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Correlations between ultimate pH and some quality traits of sheep meat

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The extent of pH fall post mortem can have important effects on the appearance and eating quality of meats. Water-holding capacity (Hamm, 1964) and susceptibility to spoilage by microorganisms (Brown, Coote and Meaney, 1957) are also pH dependent.

Howard and Lawrie (1956), and Bouton, Howard and Lawrie (1957) reported that flavour, tenderness and overall acceptability of beef were dependent upon the ultimate pH. The colour of beef was shown to be pH dependent (Winkler, 1939; Hall *et al*, 1944). Dodge and Stadelman (1960) found that pH was closely correlated with the tenderness of turkey meat, r = 0.8 approximately.

The pH of meat can be mesured easily and rapidly. This study was undertaken to determine correlations between the ultimate pH and the appearance and eating quality of sheep meat.

EXPERIMENTAL

Animals, Slaughter, Dressing and Chilling Procedures

Meat samples were obtained from the carcases of 38 Merino wethers, approximately 4 ½ years old, with a mean cold carcase weight of 25.7 kg. The animals were taken from a group of 186 animals slaughtered commercially. At slaughter, the carotid arteries and jugular veins were severed and the neck dislocated, without prior stunning. The animals were dressed »on the rail» in a way common to most Australian meatworks.

Approximately 20 minutes elapsed from the time of slaughter until the carcases entered a chiller. The chiller temperature was approximately 3° C. The mean temperatures, taken with a thermocouple placed in the *M. longissimus dorsi* (LD) 2 cm below the surface of the carcase, 4—20 cm posteriorly from the last rib and 2—3 cm from the dorsal mid-line, were 22.7, 17.8 and 11.3° C at 4, 7.5 and 18.5 hr. post mortem, respectively.

Twenty-four hours post mortem, the loins were cut from 12 carcases and the hind legs from a further 26. The legs and loins were transported to the

Meat Research Laboratory in a refrigerated vehicle. Loins were stored at 1° C for two days prior to examination and cooking and legs were stored at −20° C for 1—3 months prior to cooking.

pH determinations

pH was determined directly with an Instrumentation Laboratory pH meter 175[1]) and a surface electrode I.L. 140435[2]). The ultimate pH was read just prior to making reflectance determinations and cooking.

Subjective colour ranking of loin chops

Freshly cut surfaces of loin chops were exposed to air at room temperature, about 22° C, for at least 45 min. before being scored for colour. The chops were loosely covered with a plastic sheet to prevent excessive drying during this period. »Darkness» of red of LD was ranked by a panel of five, 1 being the darkest and 12 the lightest. Means of the panel rankings were used in the calculations.

Reflectivity

Reflectivity measurements, between 400 and 800 mμ, were made on samples 2—2.5 cm thick using a Shimadzu MPS—50L recording spectrophotometer*, with a reflectometer attachment and X 10 scale expansion. Freshly cut muscle surfaces were exposed to air for at least 45 minutes, without drying, prior to determining reflectivity. The reflectivity of the LD from 12 loin chops and of the *M. semitendinosus* (ST) and the *M. biceps femoris* (BF) from 26 leg chops was measured. Each of these chops was taken from the left hand side of a different carcase.

Cooking procedures

Loin chops (6.5 cm thick) and leg chops (2 cm thick) from both legs were deep fried to a central temperature of 75° C; the cooker thermostat was set at 177° C. The chops were allowed to cool overnight at 2° C prior to shear force determinations being made. Frozen legs were allowed to thaw at 2° C overnight and were kept at room temperature for a furher four hours prior to cooking. For panel evaluation the leg chops were cooked in an oven at 260° C to a central temperature of 80° C.

Shear force determination

Cooked meat samples were allowed to cool overnight at 2° C before being tested. Pieces of meat 1.5 × 0.7 cm were cut, using two double-bladed scal-

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1) Instrumentation Laboratory Inc., Watertown, Mass., U.S.A.
2) Shimadzu Seisakusho Ltd., Kyoto, Japan.

pels, so that muscle fibres would finally be sheared at right angles to their long axes. The shear device was a recording, Warner-Bratzler-type machine, with a constant shear rate. The stainless steel shear blade was 0.71 mm thick. Seven to twelve shear force determinations were recorded on one loin chop from each carcase and the means of the readings used in the calculations. Shear force determinations (13—21) were made on one chop from each leg of each carcase and the mean of all readings on the two chops from the same carcase used in the calculations.

Panel evaluation of eating quality

Only leg chops were evaluated by the ten-member »analytical» panel. Duplicate samples of meat, approximately $1.5 \times 1.5 \times 1.5$ cm in size, from each of the two hind legs of two animals were presented to the panel at one sitting. Odour, flavour, juiciness, colour (cooked), and overall acceptability were assessed by the panel. The sensory scales used have been described by Howard (1956). The extremes of the scales are shown in Table 1. The scores for left and right leg chops were added together to evaluate the eating quality of leg chops from each animal.

Table 1. *Outline of sensory scores*

Score	*0*	*8*
Odour	No meat odour	Very strong meat odour
Flavour	No meat flavour	Very strong meat flavour
Tenderness	Very tough	Very tender
Juiciness	Very dry	Very juicy
Colour	Very light	Very dark
Overall Acceptability	Accepted in preference to others.	Nauseating, very poor acceptability.

RESULTS

Loin chops

Ultimate pH and subjective colour ranking of the uncooked LD were significantly correlated, r= —0.873 ($P<0.05, > 0.01$). Reflectivity at 700 mμ and ultimate LDpH were also significantly correlated r= — 0.918 ($P< 0.01$). Subjective colour ranking was significantly correlated with reflectivity at 700 mμ, r = 0.907 ($P<0.05$). Darkness of red increased and reflectivity at 700 mμ decreased with increasing pH.

The simple correlation between ultimate pH of the LD and shear force, r=0.260, was not significant. A line of best fit, with a quadratic component, indicated maximum toughness at a pH of 6.05 and tenderness increased as pH increased or decreased around this value.

Leg chops

Reflectivity, at 700 mμ, of the ST and BF was correlated with the ultimate pH of these muscles, r = −0.510 and −0.557 (P<0.01), respectively.

There was no significant simple correlation between the ultimate pH of the ST and BF and mean shear force of leg chops. The range and mean panel scores for taste panel evaluations and shear force determinations for leg chops are given in Table 2.

Table 2. *Range and mean scores for taste panel evaluations and shear force determinations of leg chops*

	Range	*Mean*
Odour	3.2— 5.1	4.03
Flavour	3.2— 4.5	3.82
Tenderness	3.0— 6.0	4.64
Juiciness	2.9— 5.6	4.97
Colour (cooked)	3.4— 5.4	4.65
Overall Acceptability	1.5— 3.7	2.35
Shearing Force (lb.)	6.5—12.2	8.60

Mean panel scores for most attributes were about 5 which suggested that the meat was slightly below average quality. The detected variation in eating quality between leg chops was not great, a maximum range of 3.0.

Simple correlations between the ultimate pH of the ST and BF and panel evaluations of the eating quality of leg chops are shown in Table 3.

Table 3. *Simple correlations between the ultimate pH of the BF and ST and mean panel scores for eating quality of leg chops*

	S.T.	*B.F.*
Odour Score	0.028 NS	0.208 NS
Flavour Score	−0.321 NS	−0.038 NS
Tenderness Score	−0.295 NS	−0.274 NS
Juiciness Score	−0.363 NS	−0.428*
Colour Score (cooked)	0.062 NS	0.184 NS
Overall Acceptability Score	0.479*	0.241 NS

* Significant, P<0.05; with 26 samples r = 0.388 for significance at P = 0.05 and 0.496 at P = 0.01.

NS = Not significant.

The ultimate pH of the BF and ST were not significantly correlated with odour and flavour scores, although meat flavour tended to decrease with increasing ultimate pH and for the ST the correlation between pH and flavour approached significance at $P=0.05$. Tenderness tended to decrease with increased ultimate pH, though the simple correlation was not significant. Curvilinear correlations between ultimate pH and tenderness score, with a quadratic term, although not significant, suggested maximum toughness for the ST at a pH of 5.9 and for the BF at 5.64. The correlation between juiciness and pH was significant for the BF and approached significance for the ST. Juiciness tended to decrease with increasing pH.

Correlations between ultimate pH and colour of cooked meat were small and non-significant. Overall acceptability, in terms of eating quality, decreased significantly with increasing ultimate pH for the ST but not for the BF.

DISCUSSION AND CONCLUSIONS

Ultimate pH was related to subjective colour rank and to reflectivity at 700 mμ. The observed colour of meat is influenced by the nature and concentration of pigments and the light scattering and absorbing properties of the surface. Stewart, Zipser, and Watts (1965) reported that total extracted haematin concentration was proportional to K/S[3]) ratio at 525 mμ. However, as the pH was adjusted from 5.1 to 7.1 this ratio nearly doubled. It would appear that, for a particular muscle, between animal differences in pH influenced the reflectivity of meat surfaces sufficiently to affect subjective colour ranking. The pigment concentration of the loin chops was not determined so that the proportion of the variation in subjective colour due to pigment differences could not be estimated. The correlation between ultimate pH and reflectivity at 700 mμ would further indicate that pH had an appreciable effect on the light scattering and absorbing properties of the meat.

A peak toughness of loin chops coincided with a pH of the LD of approximately 6.05 and maximum toughness of leg chops occurred when the pH of the ST was approximately 5.9, and BFpH 5.64. Howard (1964) reported that minimum tenderness of sirloin roasts, topside roasts and rump grills occurred at a pH of approximately 5.9 with tenderness increasing on either side of this pH.

As Hamm (1960) has reported that the percentage of bound water of beef muscle inscreases as pH increases from 5.3 to 7.0, it was anticipated that juiciness would increase with increasing pH. However, in the present study juiciness of the BF decreased significantly with an increase in ultimate pH.

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[3]) K/S is related to the reflectance of an infinitely thick sample;
K is the absorption coefficient and S the scattering coefficient.

The ultimate pH of the BF varied from 5.50 to 5.80 and of the ST from 5.60 to 6.44. This result is in general agreement with data of Howard and Lawrie (1956) which suggests that juiciness may reach a minimum when the pH of beef is about 5.6 to 5.8. pH is a simple and rapid measurement which is related to meat colour. Although few correlations between muscle pH and eating quality were significant it is possible that pH may be a useful index of the eating quality of sheep meats.

ACKNOWLEDGEMENTS

The authors would like to acknowledge the co-operation of the manager of the New England County Council Abattoir, Guyra, New South Wales, Mr. Jackson. The sheep came from experiments of Dr. W. Southcott, CSIRO Division of Animal Physiology, Armidale, New South Wales. The technical assistance of Messrs. J. W. Ryan and T. Larsen is acknowledged. This work was supported in part by funds from the Australian Meat Research Committee.

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