SUPPLEMENTATION OF HEIFERS WITH RUMINALLY-PROTECTED POLYUNSATURATED FATTY ACIDS: EFFECTS ON COLOUR STABILITY OF RETAIL-PACKAGED MINCED BEEF

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Introduction

Meat and milk of ruminant origin contain a substantial proportion of saturated lipids which result from lipolysis and biohydrogenation of dietary unsaturated lipids by rumen microorganisms (MacRae *et al.*, 2005). If a more unsaturated lipid composition is desired rumen hydrogenation must be prevented. Strategies to achieve this usually involve chemical modification of dietary lipids or feeding a seed source of dietary lipids where the oilseed itself provides some degree of protection from rumen microbial activity. Supplementation of cattle with ruminally-protected polyunsaturated fatty acids (RP-PUFA) and a consequent increase in PUFA in muscle lipids, would be expected to decrease the colour stability of the meat. Dietary PUFA are preferentially deposited in membrane phospholipids in ruminants (DeSmet *et al.*, 2004) and the fatty acid composition of phospholipids rather than triglycerides has been shown to be largely responsible for the susceptibility of meat to lipid oxidation.

Lipid oxidation and oxymyoglobin oxidation, manifested as meat discolouration, are linked (O'Grady *et al.*, 2001). Additionally, mincing of beef destroys cellular compartmentalisation and thus brings pro-oxidant components into close proximity with labile PUFA. There is also evidence that packaging of meat in a high oxygen atmosphere typical of beef retail packs provides an additional challenge to the oxidative stability and thus colour stability of meat, particularly if mincing has occurred (Monahan, 2000). The objective of the present study was to determine the effect of supplementation of heifers with a source of long chain ω-3 RP-PUFA on the colour stability of minced beef. We hypothesised that such supplementation would decrease the colour stability of beef under simulated retail display conditions.

Materials and Methods

Continental crossbred heifers were individually offered a daily bolus ration of 1kg (freshweight, approximately 850g dry matter (DM)) that contained the ω-3 RP-PUFA supplement of eicosapentaenoic acid (EPA, C20:5ω-3) and docosahexaenoic acid (DHA, C22:6ω-3) (Nutreco Holding N.V., 3800 AG Amersfoort, The Netherlands) at 0 (control), 69, 138 or 275g PUFA per kg (PU00, PU69, PU138 and PU275, respectively). This was followed by 1.5kg (1.278kgDM) of a high crude protein (26.2g/100g) balancer ration. Each afternoon 3.5kg (3.028kgDM) of another balancer ration was offered to all heifers with 1.5kg (1.24kgDM) of straw. Diets were formulated to be isoenergetic, isolipidic and isonitrogenous. Vitamin E, as *dl*-α-tocopheryl acetate was added to the RP-PUFA supplement at a rate of 5,000mg/kg and to the vitamin/mineral supplement included in the balancer rations at a rate of 10,000 I.U./kg (1mg *dl*-α-tocopheryl acetate = 1 I.U. (international units)). After 8 weeks of supplementation, heifers were humanely harvested, samples of neck muscle were recovered and were stored at -80°C (6 months) prior to mincing.

Eighteen hours before mincing samples were placed in a dark chill room at <2°C to thaw. Sections of neck muscle were minced by passing through a mincer with 3mm holes. When minced, samples were divided into six approximately equal portions, formed into patties of least 2.54cm thickness and dispensed into styrofoam trays with absorbent pads. Trays were sealed under oxygen impermeable barrier film (oxygen transmission rate: 8cm^{3}O$_2$/m^2/24h at 23°C and 75% relative humidity) following evacuation and flushing with 80%O_2:20%CO_2 in a modified atmosphere packaging machine. Trays were randomly positioned in an open-fronted retail display cabinet under permanent fluorescent lighting (2800 lm) and permanently shielded by an insulating blind, to maintain a uniform temperature distribution. Cabinet temperature was monitored using three needle thermocouples.

Approximately 3hours after packaging, the 'L' (lightness), 'a' (redness) and 'b'(yellowness) values of the minced beef were measured (day 0) using a benchtop Hunter lab UltraScan XE spectrocolorimeter. Saturation and hue angle were calculated as $\sqrt{(a^2+b^2)}$ and $[\tan^{-1}(b/a)][180/\pi]$, respectively. Colour was measured again on days 1, 3, 5, 7 and 10. Data were analysed using ANOVA appropriate to a split-plot design. Treatment (4 levels) was in the main plot and display time (6 levels) in sub-plot.

Results and Discussion

There was no effect of treatment or treatment × display time interaction for any of the measured colour variables except for 'b' value (treatment × display time, $P = 0.038$). Thus while the PU00 'b' value tended to be lowest up to day 5, it was equal to PU275 on day 7 but higher ($P<0.05$) on day 10. Between days 7 and 10, the PU00 'b' value tended to

decrease (Δ= - 0.46 b units, P>0.05) whereas the PU275 'b' value decreased (P<0.05) by 1.04 b units. This may prove useful in providing an index of colour stability for display periods in excess of 7 days but future trials are required to reinforce this suggestion. Redness and saturation are normally used as indices of colour stability (Figure 1), although Insausti *et al.* (1999) and Lindahl *et al.* (2001) claimed that changes in the 'b' value could be valuable in interpreting changes in pigment proportions, which are responsible for the phenomenon seen as unstable surface colour of meat, as red oxymyoglobin is converted to brown metmyoglobin. Critical considerations in the present study may be the muscle concentration of vitamin E as well as PUFA and also the low mean cabinet temperature (2.6°C).

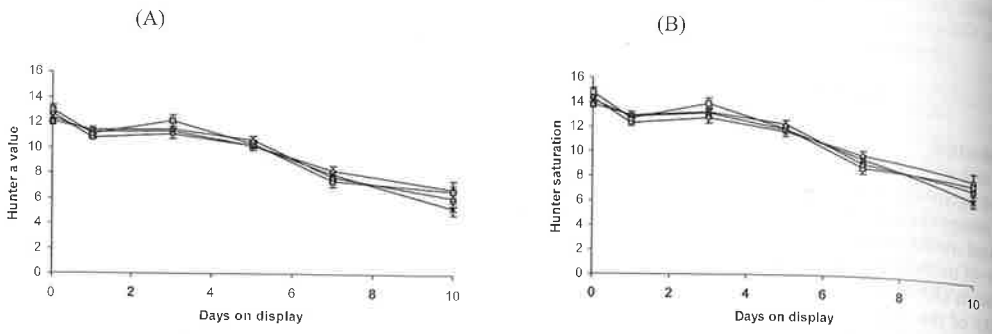

Figure 1: (A) Redness (Hunter 'a' value) and (B) saturation of minced beef from heifers offered ruminally-protected PUFA at 0 (PU00 (control)◇), 69 (PU69, □), 138 (PU138, △) or 275 (PU275, ×) g/kg and packaged in 80%O_2:20%CO_2 under permanent fluorescent lightning (2800lm).

Conclusions

Supplementing heifers with RP-PUFA did not have a deleterious effect on colour stability of minced beef stored for 1 week in high O_2 packs relative to control heifers, when indicated by redness or saturation. Thus, it is concluded that there were no negative effects of RP-PUFA supplementation based on usual measures but that the b value might have potential as a more sensitive index of colour stability.

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References

DeSmet, S., Raes, K. and Demeyer, D. (2004). Meat fatty acid composition as affected by fatness and genetic factors: a review. Animal Research, 53: 81-98.

Insausti, K. Beriain, M.J., Purroy, A., Alberti, P., Lizaso, L. and Hernandez, B.(1999). Colour stability of beef from different Spanish native cattle breeds stored under vacuum and modified atmosphere. Meat Science, 53:241-249.

Lindahl, G., Lundstrom, K. and Tornberg, E. (2001). Contribution of pigment content, myoglobin forms and internal reflectance to the colour of pork loin and ham from pure sire breeds. Meat Science, 59: 141-151.

MacRae, J., O'Reilly, L. and Morgan, P. (2005). Desirable characteristics of animal products from a human health perspective. Livestock Production Science, 94: 95-103.

Monahan, F.J. (2000). Oxidation of lipids in muscle foods: fundamental and applied concerns, in: *Antioxidants in muscle foods – Nutritional strategies to improve quality*. Ed by Eric A. Decker, Cameron Faustman & Clemente J. Lopez-Bote. John Wiley & Sons, Inc., New York, pp 3-24.

O'Grady, M.N., Monahan, F.J. and Brunton, N.P. (2001). Oxymyoglobin oxidation and lipid oxidation in bovine muscle-mechanistic studies. Journal of Food Science, 66: 386-392.