TEXTURE MEASUREMENTS OF SAUSAGES WITH DIFFERENT DAIRY INGREDIENTS

Pernille Baardseth, Marit R. Ellekjær, Bjørg Egelandsdal and Tormod Næs
MATFORSK, Norwegian Food Research Institute, Osloveien 1, N-1430 Ås, NORWAY

Keywords: sausage, texture, milk proteins, multivariate technique

Objectives

The objective of this study was to demonstrate the use of multivariate techniques to efficiently relate instrumental texture measurement to the texture of cooked sausages as measured by a sensory panel. The multivariate method partial least square (PLS2) regression was used to relate the instrumental texture measurement (X data) to the sensory texture attributes (Y data). This method handles many variables in both X and Y data, and compresses the information into a few linear combinations which then express the main variation and make the data easy to interprete. This paper is a supplement to the paper by Næs *et al.* (1996) on finding relationships between multivariate data matrices. PLS 2 grouped the texture attributes and pointed to the most suited instrumental method within each group.

Experimental methods

Meat preparation and processing. Sausages were produced as described by Baardseth *et al.* (1992), 64 productions in total.

Rheological measurements. The Bohlin VOR Rheometer system (Bohlin Reologi AB, Lund, Sweden) in the oscillatory mode was used to measure the low deformation viscoelastic properties (complex modulus, G*, and phase angle δ) in amplitude sweep of the sausage samples. The measuring system was parallel plates (15 mm diam.). All measurements were performed at 23°C. The sausages were carefully cut into correct shape (diam. 15 mm, height 10 mm). The plates were coated with Loctite's superglue (G. A. Lindberg AB, Stockholm) in order to fix the sample to the plates. The surface of the sample was oiled to prevent evaporation. Three samples from each production were measured.

In the amplitude sweep (deformation sweep) the frequency was 1.0 Hz and the strain ranged from 0.0005 to 0.0010. In this measuring series the phase angle δ, and complex modulus G* were picked out and used in the statistical treatment.

The phase angle δ gives information about the ratio of viscous to elastic deformation and the complex modulus G* about the total resistance to deformation.

Instron textural analysis. Firmness of sausages was determined by stretching according to Purslow *et al.* (1987) using an Instron Testing Instrument, model 4202 (Instron Ltd, High Wycombe, Great Britain, and as described by Baardseth *et al.* (1992)).

Sensory analysis. The sensory analysis was performed as described by Baardseth *et al.* (1992) and the texture parameters elasticity, juiciness, firmness, greasiness, stickiness, graininess and total texture were used in this analysis.

Multivariate statistical method. PLS is a method which relates data matrices to each others (see Martens & Næs, 1989).

Results & discussion

The sensory texture data could be reduced into two dimensions (Figure 1) for these sausages. To test which of the rheological methods that could explain the sensory texture parameters (Instron matrix 64 times 42 vs sensory matrix 64 times 7; Phase angle δ matrix 64 times 11 vs sensory matrix 64 times 7; Complex modulus G* matrix 64 times 11 vs sensory matrix 64 times 7; Phase angle δ + Complex modulus G* matrix 64 times 22 vs sensory matrix 64 times 7), the data matrices were treated by PLS2. Explained variance (Table 1) between Instron and sensory parameters was high for elasticity and firmness, while the combination of phase angle δ + complex modulus G* from the amplitude sweep and sensory parameters was high for greasiness, firmness and juiciness.

Table 1. Explained variance (%) on texture data measured by two instrumental methods (Instron and Bohlin (amplitude sweep, δ and G*)) and by sensory analysis. Numbers of components for optimum variance in brackets.

	Instron vs sensory parameters	Phase angle δ vs sensory parameters	Complex modulus G* vs sensory parameters	Phase angle δ + Complex modulus G* vs sensory parameters
Elasticity	68 % (1)	38 % (8)	20 % (3)	48 % (6)
Juiciness	48 % (3)	11 % (4)	55 % (1)	52 % (1)
Firmness	80 % (3)	28 % (4)	45 % (1)	52 % (1)
Greasiness	48 % (3)	5 % (3)	55 % (1)	58 % (1)
Stickiness	40 % (1)	37 % (4)	7 % (1)	38 % (4)
Graininess	34 % (3)	non	38 % (4)	35 % (6)
Total	57 % (3)	18 % (4)	38 % (4)	42 % (4)

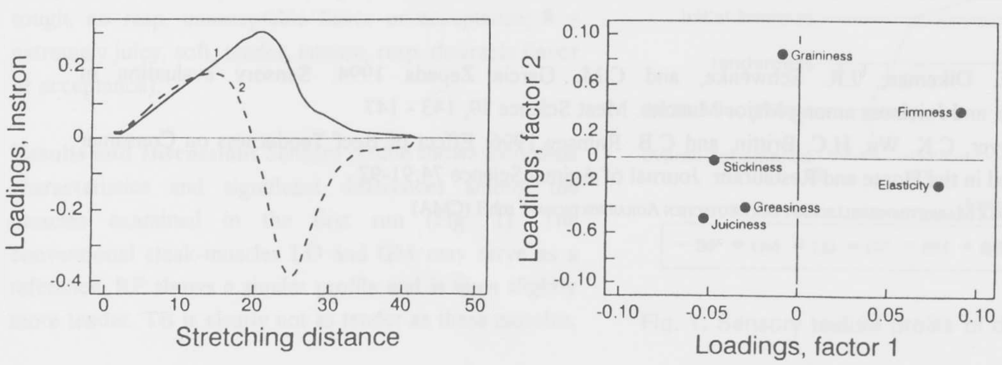

Figure 1. Relationship of Instron spectra (X data) to sensory texture data (Y data) using partial least square (PLS2) regression. Loadings for the two first PLS components for cooked sausages produced with five different dairy ingredients.

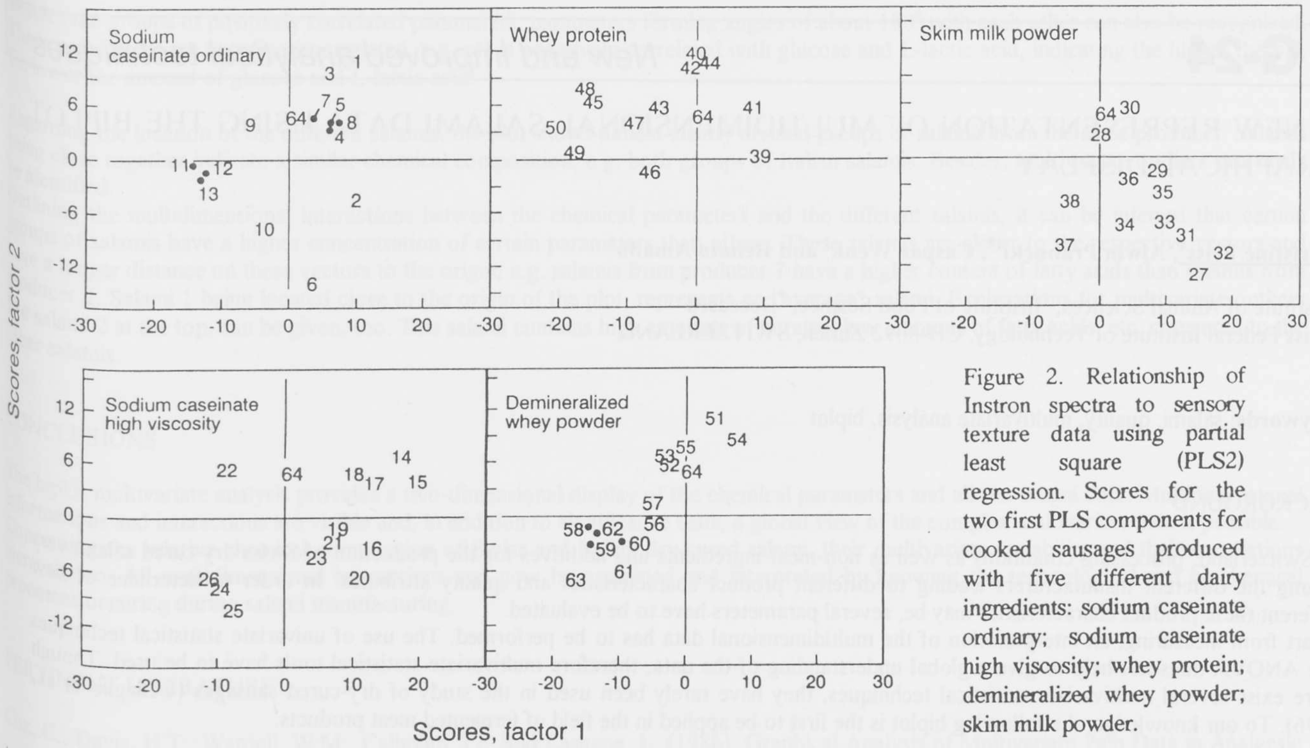

Figure 2. Relationship of Instron spectra to sensory texture data using partial least square (PLS2) regression. Scores for the two first PLS components for cooked sausages produced with five different dairy ingredients: sodium caseinate ordinary; sodium caseinate high viscosity; whey protein; demineralized whey powder; skim milk powder.

The results in table 1 show that graininess is poorly explained by mechanical measurements. Graininess correlates strongly with sensory determined colour intensity and it should therefore be possible to design a spectroscopic or image method for measuring it non-destructively. Firmness is well explained by the tension method. Fig. 1 (loadings, Instron) shows that a single point measurement should give a fair estimate of firmness compared to using the whole curve. A relative inexpensive instrument could thus be used to monitor the sensory parameter firmness. Juiciness and greasiness are usually regarded to be related to the microstructure of food products i.e. to the hetrogenicity in the food matrix. For these attributes the low deformation method (Bohlin (amplitude sweep)) explained 52% and 58% using one component, respectively. Juiciness and greasiness in cooked sausages with different fat content could also be predicted by a near infra red spectroscopic method as shown by Ellekjær *et al.* 1994.
The results from the PLS2 on the matrix Instron vs sensory parameters were analysed further. The loading and score plots are shown in Figures 1 and 2. This analysis suggested that there were essentially three groups in two dimensions of sensory texture parameters: elasticity/firmness, stickiness/juiciness/greasiness and graininess (Fig. 1). Out of the three groups of attributes, it can be questioned if graininess is a texture attribute.

When the codes for each of the sausages in the experiment are known, the plots can be analysed and interpreted (see Table 1 in Næs *et al.* 1996). Dairy ingredient types influence the sausage texture in different ways. Sausages with caseinates gave firmer texture than in sausages with whey protein and skim milk powder. Sausages with skim milk powder were more elastic and more juicy, while whey protein gave sausages with more graininess. Increased concentration of dairy ingredients and starch concentration gave sausages which were less firm and less elastic, confirming the results by Baardseth *et al.* (1992). The cooking temperature had little influence on the texture measurements.

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