Colour analysis of fat spreads

Gerard van Dalen, Robert Jan van der Velden;
Unilever Research & Development; P.O. Box 114, 3130 AC Vlaardingen, The Netherlands

Abstract

This paper compares the results of the colour analysis of about 40 different fat spreads using a digital colour imaging system (DigiEye) and two different colorimeters, e.g. the Hunterlab colorimeter (Labscan II) and Minolta colorimeter (Chroma Meter CR400). The colour and appearance of fat spreads is shown to influence the flavour perception and consumer liking. The DigiEye system records colorimetrically accurate images suitable for the measurement of colour uniformity. The three methods were used to analyse the bulk colour. The DigiEye was also used for the determination of the colour of the surface (after removal of the sealing). Linear relations were found between the colour values measured by the tested systems. However better correlations were found between the DigiEye and the Hunterlab Labscan. A linear relation was observed between the sensory scores on yellowness and those obtained by DigiEye, Hunterlab and Minolta. The short term precision of the determination of the yellowness using the DigiEye system is somewhat better than those of the colorimeter. Instead of yellowness also the b* value can be used. The additional benefit of the DigiEye is the assessment of the appearance. For instance the colour and colour uniformity of the surface of the fat spread.

Introduction

Foods have to be sensorially appealing, tasty and preferably healthy. The colour is an important marker, which for manufactured foods can be influenced by processing and used ingredients. Colour is regarded as a key sensorial attribute of foods and is often the first attribute that consumers notice about foods. The consumer perception of colour does not only effect the interpretation of product appearance, but also extends to how product flavour and overall quality is perceived [1]. Further the colour may change or fade during storage, which can be critical for consumer liking.

The preferred colour intensity of fat spreads is linked to the geographic situation e.g. in continental Europe rather pale products are preferred whereas in England (as well as Canada and Australia) deep yellow products are preferred. For fat spreads natural colorants such as annatto, carotenes and curcumin can be used. Alternatively fat spreads may be manufactured from naturally coloured vegetable oils such as palm oil. The colour of fat spreads depends on the type and amount of colorant added and on the surface area and optical density of the light reflecting particles (water droplets and fat crystals). The more particles present the less penetration of light into the product and the more it will be reflected with its original colour (white). As a consequence the product will show a less yellow appearance. The surface colour of a fat spread may darken after exposure to the atmosphere for a period of time. This may be due to evaporation, changing the light-scattering properties and increasing the concentration of the colorant in the surface layer. This surface darkening is considered by the average consumer to be objectionable and distasteful. Surface darkening may be prevented by wrapping or sealing the product.

Visual colour assessment is subjective and difficult to control, dependant, as it is, on the observer and viewing conditions. Colour can easily be measured by instrumental methods such as colorimeters or spectrophotometers [2]. For homogeneous opaque materials with a smooth surface the measured colour will be close to the consumer perception of colour. However, only very few food products are really homogeneous. The surface texture, gloss, shape and form of food products has a dramatic influence on the human perception of colour. This paper compares the results of the colour analysis of about 40 different fat spreads using a digital colour imaging system (DigiEye) and two different colorimeters. The DigiEye system records colorimetrically accurate images suitable for the measurement of colour uniformity, size and shape. This system has been developed for the textile industry [3, 4, 5] and is recently also used in the food industry [6]. Commercial fat spread samples were obtained from different countries in Europe. The three methods were used to analyse the bulk colour. The DigiEye was also used for the determination of the colour of the surface (after removal of the sealing).

Experimental

Digital images were made under controlled lighting using a DigiEye imaging system (VeriVide, UK) with Nikon D70 digital camera and Nikon 35 mm F/2 D lens. The lighting cabinet (illumination box) contains VeriVide D65 fluorescent tubes (artificial day light). With standard diffuse illumination the sample is illuminated by two lamps at 45^o to the sample. For directional illumination the D65 light was directed to the lower mirrors by selecting the angled position. Additional mirrors were placed at the top of the lighting cabinet (Figure 1). The mirrors provide gloss on the sample surface. The visual appearance depends strongly on gloss. For the camera, constant settings were used (1/20 sec – F/7.1, ISO200). For each image, a 12-bits (per pixel) raw file (NEF lossless compressed) and a TIF file were stored. An Adobe RGB colour space (mode 2) was selected. The white balance (preset) was determined using a Gretagmacbeth white balance card. The image resolution is 3008 x 2000 pixels corresponding to 34.0 x 22.6 cm^2. The camera was calibrated using a DigiTizer (DigiEye) colour target (the DigiEye software uses a 35 by 3 multivariate polynomial fit to correlate the RGB values to the known CIE XYZ values of the target). Samples were put into a cylindrical plastic container (petri dish) with an inner diameter of 5.5 cm (2.2). The container was placed at the position indicated in Figure 1.

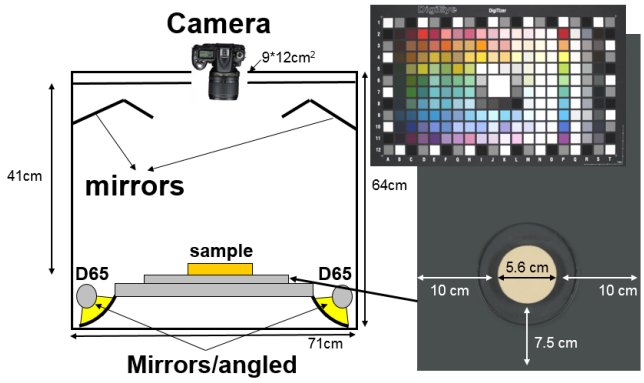

***FIGURE 1**. Schematic overview of the set-up used for imaging of fat spreads (left: front view inside the lighting cabinet of the DigiEye system, right: top view with sample and colour chart used for calibration).*

Normally for colour analysis an even diffuse illumination is needed avoiding bright specular reflections in the image. However under these conditions very dull images without surface texture were obtained. Images have to be used for both appearance and colour analysis. By using directional illumination (angled light and mirrors) gloss was introduced resulting in an image matching the actual appearance of the fat spreads very close. For colour measurement of the fat spreads an area was selected on the surface.

The method was tested using commercial fat spread samples from different countries in Europe. The fat content ranges from 10-80%. Images were made of the bulk and surface of the fat spread sample (Figure 2). Images of the bulk were obtained after removal of a thick upper layer from the top before sampling. The samples were put in plastic petri disks with a diameter of 55 mm and height of 9 mm. A flat and smooth surface layer was created by using a flat spatula (Figure 3). For the surface layer of the fat spread sample in the tub was imaged after removal of the sealing layer.

***FIGURE 2.** Imaging of the surface (left) and bulk (right) of a fat spread sample using the digieye system (diameter of sample cup 5.6 cm).*

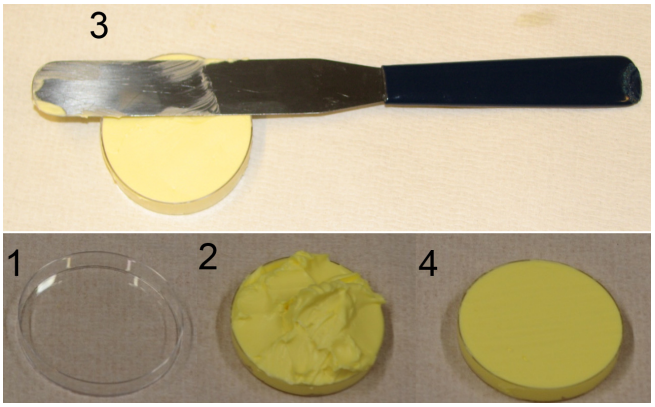

***Figure 3.** Sampling of fat spreads.*

For comparison the colour of the samples was measured using a Hunterlab colorimeter (Labscan II) and Minolta colorimeter (Chroma Meter CR400).
The Labscan II was calibrated under CIE D65, 10º, 0/45 conditions using white and black standard reflective plates. An illumination distance of 44 mm (area view: 1.75´´) and a large opening (port size: 50 mm = 2.00´´) was selected. As reference, red and green tiles were used. The plastic petri dish with sample was placed on top of the instrument port and covered with a black opaque cover (no significant difference was measured between a plastic petri dish and the standard glass containers). The opaque cover prevents any ambient light from outside the instrument from leaking into the detector. The Minolta CR400 colorimeter was calibrated under CIE D65, 2º, Diffuse illumination/0º (specular component included) conditions using a white standard reflective plate. The plastic petri dish with sample was placed on the measuring head (diameter measuring area = 8mm) of the colorimeter. Every colour measurement was made in three readings per sample.

The yellowness Index per ASTM method E313 is calculated using the following formula:

$$YI\ E313 = \frac{100\left(C_x X - C_Z Z\right)}{Y}$$

Where X, Y and Z are the CIE tristimulus values and the coefficients depend on the illuminant and observer. For D65/2º the following coefficients are used: $C_X = 1.2985$ and $C_Z = 1.1335$.

The yellowness values obtained by the DigiEye system and the colorimeters were compared with those obtained by a trained sensory descriptive panel. The spreads were evaluated in 25 sensory panel sessions. The number of panellists was 10 -13 and each panellist assessed each product twice in a randomized order. Products were offered chilled at 5 °C (from the fridge) in panel cabins and under artificial day light (D65).

The height of the samples may influence the colour analysis. The height of the tubs ranges from 36 to 80 mm whereas the height of the sample holder placed on the ground plate is 9 mm. To investigate the influence of the height, images were made of a fat spread in a sample holder at different heights (placing black circular rings with a heights ranging from 10 to 35mm below the sample holder). As can be seen from Figure 4, the colour is influenced by the height. The largest impact is on the L* value. The brightness decreases higher in the cabinet. A difference in height larger than 30mm resulted in a colour difference dE larger than 2 (a dE value of 2 is generally considered to be just visible). For comparison the samples should be measured at the same height. The surface layer of the fat spread in the tub (standard 500g spread tub) was imaged at a height of 80±5 mm (distance of spread surface to sampling plate). Smaller tubs were placed on one or more rings. The petri dishes with the bulk samples were imaged on the ground plate (9mm) and at a height of 80mm. A good correlation was found between the results at 9mm and 80mm (Figure 5). The results obtained at 80mm (top surface of fat spread) can be corrected to those at 9mm which are better in agreement with the calibration (calibration chart at the ground plate).

Results

For validation of the method 40 different fat spreads were analysed using the DigiEye system under angled illumination and two different colorimeters: Hunterlab Labscan II and Minolta CR400. The used colorimeters have different geometry (0°/45° for Labscan and diffuse/0° & specular included for the CR400). A 0°/45° geometry will better match the visual appearance of the product. For both visual assessment and colour analysis using a 0°/45° geometry, a glossy sample may appear darker and more saturated than a matte sample with comparable concentrations of colour compounds. Diffuse/0° colorimeters, used in the specular included mode, minimize the effect of differences in gloss, texture and directionality. It will result in comparable results for samples with comparable concentrations of colour compounds but with a different gloss and therefore different visual appearance. The difference between the CIE standard observers used in the Labscan II and CR400 (resp. 10° and 2°) will only have a small effect on the measured CIE Lab values.

Linear relations were found between the CIE Lab values measured by the DigiEye system and those measured by the Labscan II and CR400 (see Figure 6 and 7). The bad correlation of a* coordinate between DigiEye and Minolta can be caused by a difference in geometry (angled versus diffuse). Better correlations were found between the DigiEye and the Hunterlab Labscan (angled). The DigiEye results are in close agreement with the Labscan. However, results of the DigiEye and Labscan cannot directly be interchanged for product specification. For direct comparison, only instruments of the same geometry have to be used (preferably from the same brand and model). For inter-instrument agreement, the DigiEye system can be calibrated using fat spread samples. A reasonable correlation exists between XYZ values of the DigiEye and Labscan.

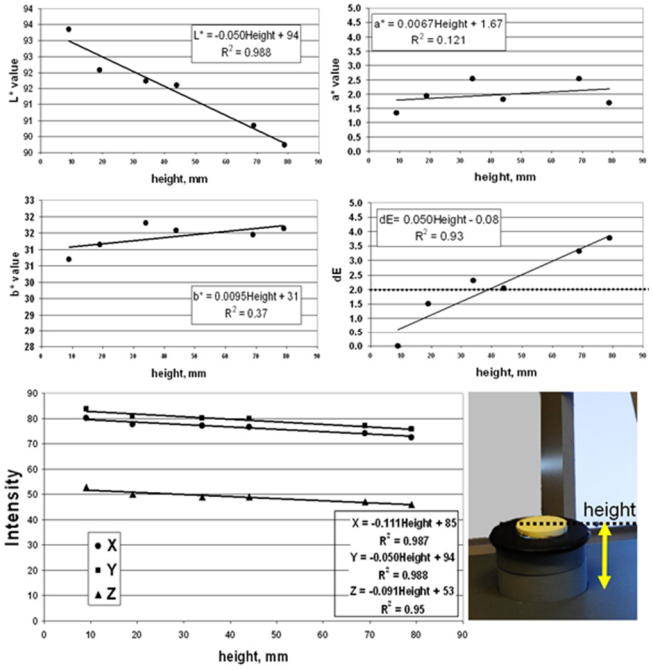

Figure 4. Influence of the height of surface on the measured colour (height = distance between surface and sampling plate).

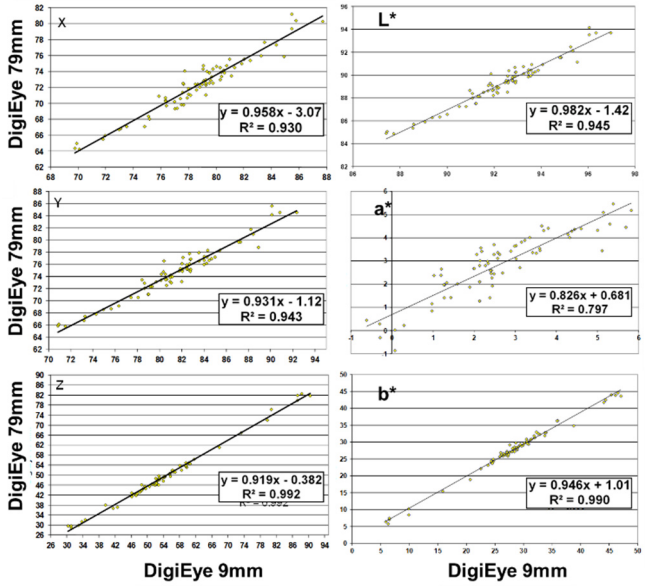

Figure 5. Comparison of the colour analysis of fat spreads at a height of 9mm and 79mm (resp. the surface height of a petri dish and a standard 500g spread tub).

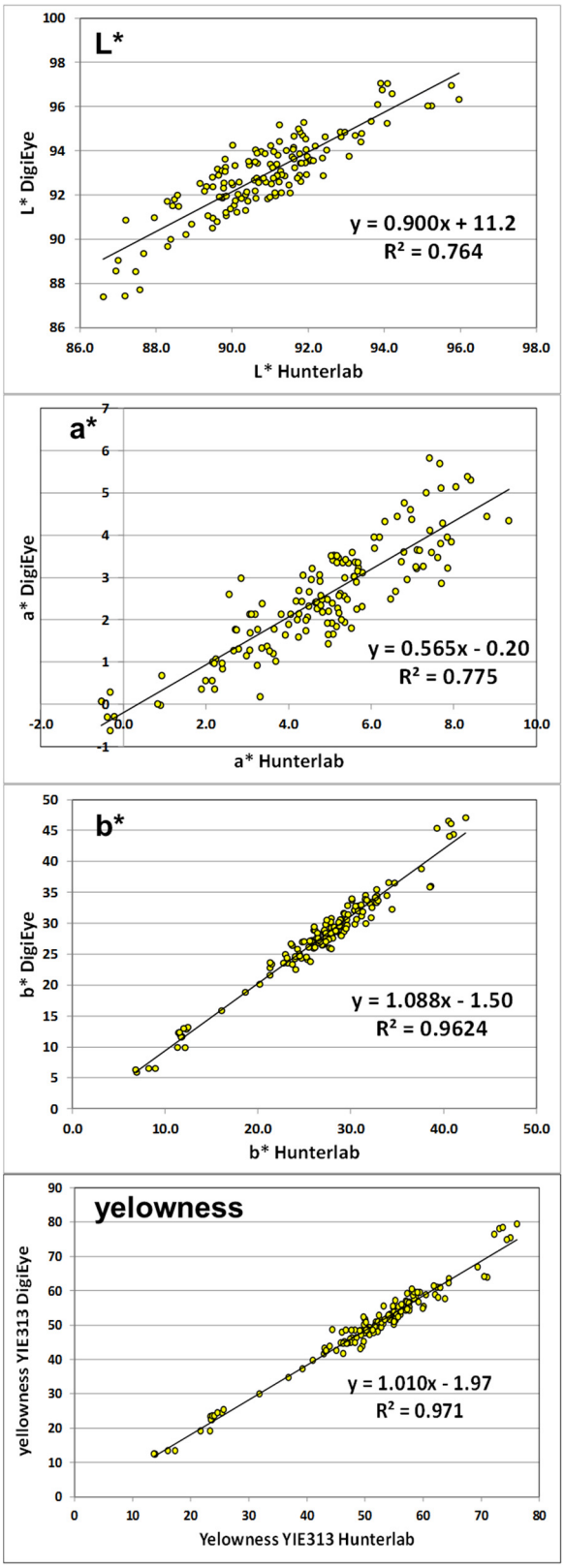

Figure 6. CIE Lab and yellowness values of fat spreads measured using the DigiEye system versus values obtained using the Hunterlab Labscan colorimeter.

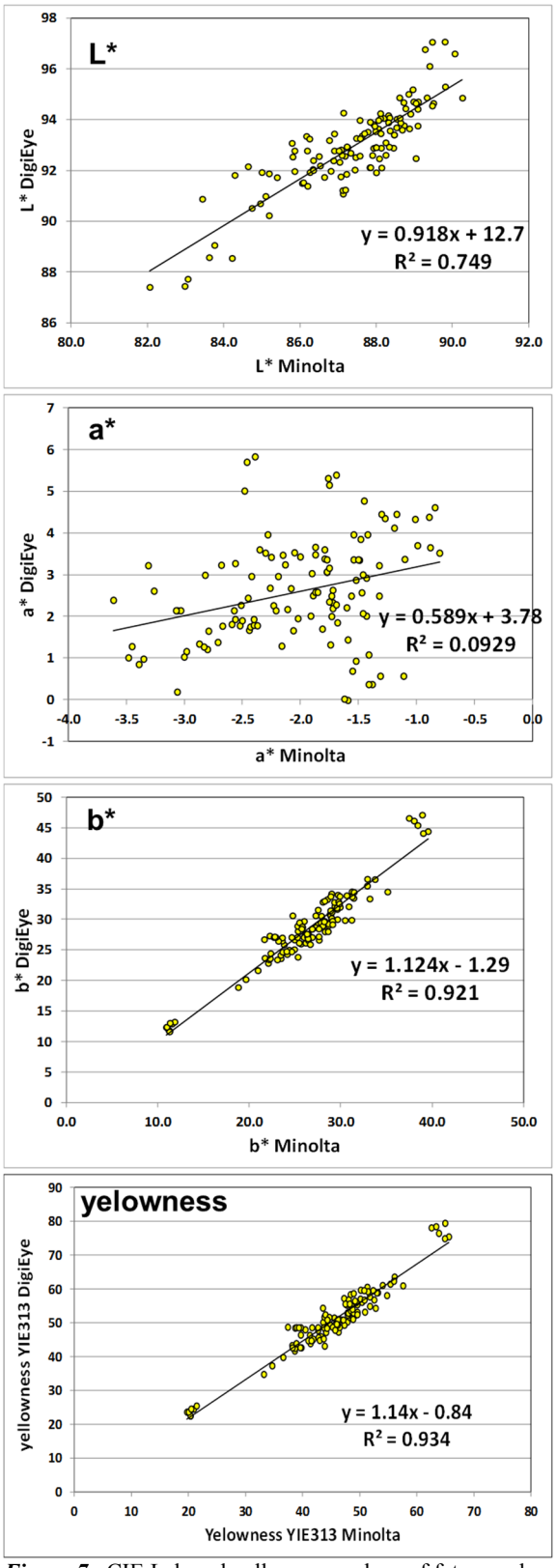

Figure 7. CIE Lab and yellowness values of fat spreads measured using the DigiEye system versus values obtained using the Minolta CR400 colorimeter.

A linear relation was observed between the sensory scores on yellowness and those obtained by DigiEye, Hunterlab and Minolta. (Figure 8).

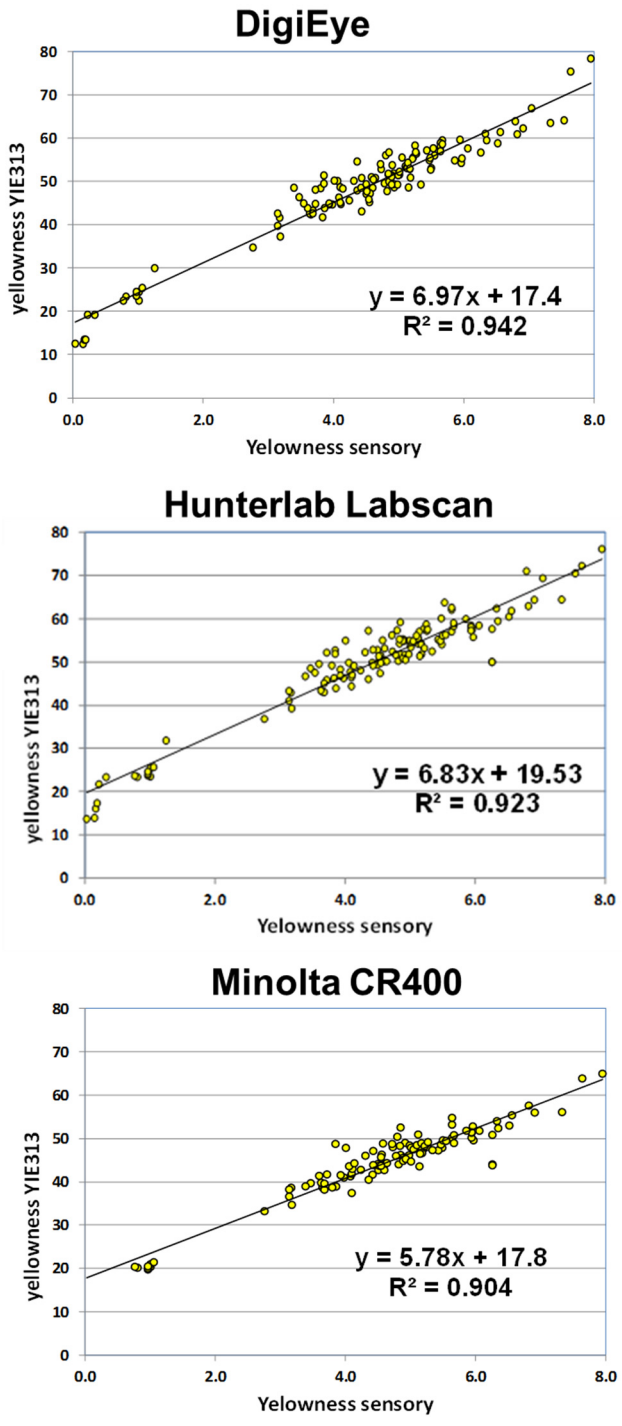

Figure 8. Yellowness (YIE313) analysed using the DigiEye system and Hunterlab LabScan and Minolta CR400 colorimeters as function of the sensory score.

The short term repeatability of the DigiEye system under directional illumination is compared to those obtained by the Labscan II and CR400 in Table 1. The repeatability of the DigiEye under directional illumination is comparable better to the Labscan 6000 and the CR400.

Table 1. Precision parameters of fat spread samples determinated by analysing 6 samples in triplicate (s1 = standard deviation of the short term repeatability (r1)).

	L*		a*		b*	
	s_1	r_1	s_1	r_1	s_1	r_1
DigiEye 9mm	**0.18**	**0.51**	**0.28**	**0.79**	**0.44**	**1.24**
DigiEye 79mm	**0.33**	**0.93**	**0.40**	**1.13**	**0.71**	**1.43**
Labscan II	**0.36**	**1.03**	**0.11**	**0.30**	**0.54**	**1.54**
CR400	**0.35**	**1.00**	**0.13**	**0.37**	**0.61**	**1.71**

For 40 fat spread samples the colour was analysed of the surface and the bulk using the DigiEye system. The colour difference is mainly due to an increase of the b* value (linear relation between ΔE and Δb*, see Figue 9). Some representative images are shown in Figure 10.

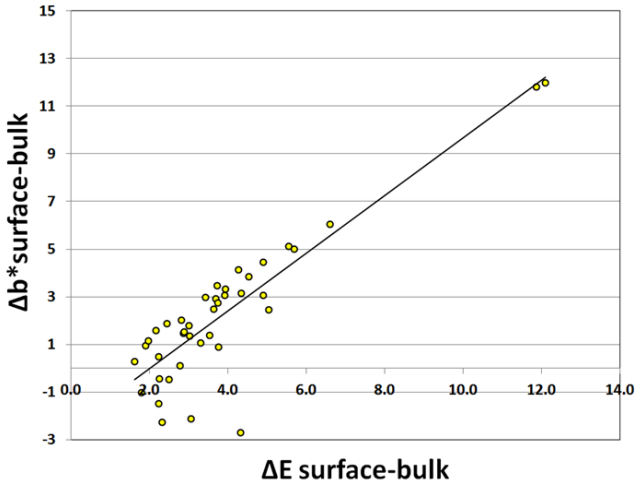

Figure 9. Colour of fat spreads (bulk sample) with colour difference between surface and bulk.

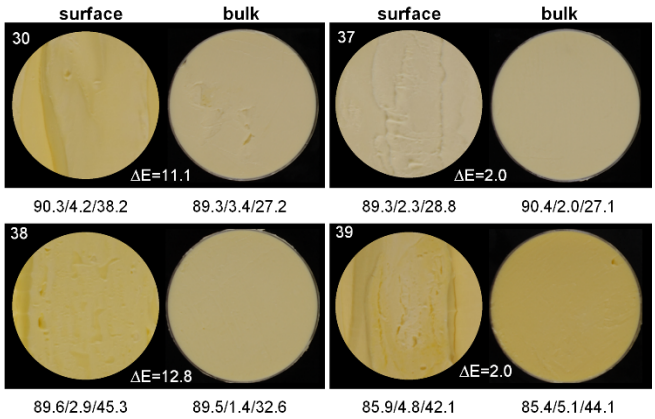

Figure 10. Comparison of images (diameter 55m) of the surface and bulk of fat spread samples (with CIE Lab values and colour difference between surface and bulk).

Conclusion

The colour of fat spreads can be measured using colorimeters (Hunterlab Labscan or Minolta CR400) or a digital colour imaging system (DigiEye). Linear relations were found between the colour values measured by these systems. However better correlations were found between the DigiEye and the Hunterlab Labscan. A linear relation was observed between the sensory scores on yellowness and those obtained by DigiEye, Hunterlab and Minolta. The short term precision of the determination of the yellowness using the DigiEye system is somewhat better than those of the colorimeter. Instead of yellowness also the b* value can be used. The additional benefit of the DigiEye is the assessment of the appearance. For instance the colour and colour uniformity of the surface of the fat spread. It allows documenting the appearance by making colorimetrically accurate images

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Author Biography

Gerard van Dalen has been working in Unilever Research Vlaardingen for 37 years and was manager for 12 years of the Atomic and Vibrational Spectroscopy unit. He is currently involved as a research scientist in the application of IA techniques for advanced imaging techniques (2D, 3D and 4D) to obtain quantitative information of the micro and macro structure, composition, texture, size, shape, colour and appearance of foods, detergents and related products. He is author of 75 papers on Spectroscopy, Microscopy and Image Analysis.