INFLUENCE OF SAMPLE ILLUMINATION AND VIEWING ON THE COLOUR MEASUREMENT OF TRANSLUCENT MATERIALS LIKE MEAT.

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Introduction.

Practically all biological products are from a optical point of view translucent. In translucent materials the penetration depth of light is in the order of several millimeters.
Measurement of colour of a translucent object with either a tristimulus or a spectrophotometer will be affected by edge loss, caused by sideward displacement of light (Ten Bosch et al.1984, MacDougall 1987).
Light is reflected by an object by specular, diffuse and volume reflection. Colour measuring instruments measure the reflection of light with or without the exclusion of the specular component (gloss) (Billmeyer & Saltzmann 1981). The surface structure of an object influences specular reflection. When the surface has a directionality -like a longitudinal cut of meat- gloss will be influenced accordingly (Judd & Wyszecki 1975).
The aim of the study, presented here, was to determine how instrumental colour measurements of translucent materials, such as meat, are influenced by the illumination and viewing geometry of the measuring instrument.

Methods and materials.

Colour measurements were made on two samples of pork, a relative dark and a relative light one. The meat samples were optically infinite thick (>5 cm) transversal cuts of m.longissimus dorsi, with no visible fat or connective tissue. The measurements were made on a fresh cut surface, in this way avoiding colour changes, caused by dehydration and blooming.
From both samples the reflection spectrum was measured with a Hunter Labscan 5000, using a 10 and a 50 mm diameter sample port.
Because of problems with colour stability and colour uniformity of meat, additional measurements were done on another translucent material, namely a sample of white teflon (106x100x35 mm). White material was used, since the effect of instrument geometry can best be determined when reflectance is high at every wavelength.
The surface of the teflon sample had an unidirectional fibrous structure, comparable to the structure of the surface of a longitudinal cut of meat.
As reference object a white, opaque, ceramic tile with no visible surface structure was used.
The objects were measured with three colour measuring instruments: Minolta CR-100 (Tristimulus meter), Hunter Labscan 5000 (Spectrophotometer) and Photoresearch PR-710/AM (Spectroradiometer). The Hunter Labscan can be used with different diameters of the sample port. Both the smallest (10 mm) and the largest (50 mm) ports were used in the experiment.
With the Minolta diffuse illumination and a 0 degree viewing angle, the Hunter a 0 degree illumination and a 45 degrees circumferential viewing angle and with the Photoresearch a 0 degree illumination and a 45 degrees unilateral viewing angle was used.
The teflon sample was measured twice, once with the fibrous structure in direction A and once in direction B, turned 90 degrees relative to direction A.
CIELAB values were calculated, according to Billmeyer and Saltzmann (1981) from the measurements using Illuminant D65 and CIE 1931 Standard Observer.

Results.

Figure 1 shows that with decreasing sample port size the total level of reflectance of the meat decreases.

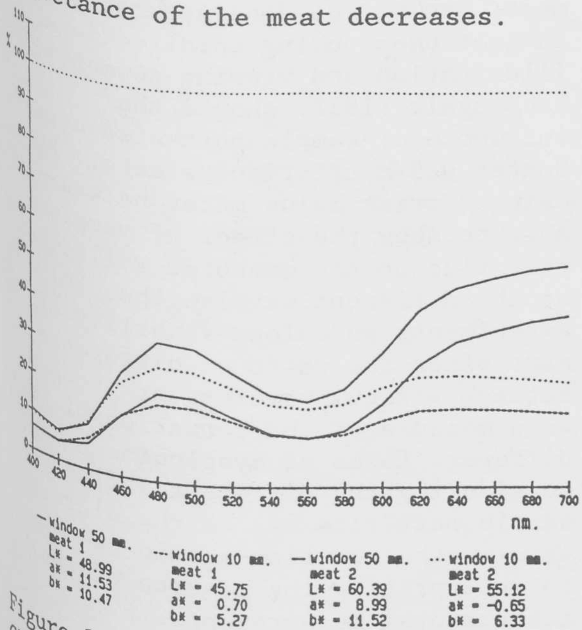

Figure 1.Reflection spectra and CIELAB values of a light and a dark m.longissimus dorsi, measured with a Hunter Labscan 5000 with a 10 and a 50 mm diameter sample port.

A decrease in sample port has the result that the meat samples become darker (lower L* value), less yellow (lower b* value) and less red (lower a* value). With the lighter (meat 2) of the two samples the reduction in a* value is that large that the a* value turns negative. This means that the instrument assesses the colour of this meat as slighly greenish.
Table 1 shows the results of the measurements of the teflon sample and the ceramic tile.
Decreasing the size of the sample port decreases both L* and b* values (Minolta and Hunter 10 mm port versus Hunter 50 mm port).
Figure 2 shows that when the sample port diameter is reduced from 50 to 10 mm, the measured reflection percentages of the longer wavelengths are more reduced than that of the shorter wavelengths.

Table 1.CIELAB values, calculated from measurements of a teflon sample and a ceramic tile with three different colour measuring instruments.

	Tile	Teflon A"	Teflon B"
Minolta CR-100			
L*	93.6	78.1	78.1
a*	-1.6	-2.1	-2.1
b*	-0.1	-4.0	-3.9
Hunter Labscan 5000 (10 mm port)			
L*	94.74	78.10	78.45
a*	0.13	-0.90	-0.84
b*	0.42	-3.92	-3.95
Hunter Labscan 5000 (50 mm port)			
L*	94.71	92.20	92.29
a*	0.19	-0.50	-0.51
b*	0.55	3.33	3.22
Photoresearch PR-710/AM			
L*	95.21	99.38	92.41
a*	-0.02	0.10	-0.26
b*	0.93	3.02	3.48

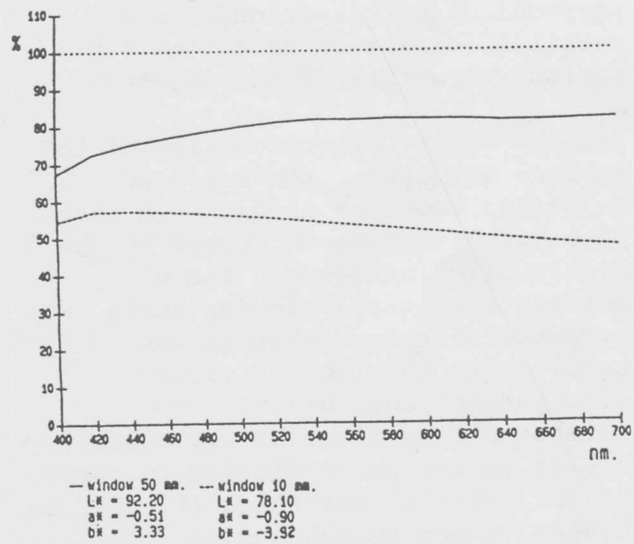

Figure 2. The reflection spectrum of a teflon sample, measured with a Hunter Labscan 5000, with a 10 mm and a 50 mm sample port.

As result the calculated L* a* and b* values will decrease.
The problems presented here, which are related to edge loss, may be

overcome when a large area of illumination is combined with small area of light collection (Ten Bosch et al 1984). This can be realized by using a spectroradiometer.
The teflon sample was measured with a spectroradiometer Photoresearch PR-710/AM, using a total object illumination.

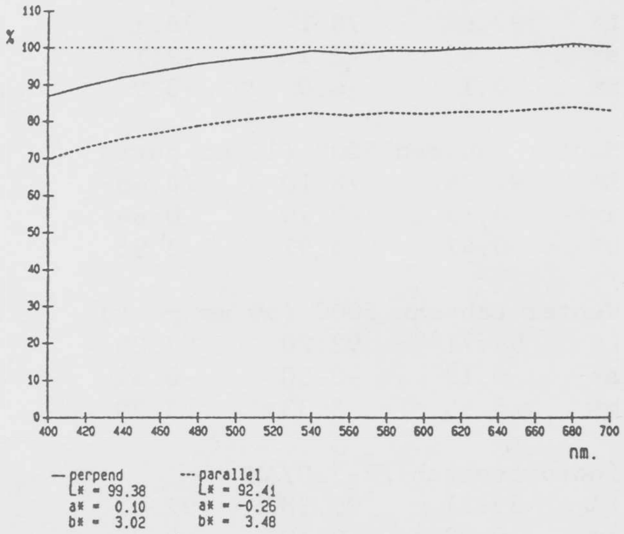

Figure 3.The reflection spectrum of a white translucent teflon sample, measured with a Photoresearch PR-710/AM with the measuring plane perpendicular (direction A) and parallel (direction B) to the fibrous surface structure of the object.

Because of the directionality of the surface structure ,the measured relection was much higher when the plane of measurement, formed by the 0 degree illumination and the 45 degrees unilateral viewing angle, was perpendicular then when it was parallel to the fibrous surface structure of the object.
Allmost all wavelengths are equally higher in the perpendicular compared to the parallel situation (fig 2). In CIELAB values this leads to practically no differences in a* and b* values. Only the L* value is considerably different. In the perpendicular situation the L* value reaches nearly the 100, which means practically perfect white.
A possible explanation might be that in the perpendicular situation gloss influenced the results.

The results suggest that colour measurements of object with a directionality in the surface structure, like a longitudinal cut of meat, can not be done accurate with an instrument using unidirectional illumination and viewing geometry.
MacDougall (1987) showed the influence of sample port size using a Hunter D25-M tristimulus meter. By using a tristimulus meter he was not able to show the effect of sample port size on the measured reflection at the different wavelengths. In experiments on colour stability of meat often the ratio or difference between various wavelengths is used as a measure of the formation of different forms of myoglobin.
Considering the different influence sample port size has on the different wavelengths, caution should be taken in interpreting the results of the instrumental measurements.

Conclusion.

Instrumental colour assessment of translucent materials with a fibrous surface structure ,such as meat, is influenced by the illumination and viewing geometry of the instrument used. This means that instrumental colour assessments, calculations derived from and related to these assessments are only true within the type of instrument used.
When a comparison between studies or experiments, in which different types of instruments for assessment of colour are used, it is essential that the measurements are taken free of edge loss and the influence of gloss.
In practice this means that meat fiber direction and instrument geometry has to be taken into account.

Literature.

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