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BACON - FARVE
Manuskript nr. 283 E

Some Experience on the Colour Measurement of Bacon

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Summary

Subjective colour measurement has many obvious disadvantages. In order to obtain results which can be compared from one time to another an objective method is required. This paper contains some initial research on an objective method of colour measurement of bacon using the international C.I.E. system.

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Introduction

Many methods are known for the measurement of colour. For meat surfaces it is possible either to extract the pigments and measure the content of each or to measure the reflected light at various wavelengths.

In cured meat there are at least four pigments, nitrosomyoglobin, myoglobin, oxymyoglobin, and metmyoglobin, as well as meat proteins etc. Using extraction methods the amount of nitrosomyoglobin alone and the amount of all four together can be determined quite accurately (by a modification of Hornsey's method). Several rather less exact extraction methods allow the determination of oxymyoglobin and metmyoglobin + myoglobin (Broumand et al. 1958). Pigment determinations alone, however, give little indication of the visual colour, since water-binding capacity, muscle structure, etc., are also of importance.

Reflection measurements with a spectrophotometer and reflectance attachment can give a good description of the colour if the reflection over the whole visible range is measured with sufficiently small wavelength intervals. From this reflectance curve the C.I.E. colour co-ordinates can be calculated. All that concerns the colour itself will come into the measurement i.e. "fluorescence" on the surface etc., but not factors such as an uneven colour distribution (only the average colour over the measuring area (which is about 2 cm square) is taken), and translucent surfaces as distinct from denser surfaces. However, by using an objective method, the really subjective factors such as the influence of the surroundings, the tiredness of the eye, the observer's humor etc. etc. as well as the level of the available samples, are not taken into account during the measurement. In addition of course an objective method gives results which can be compared from one time to another.

The C.I.E. System

The physiological visual impression of a coloured object is dependent on three things, the chemical and physical characteristics of the object, the spectral composition of the light source, and the spectral sensitivity of the eye. If any one of these factors is changed,

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the colour perceived will change. All these factors are taken into account in the C.I.E. system of colour measurement, which is calculated on the basis of the colour perception of a large number of individuals. The colour measurement is based on the combination of the three primary colours (red, green, and blue) to give the required match. The C.I.E. system represents the three attributes of colour i.e., hue, saturation, and brightness as numbers when viewed under a standard light source by a standard observer.

The C.I.E. colour space can be visualised as a three-dimensional system, consisting of a solid which is made up of all real colours about a black-white (Y) axis (shown in Fig. 1). If a slice of this colour solid is taken the so-called chromaticity diagram is produced. A chromaticity diagram is shown in Fig. 2, W being the black-white axis. The theory behind this will not be discussed but from a reflection curve, the chromaticity co-ordinates (x, y), which indicate the measured colour's place in the diagram, and the brightness Y, which gives the colour's place at right angles to the plane, can be calculated. The chromaticity co-ordinates in themselves do not indicate the colour, the dominant wavelength and saturation being used instead. The dominant wavelength is defined as the corresponding spectral colour's wavelength (B in Fig. 2) and the saturation, as the distance from the white point (W) to the co-ordinates of the colour divided by the distance of W from the corresponding spectral colour ($\frac{WA}{WB}$ in Fig. 2).

Preliminary Work

The main colouring pigment in bacon is nitrosomyoglobin which is formed by the combination of the natural pigment of fresh meat, myoglobin, with nitric oxide during the curing process. Exposure to light and air results in the oxidation of nitrosomyoglobin to metmyoglobin when the colour changes from pink to brown. These two pigments are of prime importance in bacon. Therefore, as a preliminary to further work on the standardisation of an objective method of colour measurement, the position of these two pigments in the chromaticity diagram was found.

Nitrosomyoglobin

Slices of back bacon (10), about 2 cm thick, were trimmed and vacuum packed. They were allowed to stand, at 0°C, for 24 hours to allow conditions in the meat to come

to equilibrium. The spectrum was measured at 10 mμ intervals from 400-700 mμ using a Zeiss spectrophotometer (PMQII) with a reflectance attachment, and the C.I.E. co-ordinates Y, (x, y) calculated.

Metmyoglobin

Slices of back bacon (6) were exposed to light (about 1000 lux) and air for 4-6 hours, inside a plastic bag to minimise drying out of the surface. After exposure the slices were vacuum packed and the spectrum measured immediately, so that as little colour regeneration as possible occured. The C.I.E. co-ordinates were calculated.

The average results of the two pigments with standard deviations (95 % significant) are shown in table 1.

Table 1

	Y	x	y
Nitrosomyoglobin	12.8 ± 1.7	0.383 ± 0.008	0.321 ± 0.002
Metmyoglobin	13.3 ± 2.5	0.360 ± 0.002	0.332 ± 0.005

As expected the x, y values of the two pigments are quite separate, although the brightness (Y) values were not significantly different.

Oxymyoglobin

Several attempts were made to obtain an oxymyoglobin spectrum for bacon, by exposing bacon to air in the dark. However, the concentration of this pigment was evidently so small that its presence in the spectrum could not be detected.

In addition a short investigation was carried out to estimate the influence of fat (present as marbling) on the colour measurement. For this 4 slices of back fat, about 2 cm thick, were vacuum packed and the spectrum measured as before. The C.I.E. co-ordinates were calculated and are shown in table 2.

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Sample No.	Y	x	y
1	69.55	0.328	0.328
2	66.89	0.332	0.329
3	66.34	0.332	0.330
4	65.90	0.334	0.332

All the co-ordinates are found close to the W-point (x, y = 0.333, 0.333) so that a small amount of fat in the measuring area will not change the dominant wavelength greatly. However, fat will have a great influence on the brightness value and the saturation, so that the presence of fat in the measuring area is to be avoided if possible.

Later work

Having established the positions of the two pigments in the C.I.E. colour space, a further investigation was carried out to see if the preparation of a colour scale for bacon in the C.I.E. colour space was a possibility. Vacuum packed back bacon containing little or no fat was taken as before, and after 1-2 days storage at 0°C a visual judgement of the colour was carried out. The scale used was from 0 to 10, 10 being the best possible colour, 9 very good, 8 less good, etc. The judgement was carried out under C.I.E. C-light using a colour scale, so that visual judgements were standardized from one time to another. After the visual judgement the spectrum was taken using this time, a Zeiss recording spectrophotometer (R.P.Q.20.A.) and the C.I.E. co-ordinates calculated separately for each visual score. Standard deviations were calculated for scores 6-9 but not 5-4 since the number of samples was too small.

The average figures for each visual score are shown in table 3.

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Table 3

Average figures ± 2 x standard deviation (95% significant)

Visual score	Number of samples	Y	x	y
9	14	21.94 ± 1.32	0.3665 ± 0.0040	0.3287 ± 0.0022
8	14	23.76 ± 1.68	0.3655 ± 0.0048	0.3278 ± 0.0040
7	18	26.14 ± 2.00	0.3646 ± 0.0034	0.3284 ± 0.0020
6	7	28.68 ± 2.60	0.3635 ± 0.0030	0.3289 ± 0.0034
5	3	33.13	0.3602	0.3320
4	2	34.98	0.3604	0.3390

The x values show a trend to become smaller with decreasing visual score but none of the values was significantly different from any of the others except possibly the highest and lowest. There was no difference between the y values of the first four visual scores (6-9) although scores 5-4 were rather larger than the rest. Thus no difference was found in the position in the chromaticity diagram between the various scores for 6-9. Further work is necessary to see if in fact scores 5-4 are significantly different from the others. Figure 3 shows the positions of the average values for each score on the chromaticity diagram. It can be seen that for scores 9-6 there was no difference in dominant wavelength, while as expected the saturation tended to become smaller with decreasing visual score.

Scores 5 and 4 were rather different both in dominant wavelength and saturation but in the absence of more samples, no conclusions can be drawn.

The Y-values, however, showed an increase with decreasing visual score. While the Y-values of adjacent visual scores were not found to be significantly different, those of scores separated by two were i.e. 9 from 7, 8 from 6 etc. Thus, while x, y in themselves were not significantly different from one score to another, the Y-values show some promise of being useable as a scale.

References

Broumand, H. et al. Food Techn. 12, 65 (1958)

Hornsey, H.C. J. Sci. Food Agric. 7, 534 (1956)

JLB/PB/BL

Figure 1

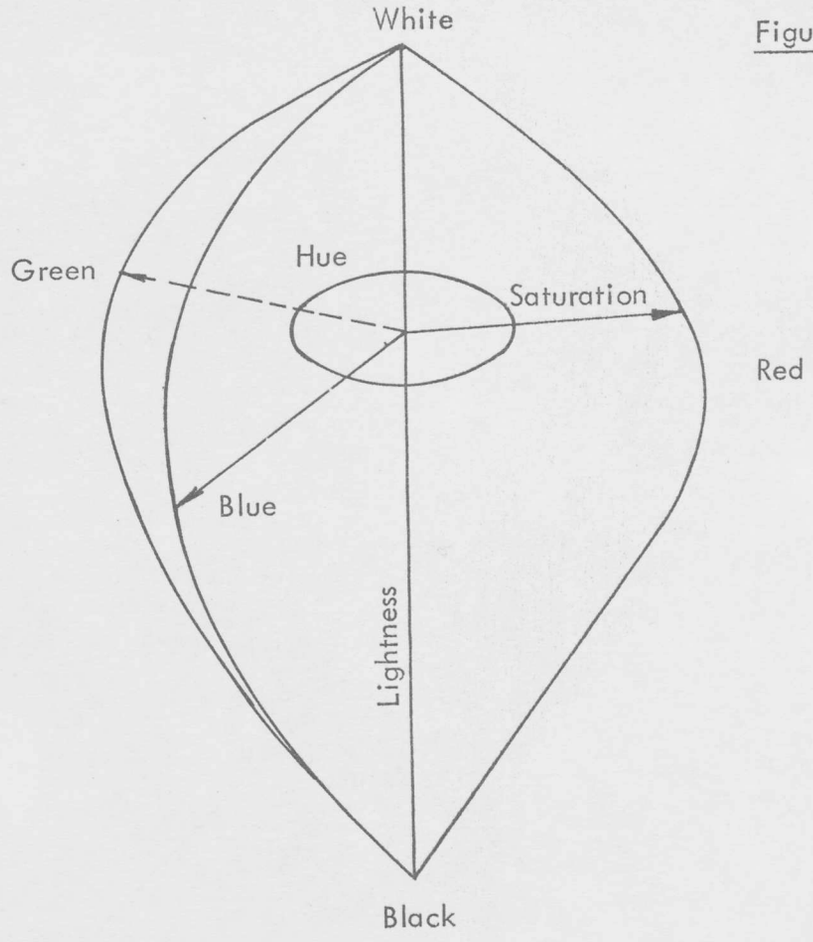

Figure 3

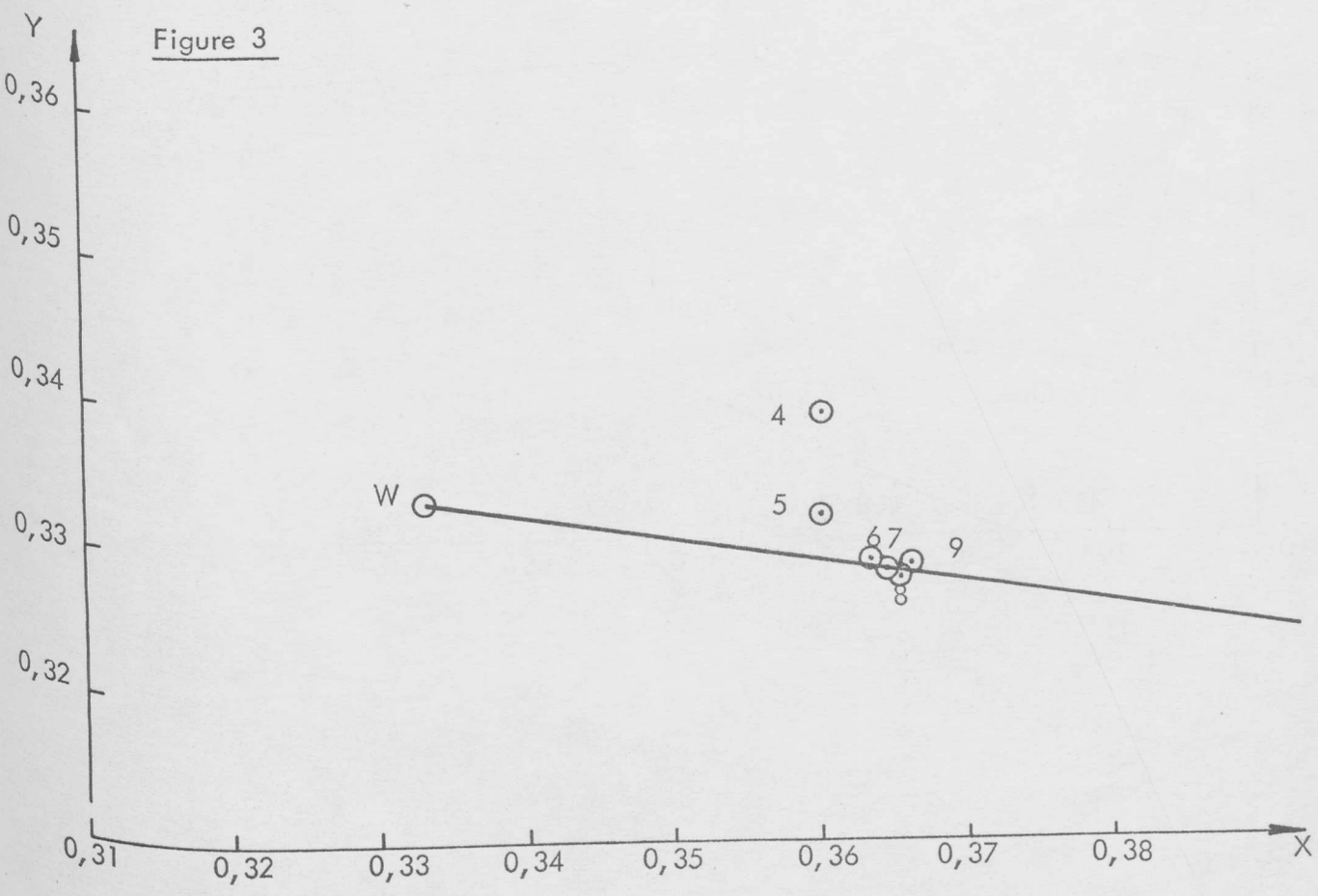

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Figure 2