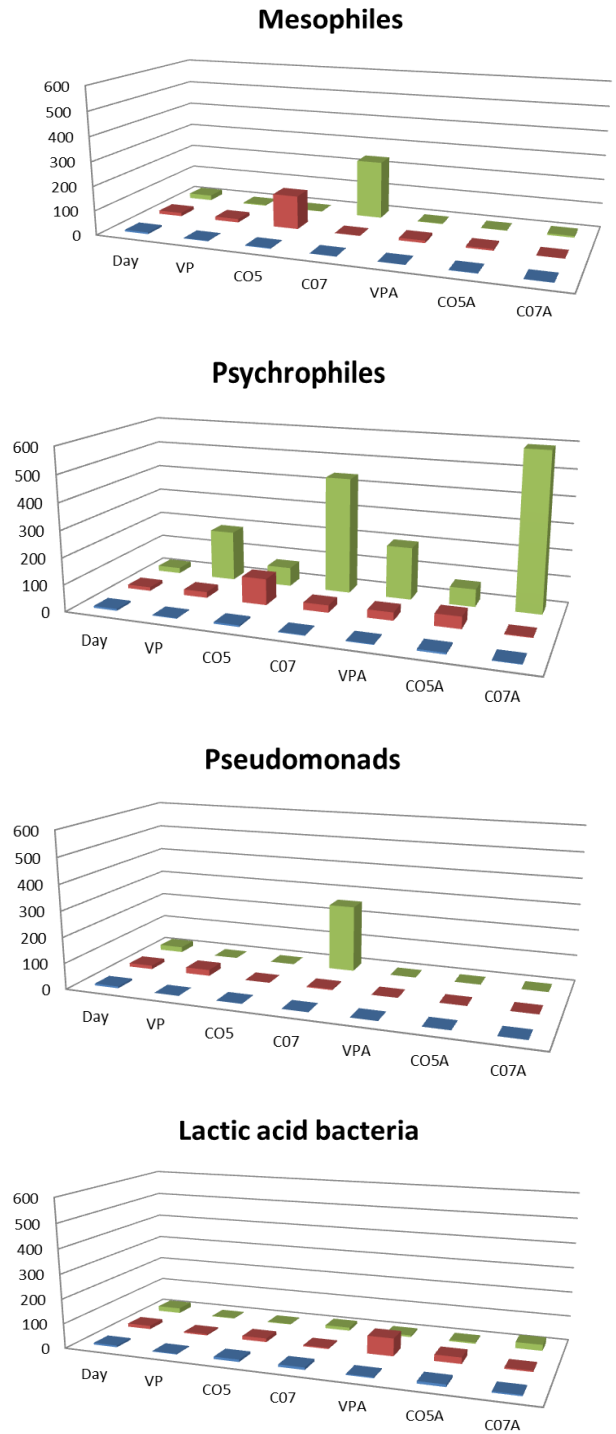

Figure 3. Microbiological analysis of steaks over time. Days 7, 14 & 21 are represented by blue, red and green (fore, mid and background positions) respectively. Samples were tested aerobically and anaerobically. Counts are expressed in cfu/cm^2 surface area.

D. Colour Analysis

Figure 4 show the effect of CO gas-mixture pre-treatment on steak colour after 1, 2 and 3 weeks. Non-pre-treated vacuum packed steaks show a decrease of redness (a* value) over time. Similar increases are evident for the 5 and 7 hour pre-treated steaks in which the colour decrease reaches the initial colour value seen in the non-pre-treated samples.

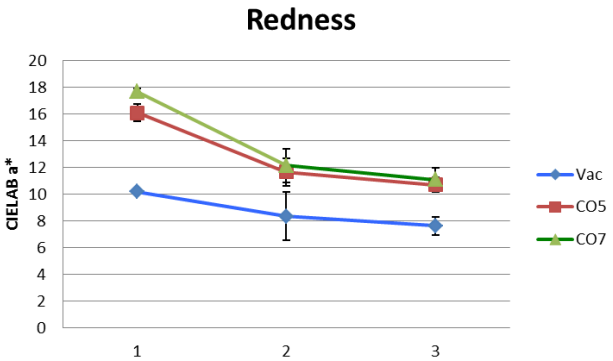

Figure 4. Steaks were analysed for colour at days 7, 14 and 21 (Weeks 1, 2, 3 as above). Standard Error bars are included for 3 replicates.

IV. CONCLUSIONS

It has been shown here that application of a CO gas-mixture pre-treatment step before vacuum packing produces steaks with an attractive fresh red colour. Pre-treatment regimes have been developed which facilitate a reduction in the induced red colour over time. This is important in addressing consumer concerns that the induced bloom may outlast the shelf-life date. Future work will see the development of pre-treatment regimes which facilitate the pre-treated meat to reach the same brown colour as seen in the final non-treated meat. The pre-treatment regimes also allow the production of steaks with a controlled richness of colour which can be targeted to consumer preferences in a variety of markets.

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