7:29 **The effect of inclusion of mechanically recovered chicken meat on the colour of a British style fresh sausage during storage under simulated retail display**

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Introduction

The mechanical recovery of meat from bones retrieves expensive animal protein in a form which may be easily and economically incorporated into a variety of products for human consumption. The topic has been extensively reviewed (Newman, 1980-81, 1983; Froning, 1981; Field, 1981). Although its composition depends on the nature of the bones used and method of recovery, a common feature of most mechanically recovered meat (MRM) is the intimate mixing of lipid, haem pigments, and air during recovery. The presence of haem pigments affects the rate of lipid oxidation (e.g. Moerck & Ball, 1974) but less attention has been paid to how the lipid and air affect pigment oxidation and colour stability in a product incorporating MRM. It is common in the UK to substitute chicken MRM for pork carcass meat in a range of products because their initial colour intensities are similar, and palatability is acceptable. This investigation examines how substitution of belly pork by chicken MRM affects the colour of a British style fresh sausage during simulated retail display.

Experimental

Materials

18 kg of MRM were produced from chicken bodies using a Protecon MRS 30 and frozen into blocks 6 cm thick in a plate freezer. A replicate quantity was collected two weeks later. On each occasion the MRM was divided into three batches and stored covered in polyethylene at -18°C for different periods. In Experiment I MRM was used after 4 days storage, i.e. as soon as practicable after collection; in Experiment II, MRM was used after 8 weeks storage of the first sample, and 6 weeks storage of the second; whilst in Experiment III, MRM was used after 31 weeks storage of the first sample, and 29 weeks storage of second (both nominally 7 months). Both samples of MRM were processed concurrently in Experiments II and III.

The MRM was tempered for 24 hours at +1°C before use. Fresh pork (skinless belly, head meat (jowl) and backfat) was obtained for each experiment from a local processing plant and held for 3 days at +1°C. Belly and headmeat were minced through a 10 mm plate before use. Headmeat, belly, and MRM were analysed for total pigment (Hornsey, 1956).

Methods

Sausage formulation and production

Sausages were formulated to satisfy existing UK regulations (Statutory Instruments, 1967) with a 50% meat content, at least 50% of which would analyse as lean. The composition of the sausages is shown in Table 1.

Table 1. Percentage composition of sausages.

Ingredient	Lean:fat ratio used in calculating substitution	Level of MRM: Control	6%	18%
Belly pork	60:40	25	18	4
Head meat	50:50	25	25	25
Back fat	0:100	0	1	3
MRM(*)	70:30	0	6.6	19.8
Seasoning		2.5	2.5	2.5
Soya isolate		2.0	2.0	2.0
Rusk		14.0	14.0	14.0
Iced water		31.5	31.5	31.5

(*) MRM rated as 90% meat.

Substitution of pork belly by chicken MRM and backfat was intended to produce sausages of similar meat content and fat to lean ratios by analysis. The weight of MRM added was 10% greater than nominal because experience in the UK has shown that MRM usually analyses as only 90% meat. Both levels of MRM addition are used in current UK commercial practice.

Sausage mixes (9.1 kg) were made in a Kramer Grebe SM3 bowl chopper. The seasoning (containing 630g kg^{-1} NaCl, 0.4 g kg-1 sodium sulphite, 0.16 g kg-1 Red 2G) and soya isolate were dispersed in 1/4 of the iced water before addition of the other ingredients. Mixes were stuffed into synthetic casings (Devro 280-211 machine link) using a vertical piston filler and hand linked. The pigment content of the finished mixes was determined.

The sausages were overwrapped in oxygen permeable film (Vitafilm, Goodyear) in packs of eight, each pack weighing about 450g. These were stored overnight in the dark at 5°C, and then illuminated at the same temperature under a light intensity of between 800 and 1200 lux, from 20w fluorescent tubes (Philips natural).

Colour

Two packs, one exposed to light, the other kept in the dark, were used for colour measurement. Colour was measured on a Hunter D25-9 Tristimulus Colorimeter with D25-A Optical Sensor in reduced area mode and a 1cm diameter sample port. Lightness (L) was measured directly and the psychological colour attributes hue angle (H°) and saturation (S) were calculated from a and b.

Results

Pigment concentration

There was an apparent loss of pigment from MRM during frozen storage, the haematin concentration in the first sample falling from 131 $\mu g\ g^{-1}$ to 117 $\mu g\ g^{-1}$ after 6 weeks and to 90 $\mu g\ g^{-1}$ after 29 weeks. Haematin concentration in the second sample was initially 170 $\mu g\ g^{-1}$ which fell to 145 $\mu g\ g^{-1}$ and 100 $\mu g\ g^{-1}$ after 8 and 31 weeks respectively.

Mean pigment concentrations in the sausage mixes before display are shown in Table 2.

Table 2. Haematin concentration in sausage mixes ($\mu g\ g^{-1}$)

	Experiment I	Experiment II	Experiment III
Control	44.6	64.6	37.4
6% MRM	48.7	59.8	41.5
18% MRM	60.7	68.4	45.4

Changes in appearance

Saturation, hue angle, and lightness of sausages on the first and last two days of display for Experiments I, II and III are shown in Tables 3, 4 and 5 respectively.

Table 3. Colour of sausages at beginning and end of display.

Experiment I

	Day of display: 0	1	6	7
Saturation(S)				
Control	14.4b	14.1b	11.8	10.7
6% MRM	15.1a,b	15.0a,b	12.0	10.6
18% MRM	16.2a	15.9a	12.0	11.0
Hue Angle (H°)				
Control	54.5a	52.9	56.4	52.8
6% MRM	53.3a	51.5	57.3	53.3
18% MRM	50.2b	49.3	57.6	54.2
Lightness(L)				
Control	63.5a	62.7a	60.7a	60.8a
6% MRM	62.6a	61.5a	59.6a	59.9a
18% MRM	59.9b	59.7b	57.8b	57.6b

For each colour attribute, means in the same column with different subscripts are significantly different (P<0.05). Least significant difference: S=1.67, H°=4.20 , L=1.29.

Experiment I

Initial S increased with substitution, the colour of the 18% MRM sausages being significantly more saturated than the controls. Sausages with 18% MRM were significantly redder (lower H°) and darker than the other treatments.

The colour of the sausages became less saturated with time (Figure 1a). The difference between 18% MRM and control was still significant on Day 2 but there was no significant difference between the sausages with MRM after Day 3. The sausages had similar S values on Days 6 & 7. The changes in hue angle with display time were complex showing a small decrease during the first two days followed by a marked increase to a maximum for all treatments on Day 6. H° was again lower on Day 7. There was no difference in hue angle attributable to MRM on Days 6 and 7. All sausages became darker with time, with relative differences between treatments being maintained.

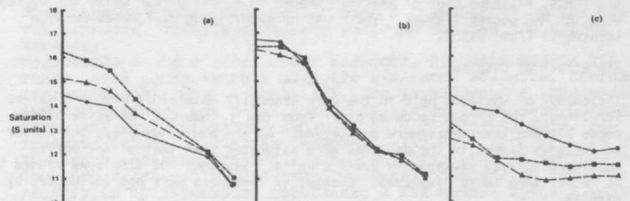

figure 1. Effect of simulated retail display on colour saturation of sausages containing 0% (-●-), 6% (--▲--), and 18% (--■--) MRM. a) Experiment I, b) Experiment II, c) Experiment III.

Experiment II

Control sausages had an initial saturation of 16.7 S units, considerably higher than those produced in Experiment I. This was attributed to the greater concentration of pigment in the head meat used for this experiment. Sausages with 6% and 18% MRM had similar S.

Saturation decreased with time similarly for all treatments (Figure 1b). There was no significant difference in S or H° between treatments at any sampling time. Sausages with 6% MRM were lighter than the other two treatments throughout storage, significantly so on Days 1 and 4. Sausages with 18% MRM were darker than the other two treatments from Day 3 onwards, differing significantly from those with 6% MRM from Day 4 onwards and from the controls from Day 5 onwards.

Experiment III

Control sausages had similar S to those produced in Experiment I. Sausages with 6% MRM had least saturated colour whilst those with 18% MRM were intermediate between the two; these differences were significant. The control sausages were redder than those with MRM, but not significantly. Sausages with 18% MRM were darker than the other two treatments.

The colour of the control sausages became less saturated with time (Figure 1c) but was significantly more saturated than that of 6% MRM sausages throughout display. Change in H° with display time was again complex and appeared to differ with level of substitution. Greatest change was observed in the

Table 4. Colour of sausages at beginning and end of display.

Experiment II

	Day of display			
	0	1	6	7
Saturation (S)				
Control	16.7	16.6	11.7	10.9
6% MRM	16.3	16.1	11.7	10.9
18% MRM	16.4	16.4	11.9	11.0
Hue Angle (H°)				
Control	44.1	44.4	55.2	51.9
6% MRM	45.9	45.8	55.0	52.4
18% MRM	44.7	45.7	54.7	51.7
Lightness(L)				
Control	56.4	56.0b	55.9a	52.8a,b
6% MRM	57.4	57.3a	56.2a	53.1a
18% MRM	56.4	56.2b	54.7b	51.8b

For each colour attribute, means in the same column with different subscripts are significantly different ($P<0.05$). Least significant difference: S=0.62, H°=2.54, L=1.10.

Table 5. Colour of sausages at beginning and end of display.

Experiment III

	Day of display			
	0	1	6	7
Saturation(S)				
Control	14.4a	13.8a	12.0a	12.1a
6% MRM	12.7c	12.3b	11.0b	11.0b
18% MRM	13.3b	12.5b	11.5a,b	11.4b
Hue Angle (H°)				
Control	51.0	51.1b	50.0c	50.0b
6% MRM	53.4	52.2a,b	56.9b	57.7a
18% MRM	53.8	56.2a	63.4a	61.0a
Lightness (L)				
Control	63.6a	63.0	62.4	61.9
6% MRM	63.2a	62.1	63.3	63.0
18% MRM	61.4b	61.2	62.8	62.9

For each colour attribute, means in the same column with different subscripts are significantly different ($P<0.05$). Least significant difference: S=0.47, H°=3.88, L=1.24.

sausages with 18% MRM which increased steadily in H° to 63.4 on Day 6. Sausages with 18% MRM had highest H° from Day 1, significantly greater than the controls throughout subsequent display, but only significantly higher than the sausages with 6% MRM on Day 6. The controls were significantly redder than 6% MRM on Days 3, 5 & 7. There was little effect of display time on lightness, although control sausages tended to become darker while the sausages with 18% MRM became lighter. There was no significant difference between treatments from Day 4.

The effect of display

The colour of sausages held in the dark generally maintained higher S values for longer, the effect becoming clear from Day 3 onwards. Relative differences between treatments were maintained. At the end of display, the colour of sausages stored in the dark was more saturated than that of the corresponding displayed sausages by 0.5-2.0 units. Sausages not displayed tended to be redder than those displayed. Changes in lightness were not influenced by display.

Discussion

The most obvious effect of substitution of chicken MRM for belly pork was on the appearance of the sausages at the beginning of display. In Experiment I, increasing substitution produced sausages noticeably darker and redder than the controls but substitution with MRM previously stored for 6 or 8 weeks (Experiment II) had little effect on appearance. In Experiment III, using MRM stored for 7 months, substitution of 6% MRM produced sausages greyer and more yellow than the controls. When substitution was at 18% the sausages were darker than either of the other two treatments, but were closer to the controls in hue angle and colour saturation than those with 6% MRM.

Fading has been defined as a weakening of colour which may involve a change in hue (ASTM, 1967). Weakening of colour equates with loss of S which in fresh meat is directly related to formation of metmyoglobin from oxymyoglobin oxidation (MacDougall, 1977). In the present study, reflectance spectroscopy confirmed that a similar mechanism operates in fading of sausage. The way in which MRM affected fading was different in each Experiment. In Experiment I more change in saturation and hue was observed in sausages with MRM than in the controls over the same display period, implying increased rates of fading with increasing substitution. In Experiment II MRM did not appear to alter the rate of fading. In Experiment III, the saturation of the control sausage fell more during seven days display than the other treatments, so fading rate was reduced by the presence of MRM. It is probable that the large differences in change in H° arising from level of substitution would be visually more important in this instance.

Rate of change in S could depend on the initial colour saturation of the sausages and be independent of MRM. This simple explanation, which ignores changes in H°, is suggested from Figure 1 and the small range of S on Day 7 across all experiments. The results of Experiment II, in particular, in which the sausages of all three treatments had similar initial appearance and behaved similarly in response to display further suggests that MRM does not influence rate of change in S.

Church & Jeffery (1983) studied the effect on quality of substituting pork MRM in pork sausage and beef MRM in beef sausage. They considered that addition of 5-15% MRM by weight would not greatly affect quality but stressed the importance of re-assessing shelf life. A tentative conclusion from our work, including additional data broadly in agreement with Experiment I (Allison, 1983), is that the influence pigment concentration and oxidative state of the MRM has on initial colour saturation subsequently affects fading rate. However such effects are no greater than those brought about by other ingredients.

Our results also suggest that the delay between freezing and use of MRM may be a critical factor in determining initial appearance. The different consequences of using MRM after either 4 days or 6 or 8 weeks frozen storage was so marked in this study that a further investigation of the effects of short term frozen storage of MRM on pigment loss and oxidation seems warranted.

Acknowledgements

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References

Allison, G.B. (1983) M.Sc. Thesis, University of Bristol.
ASTM Designation E284 (1966) Terms relating to appearance of materials. American Society for Testing and Materials, Philadelphia, Pa. USA.
Church, P.N. & Jeffery, A.B. (1983) Leatherhead Food R.A. Research Report No. 404.
Field, R.A. (1981) Advances in Food Research 27, 23.
Froning, G.W. (1981) Advances in Food Research 27, 110.
Hornsey, H.C. (1956) J. Sci. Fd Agric. 7, 534.
MacDougall, D.B. (1977) In "Sensory properties of food", (eds. G.G. Birch, Brennan, J.G. & Parker, K.J.), Applied Science, London.
Moerck, H.C. & Ball, H.R. (1974) J. Fd Science 39, 876.
Newman, P.B. (1980-81) Meat Sci. 5, 171.
Newman, P.B. (1983) In "Upgrading Waste for Feeds and Food," (eds. D.A. Ledward, A.J. Taylor, & R.A. Lawrie), Butterworths, London.
Statutory Instruments (1967) The Sausage and other Meat Product Regulations 1967, SI No. 862.