Available online at www.sciencedirect.com
SCIENCE DIRECT®
Food Research International 39 (2006) 265–276
FOOD RESEARCH INTERNATIONAL
www.elsevier.com/locate/foodres

Application of liquid and solid rheological technologies to the textural characterisation of semi-solid foods

Tim Kealy *

Technical Department, Rheology Solutions Pty Ltd, P.O. Box 754, 15–19 Hillside Street, Bacchus Marsh, Vic. 3340, Australia

Received 26 July 2005; accepted 27 July 2005

Abstract

Rotational rheometers and texture analysers are commonly used to test liquid and solid samples, respectively. This paper explores data provided by a texture analyser and a rheometer compared with that provided by a trained taste panel for semi-solid food.

Associations are shown to exist for four different types of cream cheese with respect to the findings of a taste panel, rotational rheometry and texture profile analysis (TPA). Hardness, cohesiveness and adhesiveness are discussed for both taste panel and TPA. Good relationships were found between these techniques for hardness and adhesiveness, cohesiveness exhibited a less satisfactory correlation. In the case of the rheometer, yield stress, complex viscosity and viscoelastic moduli were measured. Yield stress was found to relate to hardness and adhesiveness, and complex viscosity and viscous modulus had relevance for cohesiveness. Elastic modulus, measured by the rheometer, and TPA elastic quality also correlated well. The relationships between textural measurements and microstructural engineering of the products have been discussed. The presence of vegetable gums, in particular addition of guar in instances where fat content is low can reduce the textural impact of the fat removal. The effects of high levels of calcium in spreadable products can be reduced by the addition of citric acid, which has been shown in the past to solubilise colloidal calcium phosphate.

Combining instrumental techniques with a taste panel can increase the efficiency product quality assurance and design.

Keywords: Texture profile analysis; Rotational rheometry; Taste panel; Hardness; Cohesiveness; Elastic quality; Viscoelastic moduli; Complex viscosity

1. Introduction

One of the most important challenges currently facing food producers is the measurement of the texture of their products. It is this criterion many consumers use to assess the freshness and quality of a product, but manufacturers do not always attach high priority to its measurement. "Although it may be one of the most important organoleptic properties, a food's mouthfeel is probably the least understood and most neglected by food producers" (Marsilli, 1993). Texture is of varying importance in food products. In the case of celery or potato chips, texture is a crucial characteristic. For products such as cheese or bread, texture plays a very important role, but perhaps not as critical. Products such as thin (watery) soups, etc., have few textural characteristics, although it could be asserted that the absence or 'minimisation' of texture is an important element in the perception of these products.

Traditionally, textural assessments have been carried out by taste panels, which may or may not be formally trained in the appraisal of textural characteristics. Defining the textural properties and their relative magnitude with respect to other similar products will increasingly

* Tel./fax: +61 3 53677477.
E-mail address: timkealy@rheologysolutions.com.

0963-9969/$ - see front matter
doi:10.1016/j.foodres.2005.07.016

become a critical criterion for food manufacturers seeking to design new products, maintain the quality of current ones or understand strengths and weaknesses relative to their competitors. The most notable early development in this area was made by Szczesniak and co-workers, Szczesniak (1963a, 1963b), in which it was attempted to classify textural properties, for example hardness, adhesiveness, cohesiveness and elastic quality, and propose scientific methods for their measurement.

This classification system and the instrumental techniques developed with it are still widely used, especially in the case of solid foods. In tandem with a taste panel, Szczesniak introduced the use of a uniaxial testing machine with purpose built probes to evaluate important textural characteristics of products. Recently, there has been some review (Halmos, 1997) and revision of this work. Pollard, Halmos, Seuret, and Sherkat (2000a, 2000b) presented data proposing that more fundamental information might be appropriate for measuring the textural performance of cheddar cheese and similar, fundamental, data were used by Truong, Daubert, Drake, and Baxter (2002). These analyses involved using the degree of compression at fracture, and the force at fracture rather than more empirical criteria such as hardness and springiness. The successful work of these teams indicates that use of fundamental data have merit.

Brennan and Kuri (2002) recently completed interesting work regarding the perception of consumers towards price and texture for organic foods, using both a taste panel and a texture analyser. They found that although many consumers would move towards organic-based foodstuffs if the price was comparable, but a 'blind' test revealed that they would not in fact alter their preference based on texture, highlighting the fact that new products must account for this aspect to achieve a viable product. Recently, Halmos and Foo (2002) examined the textural characteristics of hard cheeses using uniaxial testing, and compared their data with that of a taste panel. They found good agreement between the instrument and panel for hardness and adhesiveness, and to a lesser extent for cohesiveness.

In parallel with the development of techniques for testing of solid food products, many investigators have begun to examine the importance of rheological flow properties in the quality of liquid and semi-solid foods. Mounsey and O'Riordan (1999) compared empirical meltability data with dynamic rheological analyses and found that the fundamental data obtainable from a rheometer may prove to be a useful method to assess the meltability of cheese. Labuza (2000) notes that rheology may be a useful technique for measuring shelf life and texture. In an attempt to correlate dynamic and steady flow characteristics of foods, Yu and Gunasekaran (2001) assessed the rheological properties of eight different liquid and semi-solid foods but had limited success with diary samples. Nonetheless, they proposed a modified Cox–Merz rule which may apply to many foods. Truong et al. (2002) recognised the need for comparative data between taste panel, uniaxial textural analysis and classic rheometric analyses. Their work was for cheddar cheeses, comparing data collected using the vane technique with that of a taste panel and uniaxial compression. The vane technique was found to be comparable with the other techniques, especially for assessing cohesiveness and firmness. Amongst the considerable body of rheological measurements this author has been unable to find attempts to directly relate the experience of the consumer to absolute scientific data for semi-solid foods, such as spreadable cheese and empirical measurements using texture analysers.

This paper examines the two main instrumental techniques for texture measurement, namely uniaxial compression and rotational rheometry and compares them with the results of a trained taste panel.

2. Experimental materials and results

2.1. Equipment

The initial aims of this investigation were to ascertain the relevance of data obtainable from two different instruments, a controlled rate/controlled stress (CR/CS) rheometer (Thermo Electron (Karlsrhue) Gmbh Haake RS150) and a texture analyser or universal/uniaxial testing machine (Shimadzu Ez-Test). The data collected by these instruments is compared with that obtained from a trained taste panel.

2.2. Samples

The samples chosen for this test were four different types of cream cheese, purchased from the supermarket. The products used are listed in Table 1. Because of the somewhat confusing labelling used by the producer, the samples will be referred to as A (Original), B (Light Original), C (Spreadable) and D (Light Spreadable), and not by their stated fat content or label designation.

More extensive details of the composition of each test product, as per the labelling on each package, are documented in Table 2.

In Table 2, vegetable gum 410 denotes locust bean gum, vegetable gum 412 denotes guar gum and food acid 330 is citric acid.

The different samples contain many of the same ingredients in similar proportions, the most notable exceptions being that D contains cottage cheese and guar gum and that A and C have high levels of calcium (Ca) compared with the others. The ingredients, as per the label on each product, are listed in Table 2. The two vegetable gums, guar and locust bean, are leguminous polysaccharide food thickeners which con-