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Prediction of sensory properties of low-fat yoghurt and cream cheese from surface images

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Abstract

The sensory properties of 25 plain yoghurts and 18 low-fat cream cheeses were investigated by descriptive analysis. In parallel with sensory analysis digital images of sample surfaces were captured and the relationship between image properties and sensory properties were investigated. Global image features of the yoghurt and cream cheese surfaces were extracted using the Angle Measure Technique (AMT). Multivariate data analyses (Partial Least Squares Regression) were applied for investigation of the relation between digital image global features and sensory properties. For both product categories all sensory properties could be predicted with Root Mean Square Error of Cross Validation (RMSECV) for the yoghurts in the range [1.00; 1.97] and for the cream cheeses [0.29; 2.80]. For yoghurts, the largest RMSECV is for the prediction of *Creaminess*, indicating that it is not well predicted from structure alone. Due to covariation with appearance and structure, sensory properties relating to different modalities (taste and flavour) could also be predicted.

Keywords: Yoghurt; Cream cheese; Sensory descriptive analysis; Creaminess; Angle measure technique; Image analysis; Multivariate data analysis; Partial least squares regression

1. Introduction

Texture derives from the structure of food and the way ingredients interact as discussed by Wilkinson, Dijksterhuis, and Minekus (2000) and the perception of texture is a combination of information from several senses. Assessment of appearance is one of the first steps in sensory evaluation of food, and is also the step with the shortest response time (Jones & O'Neil, 1985). Visual cues such as colour, gloss, grains and heterogeneity provide information about the surface properties of a food. The appearance provides the initial texture analysis of the product and sensory expectations of oral texture properties are created based on experience and familiarity with other more or less similar products. Additional information is obtained by handling the food, e.g. stirring, cutting or spreading. However, the most important part of the dynamic texture perception occurs in the mouth. During mastication textural parameters are perceived when the food is broken into small particles by chewing, wetted and lubricated with saliva, and formed into a bolus suitable for swallowing. Hutchings and Lillford (1988) suggested that each food has a characteristic 'breakdown path' in the mouth comprised of three dimensions: breakdown of structure, degree of lubrication and time. Perception of a given food is a result of sensory input through all the senses, interpreted by the mind and influenced by personal experience. If the psychological element of expectation based on surface appearance or past experience is not met during the oral perception of the food, it can have a strong influence on reducing the level of texture acceptance (Szczesniak, 2002).

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Surface characteristics provide important textural cues (Ball, Clauss, & Stier, 1957). Smoothness relates to the surface texture perception produced by moisture and/or fat content, whereas graininess relates to size, shape and arrangement of particles (ISO-11036, 1994; Szczesniak, 1963). Rohm, Kovac, and Kneifel (1994) observed a close relationship between appearance of yoghurt surfaces and perceived mouthfeel. A smooth mouthfeel correlates with a uniform surface whereas an irregular surface has a grainy texture. When assessing yoghurt surface properties, visual gloss – a measure of light reflectance – is an important attribute. According to Beck and Prazdny (1981) there are two types of light reflectance. The mirror-like shine perceived when an actual image of the light source appears on the product surface and diffuse reflectance where the light reflected is scattered by the product surface. They reported that highlights produce perception of glossiness, if an intensity gradient causes the surface to appear curved. However, one should be aware that luminance has been reported to be highly correlated with changes in the visible surface (Lederman & Abbott, 1981). Still, there is good evidence of high correlation between appearance and textural properties, thus making prediction of oral texture and mouth feel properties from surface images feasible. Little has been published on instrumental measurements of surface properties of acid milk gels such as yoghurt and cream cheese.

Creaminess is essential to many dairy products as it relates positively to product liking (Richardson-Harman et al., 2000). Consumers seem to consider a product creamy when it has a high fat content, has dairy flavour and a viscous, slippery, greasy and mouth coating texture (Richardson-Harman et al., 2000). Several researchers have found that creaminess relates both to thickness (depending on physical viscosity) and smoothness (depending on physical frictional forces) (Guinard & Mazzucchelli, 1996; Kokini & Cussler, 1983; Richardson, Booth, & Stanley, 1993). Other studies have found that creaminess is highly correlated to perceived fattiness in different dairy product categories (Frøst, Dijksterhuis, & Martens, 2001; Hyvönen, Linna, Tuorila, & Dijksterhuis, 2003). Some studies have shown that creaminess is more complex, depending not only on texture characteristics, but also on flavour (de Wijk, Prinz, Engelen, & Weenen, 2004). Research on the perception of fat in milk suggested a so-called meta-descriptor, 'total fattiness' to describe the overall sensory properties of fat in milk (Frøst et al., 2001). The nature of a meta-descriptor is that it consists of a specific combination of a number of other more simple or straightforward descriptors.[2] Results from (Frøst et al., 2001) suggest that the use of the meta-descriptor 'total fattiness' is appropriate, as this descriptor alone best preserve the data structure from the full set of descriptors (Dijksterhuis, Frøst, & Byrne, 2002), *i.e.* it is the descriptor carrying the highest amount of information, and best separates the different products under examination. We suggest that creaminess is a meta-descriptor as well.

In the present study, global image features were extracted using the Angle Measure Technique (AMT). This technique was originally introduced as an alternative method to fractal analysis (Andrle, 1994). It allows extraction and quantification of global properties of an image. The technique has subsequently been used for feature extraction in images of several types of food: bread texture (Esbensen, Hjelmen, & Kvaal, 1996; Kvaal, Wold, Indahl, Baardseth, & Næs, 1998); model dressings (Egelandsdal et al., 1999); mayonnaise (Indahl & Næs, 1998); and some non-food applications: powder (Huang & Esbensen, 2000, 2001). A thorough investigation of the methodology of the AMT principle and software has performed by Laugesen, Johansen, and Frøst (submitted for publication). Results indicate that AMT is most effective as an analysis tool for isotropic images – which is the case with images of yoghurt and cream cheese surfaces. The present study investigates the relation between sensory properties (concentrating on structure-related properties – appearance, mouthfeel and perceived texture) and surface structures of plain yoghurt and cream cheese. Of particular interest is the prediction of creaminess from surface images.

2. Materials and methods

2.1. Experimental design and product manufacture

2.1.1. Yoghurt

A total of 25 plain stirred yoghurts were produced and analysed in a fractional factorial design as indicated in Table 1. The total fat content was adjusted by addition of full fat cream (40% milk fat) to the milk base. The yoghurts were produced according to standard methodology for manufacture of stirred yoghurt (blending, pre-pasteurisation (65 °C), homogenisation (200 bar), pasteurisation (95 °C for 5 min), cooling (42 °C), inoculation (YC-183, Chr. Hansen A/S, Denmark), incubation (below pH value 4.6), cooling (22 °C), mixing, filling and final cooling (below 10 °C)). The fermentation conditions were kept constant (final pH value 4.10–4.30). All yoghurts were stored at 4 °C for exactly one week before further analysis, ensuring similar structural development. The yoghurts were produced and analysed in three true replicates, except for the reference which was produced each day and analysed in 12 replicates. For each session, six different yoghurt and one reference sample was photographed and analysed by descriptive sensory analysis.

2.1.2. Cream cheese

A total of 18 different cream cheeses and replicates of two was produced and analysed in a factorial design as indicated in Table 2. The cream cheeses were produced in a pilot plant, according to standard methodology for manufacture of cream cheese. A milk base was homogenised, pasteurised,

[2] Naming the phenomenon a meta-descriptor should be credited to Garmt Dijksterhuis.