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Abnormal pH_2 values in pigmeat and their effect on the quality of bacon.

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Introduction

In our experience complaints about the colour of bacon fall into two main categories, uneven colour and beefy, glazy colour . In the first case the contrast in colour present diminishes the visual appeal of vacuum packed bacon, and in the second case the bacon has a poorer keeping quality and the colour present rapidly fades, even in vacuum packed bacon, to give greyish-brownish discolourations. This paper describes and discusses investigations into the relationship between pH_2 values in the longissimus dorsi muscle of pigs and the quality of that muscle as bacon.

Experimental material

Samples of the longissimus dorsi muscle of Danish Landrace pigs, slaughtered at approximately 90 kilos live weight, were cut from the lumbar region 24 hours after slaughter. The samples were trimmed of fat and 10 slices of 3 mm, and 2 slices of 2 cm thickness were cut across the meat fibres starting from the end nearest the last rib.

Slice-curing

The 10 thin slices were cured with 4% salt containing 0.5% sodium nitrite. After vacuum packing and storing at 4°C for 3 days, the sample was repacked to remove any meat juice present.

Colour measurement

The brightness value was measured as the reflectance at 535 nm using an Elrepho photometer. Each sample was measured 3 times on each side and the brightness value given as the average of the 6 measurements. The uniformity of the colour was given as the variance (s^2 -value) about these 6 measurements.

Visual judgement

The samples were visually judged for colour, colour uniformity, and structure under CIE C-illumination. The judgements for structure were used to establish whether the sample had been pale, soft and exudative (PSE) or not in the uncured state.

pH_2 measurement

The 2 thick slices were minced once and after mixing well, the pH_2 value was determined on a 5 g sample after addition of 5 ml de-ionised water using a Radiometer 28 pH-meter.

Experiment 1. Comparison of pH_2 values and visual judgements of the colour and structure of raw, cured longissimus dorsi muscle

Relationship with PSE structure

From the samples of raw, cured longissimus dorsi judged, 5 groups were selected which represented,

1. a uniform, dark colour (not PSE in structure)
2. a uniform or fairly uniform, light colour (PSE in structure)
3. a PSE structure but dark in colour (high pigment content)
4. a light PSE area in the centre of an otherwise non-PSE muscle
5. other non-uniform PSE samples

The pH_2 values of these groups were averaged and compared.

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When the PSE area was large enough, samples from group 4 were divided into the lighter and darker areas and the pH determined in each. To ensure that any differences found were not due to a natural pH variation over the longissimus dorsi muscle, 28 uniform or fairly uniform and 30 non-uniformly coloured raw, cured samples were divided into 3 portions, the areas adjacent, median and furthest from the spine respectively, and the pH determined in each. Finally, to determine the relationship between pH_2 values and pH values after curing, the pH was determined in 172 samples of raw, cured longissimus dorsi and the result compared with the pH_2 values in the uncured muscle.

Relationship with DFD structure

Samples visually judged to be beefy and/or glazy in appearance were divided into 4 groups which represenied,

1. a very beefy and glazy appearance
2. a beefy and glazy appearance
3. a slightly beefy and glazy appearance
4. other beefy and glazy samples (very slightly affected or affected in part of the muscle only)

The pH_2 values of these groups were averaged and compared.

Results

All 4 groups which had been to a greater or lesser extent PSE in the uncured state had lower average pH_2 values than the normal non-PSE group (Table 1), but only with the group showing a PSE area in an otherwise normal muscle was the difference statistically significant. This was somewhat unexpected since at least 1/2 - 2/3 of the muscle in this group appeared normal in structure. All 4 groups which had been judged to be beefy and/or glazy in appearance had signiticantly higher pH_2 values than the normal, non-PSE group.

Table 1. Relationship between visual judgements and pH_2 values

Group description	No. of samples	pH_2 value			
		Average	s	Highest value	Lowest value
Uniform/fairly uniform light colour(PSE)	53	5.36	0.11	5.49	5.00
PSE area in centre of a normal muscle	155	5.28	0.08	5.50	5.08
Other non-uniform PSE samples	149	5.34	0.12	5.59	5.10
PSE structure but dark in colour	35	5.38	0.08	5.50	5.21
Uniform, dark colour (non-PSE)	239	5.43	0.10	5.65	5.28
Very slightly beefy and glazy	18	5.78	0.10	6.01	5.68
Slightly beefy and glazy	42	5.82	0.14	6.13	5.60
Beefy and glazy	25	6.07	0.29	7.22	5.62
Very beefy and glazy	16	6.39	0.31	6.93	5.80

There was little variation in pH over longissimus dorsi samples which had a uniform, dark colour in the raw, cured state. Samples which were uneven in colour showed a slightly greater variation in pH, while samples with a PSE area in an otherwise normal muscle showed the greatest variation of all (Tables 2 and 3).

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Table 2. Variation in pH over raw, cured longissimus dorsi muscle ± 2 x total standard deviation (95 % confidence level)

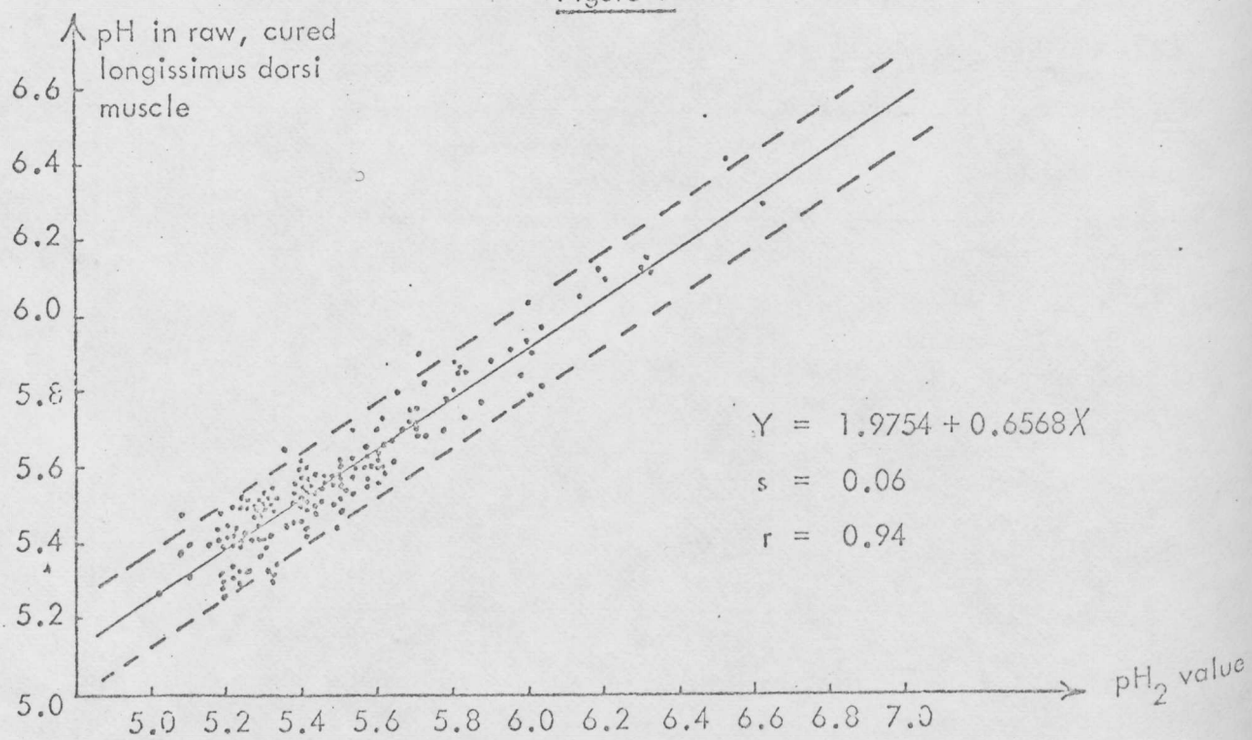
Group	No. of samples	pH value in raw, cured state				
		Adjacent	Median	Furthest	Average	Range
Uniform colour	28	5.61 ± 0.14	5.59 ± 0.14	5.60 ± 0.14	5.60 ± 0.14	0.03 –
Non-uniform colour	30	5.48 ± 0.14	5.43 ± 0.18	5.46 ± 0.22	5.45 ± 0.18	0.08 –

Table 3. pH values in the light and dark areas of raw, cured longissimus dorsi samples with a PSE area in an otherwise normal muscle ± 2 x total standard deviation (95 % confidence level)

No. of samples	pH_2 value	pH value in raw, cured state		
		Light area	Dark area	Difference
12	5.29 ± 0.16	5.29 ± 0.16	5.43 ± 0.10	0.14 –

The relationship between pH values before and after curing (Figure 1) shows that the pH was considerably levelled out on curing, so that the lower pH_2 values showed an increase in pH on curing, while the higher pH_2 values showed a decrease. The cross-over point occured at a pH of 5.7.

Figure 1



Using the above equation, it can be seen that the pH_2 values in the light area of the samples in Table 3 must have been very low indeed, probably less than 5.00 in several cases.

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Experiment II. Relationships between pH_2 values and R_{535} and colour uniformity values in raw, cured longissimus dorsi muscle

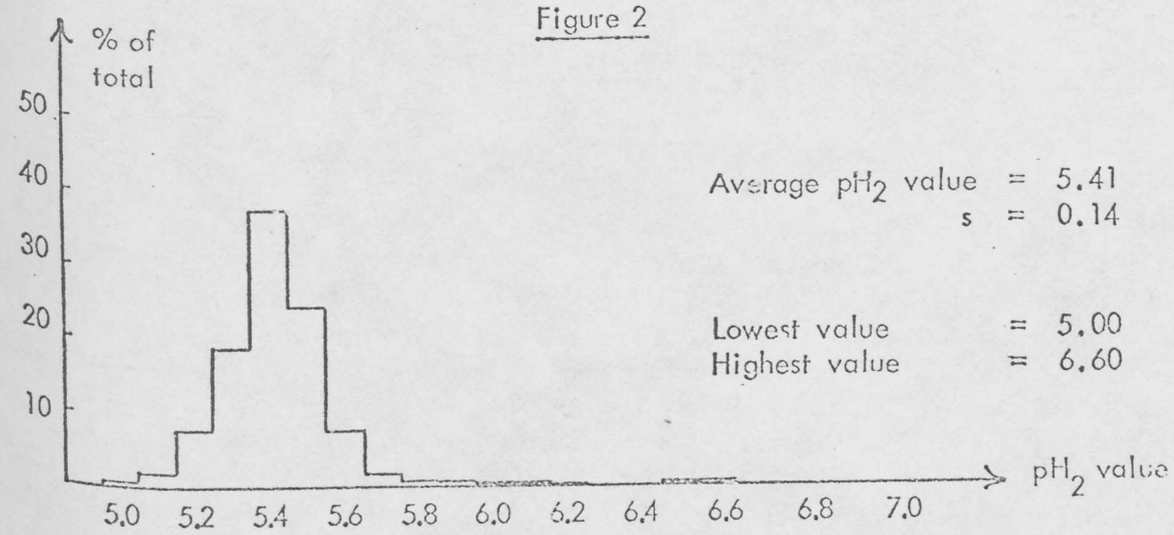
The results of pH_2 determinations and R_{535} and colour uniformity measurements on the raw, cured longissimus dorsi muscle of 2,900 pigs, subjected to a similar pre-slaughter treatment (transportation distance 3 km ; holding time in pens generally under 10 minutes) were treated statistically.

Results and discussion

Distribution in results

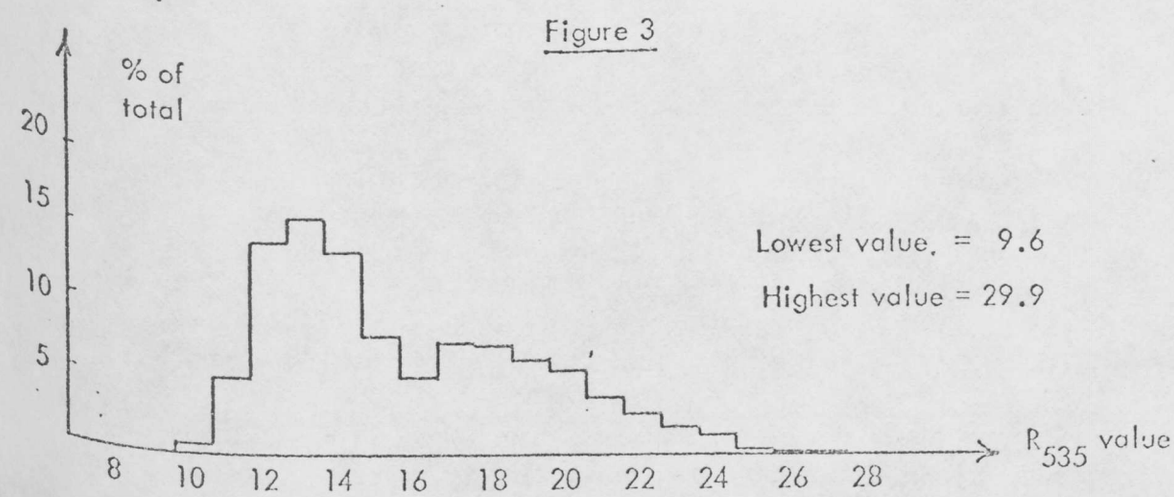
The distribution in pH_2 values was normal (Figure 2).

Figure 2



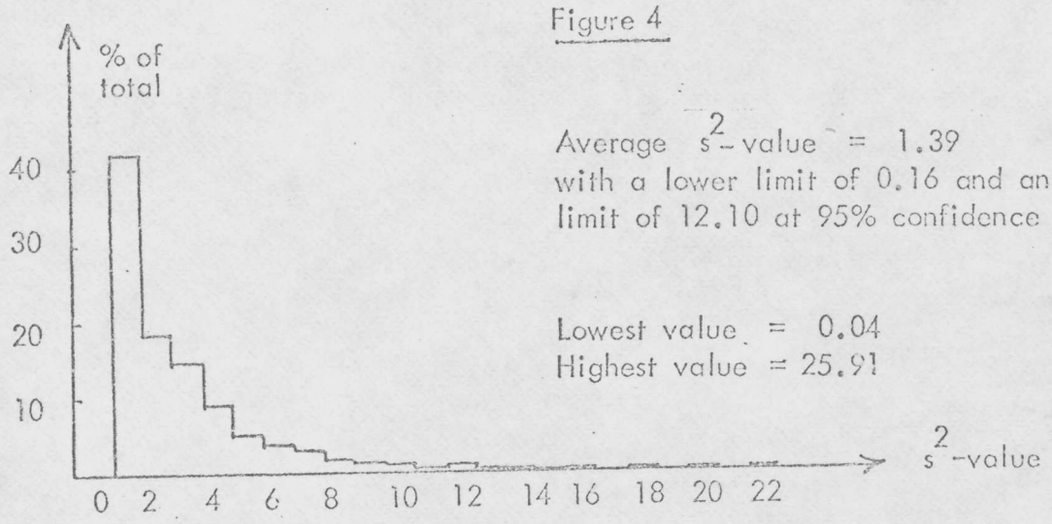
The distribution in R_{535} values was not normal but bimodal (double-peaked) (Figure 3). A closer investigation showed that it was a mixture of 2 normal distributions, one with a maximum of approximately 12.8 reflectance units and one with a maximum of approximately 17.8 reflectance units. 44% of the pigs belonged to the first population and 56% to the last. The 2 populations divided at a reflectance value of approximately 15.0, which is the level at which a sample becomes visually PSE in structure (author, unpublished work). The bimodal distribution in R_{535} values is, therefore, a reflection of the distribution in pH_1 values which is known to be bimodal for Danish Landrace (Wismer-Pedersen and Riemann (1960) ; Buchter (1970)).

Figure 3



The distribution in colour uniformity values was logarithmically normal (Figure 4).

Figure 4



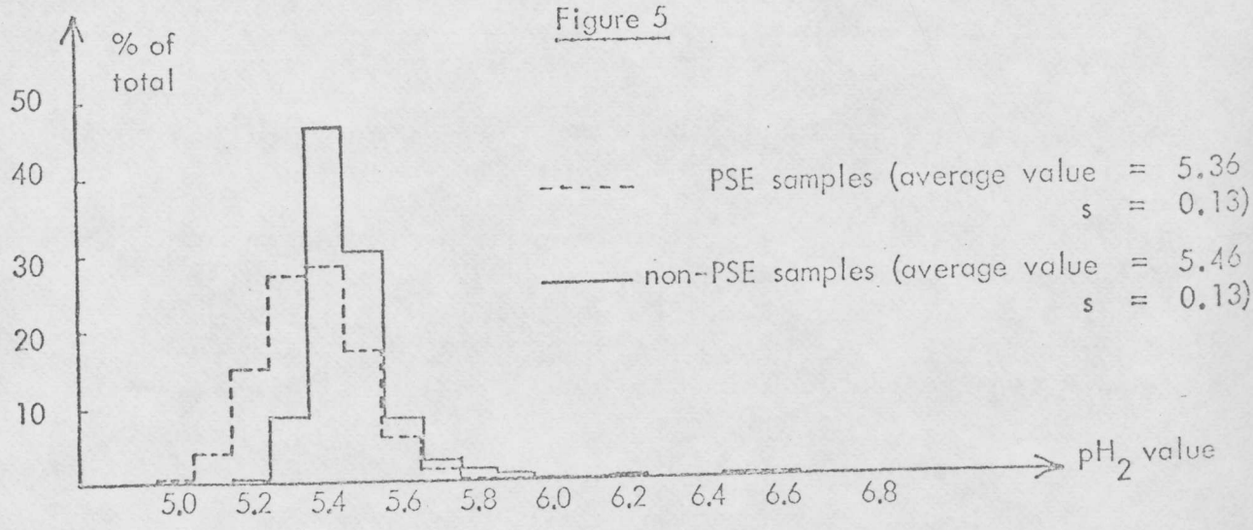
Average s^2-value = 1.39
with a lower limit of 0.16 and an upper limit of 12.10 at 95% confidence level.

Lowest value = 0.04
Highest value = 25.91

Relationships between pH_2, R535 and colour uniformity values

The statistical analysis showed that pH_2 values of 5.30 and below were related to that population in R535 values with a maximum at 17.8 reflectance units, i.e., the PSE samples. A plot of pH_2 values for non-PSE samples ($R535 < 15.0$) and PSE samples ($R535 > 15.0$) respectively (Figure 5) showed that on average PSE samples had a lower pH_2 value than non-PSE samples, and that 35.6 % of the PSE samples had pH_2 values of 5.30 and below, whereas only 3.4% of the non-PSE samples had such low pH_2 values.

Figure 5



Keeping the pH_2 value constant, a plot of variance against R535 value also showed a change in character at an R535 value of 15.0, i.e., at the point where non-PSE and PSE samples divide. For non-PSE samples ($R535$ value < 15.0), the uniformity of the colour was linearly related to the R_{535} value, (the darker colours being the most uniform) but the slope and level of the relationship were dependent on the pH_2 value. The highest numbers of pigs with an uneven colour were found with pH_2 values of 5.30-5.34 or less. For PSE samples ($R_{535} > 15.0$) the uniformity was independent of the R535 value but dependent on the pH_2 value, the lower the pH_2 value the more uneven the colour.

Generally the variance was larger than 2 for PSE samples and less then 2 for non-PSE samples with pH_2 values greater than 5.30-5.34.

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Conclusions

pH_2 values of 5.30 and under and 5.70 and over were found to give a poorer quality in raw, cured longissimus dorsi muscle.

pH_2 values of 5.30 and under were found to be generally associated with a PSE structure in raw, cured longissimus dorsi muscle and nearly always with an uneven colour in that muscle. The uniformity of the colour in PSE samples was directly related to the pH_2 value, the lower the pH_2 value the more uneven the colour. The uniformity of the colour in non-PSE samples was not directly related to pH but again the lower pH_2 values gave the most uneven colour.

pH_2 values of 5.70 and over in longissimus dorsi muscle were found to be associated with a beefy, glazy appearance in the bacon produced.

References

Buchter, L. (1970) Private communication.
Wismer-Pedersen, J. and Riemann, H. (1960) Pre-slaughter treatment of pigs as it influences meat quality and stability. Proc. 12th Res. Conf. A.M.I.F. p. 89.

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