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THE RELATIONSHIP BETWEEN COLOUR AND THE OTHER QUALITY
COMPONENTS IN FRESH PORK MEAT.

In connection with research work carried out in Poland concerning the effect of hereditary factors, feeding and management practices on the quality of pork meat, a vital problem to us was the choice of a practical method of measuring the original colour of fresh meat in order to obtain some comparative values in husbandry experiments. The method of estimating the colour of fresh meat on the base of total spectral curves is a rather awkward one does not yield satisfactory results /Mirna, 1955/. Moreover, the use of a spectrophotometer in mass experiments would involve considerable difficulties.

We propose therefore to investigate the usefulness of different simplified techniques of colour measurement in fresh meat. The present report brings the results of our experiments with the use of a Pulfrich reflectometer with Ulbricht ball, which had recently been made use of for the same purpose by several other authors /Kürbs, 1953; Hofmann and Kürbs, 1956; Otto, 1959/.

Methods.

The investigation was carried out on sixty samples of pork meat taken from bacon hogs from a progeny testing station, all uniformly fed and slaughtered under standard conditions. After forty-eight hours' refrigerating in wholesale cuts, the loins which had been carved out were carefully trimmed and a 1-cm slice was cut off from each, while the remainder was quickly cut up and minced twice in a meat grinder, then mixed and immediately subjected to colour measurement tests. The colour of the slices was measured after twenty minutes' cooling in the refrigerator.

For the estimate of the quality of colour, reflectance was determined with the use of filters K_1 and K_4 with maximum transmittance at 633 and 541 m μ . Lightness of colour was determined by reflectance with a K_7 filter. All the operations were performed upon meat which had been well refrigerated and

in a cool dark place.

Water in the meat was determined by drying, fat by the Soxhlett method, water-holding capacity by that of Grau and Hamm in Pohja & Niinivaara's modification /1957/. For the purpose of determining total pigments the method of Wierbioki et al. /1955/ was used but with extracts five times stronger and with all-night extraction.

Results and Discussion.

The colour quality expressed by the relation of reflectance when using the K_1 and K_4 filters /Otto, 1959/ showed little variation and yielded results with a low statistical significance. It is possible that the reason for that lay in the comparatively great uniformity of the meat /the hogs being all of one race, all coming from the progeny testing station, and the pH of the meat possessing a very low variation/; it is also possible that the methods adopted gave less chance for oxidation changes to manifest themselves -an end, in fact, that was purposely aimed at.

The lightness of colour, on the other hand, produced much greater variation as well as results showing very definite tendencies. That is in agreement with the opinion of authors investigating the colour of fresh pork meat by means of quick methods /Otto, 1959/ Batcher & Dawson, 1960/.

That proves that the factor possessing the fundamental significance in estimating the original colour of fresh pork meat, is lightness. It is thought that if together with that point were also furnished the estimation of the tendency to oxidation changes that would supply a sufficiently informative summing-up of colour for practical husbandry purposes.

An important, but so far insufficiently solved, question is the problem of how the sample should be prepared for measurement. The method universally adopted now consists of using freshly-out slices which, for purposes of oxygenation, have for a suitable length of time been exposed to the action of air. However, the surface of a section through the muscles is very uneven in colour, so that, for instance, we have been unable to measure the reflectance of many longiss. dorsi muscles, because the differences within one slice often amounted to over 25 per cent of the values obtained.

We had recourse therefore to mincing the meat on a grinder. Oxygenation then took place practically during the very process of mincing. Naturally, the chemical changes in meat which has been thus treated are accelerated. But our tests proved the usefulness of this method as enacted under the conditions in which we practised it. For, when we had meat sufficiently uniform in colour, then the measurements of its reflectance at 541 M u before and after mincing, never proved to be significantly different.

The practical results of the method of mincing the meat prior to colour measurement were very satisfactory. For example, hereinafter carrying out the tests on slices disclosed no close correlation between colour and intramuscular fat content, that dependence became quite manifest when the samples used were those of minced meat. In view of that, it was decided to consider rather this latter method of preparation in our calculations.

Adopting the above presented methods we did some preliminary tests in order to ascertain which factors in pork meat exercised the decisive effect upon its colour. Table 1 presents the arithmetical means of the quality factors in meat, while their simple coefficients of correlation with colour are shown in table 2.

TABLE 1

The arithmetical means \bar{x} and their standard deviations s , as well as the coefficients of variation C , of the quality components investigated.

Quality Component	\bar{x}	s	C
Colour/per cent of reflectance at 541 m u/	27.70	3.85	13.91
Water /per cent/	74.41	0.73	0.96
Fat /per cent/	2.11	0.76	36.02
Total pigments/ mg per cent/	69.00	17.21	24.94
Water-holding capacity /per cent of loose water/	28.16	3.54	12.56

TABLE 2.

Coefficients of correlation r of the quality components with meat colour.

Quality Component	r
Water	- 0.2867 ^x
Intramuscular fat	+ 0.4120 ^{xxx}
Total pigments	- 0.7679 ^{xxx}
Water-holding capacity	+ 0.5028 ^{xxx}
^x	significant at P= 0.05
^{xx}	" " P= 0.01
^{xxx}	" " P= 0.001

As can be seen from the table the highest correlation with colour is present in the case of pigment content. Although such a statement seems very obvious, since meat from which pigments have been extracted presents extremely low absorption of light rays /Pirko & Ayres, 1957/, nevertheless not all the authors are inclined to regard pigments as having the decisive role in affecting colour differences of meats, attributing that role rather to fat or water content /Craig et al. 1959/.

However, most of the literature on the subject seems to point toward the conclusion that colour is in the first place a function of the concentration of pigments /Mackintosh and Hall, 1953; Hall et al. 1944/. Similarly Wisner-Pedersen /1959/ while on the one hand stressing the importance of water-holding capacity for the colour of meat, also thinks, on the other, that the presence of pigments in a suitable concentration may even be capable of neutralizing the effect of improper structure of meat.

Thus it may generally be said that, in the case of meat of normal animals, which have been uniformly fed and slaughtered under standard conditions, the chief source of colour variation are meat pigments.

There seems to be no doubts as to the correlation of meat colour and water-holding capacity. The statistically highly significant relation obtained by us is in perfect agreement with results obtained by Grau & Mirna /1957/ as well as by Wisner-Pedersen /1959/. It also finds indirect confirmation in a number of investigations demonstrating the dependence of colour on the hydrogen ions concentration in meat /Callow, 1935; Hall et al. 1944; Bate-Smith, 1948/

which is correlated, as has been demonstrated, with water-holding capacity /Grau, 1953; Janicki & Waloza, 1954/.

No effect of water-holding capacity on the colour of meat has been discovered by Heim /1955/.

It would appear that fat ought to account for the colour of meat. And that was just the result we obtained by adding to a number of meat samples some given quantities of fat. Parallel to the increase of the percentage of fat, went an increase of the colour of the meat, expressed in terms of reflectance; the regression obtained following a straight line—at least, for the 2-6 per cent of fat examined.

Also in agreement with the above findings, were the results of our research carried on on pork loins. The correlation coefficient obtained there / $r=+0.4120$ / is sufficiently high and leaves no doubt as to significance.

In research on beef a significant correlation with fat has been obtained by Mackintosh & Hall /1935/. Similar results were got by Craig et al. /1959/, who actually assigned a greater role to fat than to pigments in the question of colour in beef meat.

On the other hand, in pork meat, no effect of fat on colour has been found either by Heim /1955/ or Henry & Bratzler /1959/. As already mentioned neither in our own research have we been able to discover any such dependence when doing colour tests on slices. It is possible therefore, that the dominant role in this case is played by the unevenness of colour in loin sections.

There is no decided opinion as to the importance of water content as a factor modifying meat colour. Neither Heim /1955/ nor Henry & Bratzler /1959/ consider it of any major importance; while Craig et al. /1959/ on the other hand, see in it just the very factor affecting the colour of meat.

The correlation coefficient between colour and water content obtained by us is not very high, but is statistically significant / $r=-0.2857$; $P < 0.05$ /. The negative value of the coefficient means that meats with a higher water content are darker. That is probably connected with the well-known converse relation existing between water content and fat content in meat.

SUMMARY.

Research was done on sixty pork loins, obtained from bacon hogs all uniformly fed and slaughtered under standard conditions.

The loins were tested to determine colour, water-holding capacity, water content, intramuscular fat content and total pigments content. The factor of the fundamental importance in estimating the original colour of fresh pork meat was found to be lightness of colour and the following simple correlation coefficients were obtained for it: water, -0.2867^X ; fat, $+ 0.4120^{XXX}$; pigments, -0.7679^{XXX} ; water-holding capacity, $+ 0.5028^{XXX}$.

A discussion of the methods of determining colour and of the results obtained has been presented.

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