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THE RELATION BETWEEN VISCOELASTIC AND SENSORY PROPERTIES OF EMULSION SAUSAGES.'

K. PERSSON AND E. TORNBERG
Swedish Meat Research Institute, P. O. Box 504, S-244 24 Kävlinge, Sweden

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Background

The texture of emulsion sausages has been measured instrumentally using many different techniques. Usually some imitative tests are used, where the stress-strain set-up is badly defined. In more fundamental rheological tests stress and strain are controlled and thus a more basic knowledge of the correlation between the mechanical and the molecular properties of the food item can be obtained. These types of measurements can be performed either with small or large strains, i.e. in a non-destructive or destructive way.

Persson & Tornberg, 1992, have, for the same type of sausages used in this investigation, studied the correlation between the texture of sausages, as determined sensorially, and a destructive fundamental rheological test like tensile strength measurement. In that study it was found that the sensorially determined overall acceptability correlated well with fracture strain (r=0.74***). Montejano *et al.*, 1985, also found the best relationship between torsion strain at failure and sensory textural attributes of 8 different heat-induced protein gels, made out of egg white, fish, turkey, beef and pork muscles.

For the non-destructive tests, like small-strain dynamic testing, the elastic and viscous components of the gel can be evaluated. The viscoelastic properties of gels of actomyosin and myosin have been investigated (Samejima *et al.*, 1981; Egelandsdal *et al.*, 1986) as well as myofibril suspensions (Egelandsdal & Mitchell, 1987). Saliba *et al.*, 1987 have compared the rheological properties of emulsion sausages determined by failure (torsion tests) and non failure analyses (TSRM) and found that the heating rate affected the former but not the latter properties. So far the viscoelastic properties of emulsion sausages determined in a non-destructive test have not been compared to the sensory assessment of texture and are therefore the object of this study.

Materials and Methods

Materials: The sausage batters (n=27) were prepared from pork or beef meat, rindless pork fat, nitrite salt and water. In order to generate different textures in the heated sausage batters, they were made using different recipes, composed of different water, fat and protein contents (61-79 %, 10-25 % and 8-13 %, respectively). The connective tissue and the salt content of the sausage batters also varied in the investigation between 0.7-3.0 % and 1.5-2.5 %, respectively, as well as the pH (5.5-5.8). The sausage batters were made, stuffed and then heat-treated, in accordance with the procedure in Persson and Tornberg, 1992.

Viscoelastic measurements: The viscoelastic properties were followed by subjecting the sausages to a sinusoidal shear at 1 Hz (Bohlin Reometer system, Bohlin Rheology AB, Lund, Sweden) at a temperature of 20°C. The sample cell consisted of a parallel plate. The thickness of the sample was 7 mm and 30 mm in diameter. All measurements were performed in the linear viscoelastic region checked in a strain sweep, whereafter the strain was set constant to 0.0125. The rheological behaviour was monitored as storage, loss and complex modulus (G', G" and G*) and the phase angle (δ).

Sensory analysis: Sensory analysis was carried out on fried (160°C) slices (10 mm) of the sausages. The fried sausages were served immediately to the assessors. The sensory attributes were determined using a trained expert panel consisting of 10 assessors. The profile for the sausages included the attributes hardness (1=very soft, 9=very hard), rubberiness (1=none, 9=very rubbery), texture and overall acceptability (1=dislike, 9=like very much).

Statistical analysis: Linear regression analysis and Pearson correlation coefficients were performed using SYSTAT for Windows (version 5.0).

Results and Discussion

The different recipes gave rise to varying viscoelastic behaviour and sensory evaluated attributes in the sausages. The storage modulus increased from 9.6 to 38.6 kPa, the loss modulus varied between 2.1 and 6.6 kPa, while the phase angle changed between 7.9 and 12.3 degrees. The sensory attributes varied between 1.3 and 7.1.

The linear interrelationships between the different viscoelastic and sensory attributes can be seen in Table 1.

Table 1. The interrelationships between viscoelastic parameters and sensory attributes of the different sausages, expressed as correlation coefficients of linear regression analysis.

Parameter (n=27)	G'	G"	Phase angle	Hardness	Rubberiness	Texture acceptability	Overall acceptability
G'	1.00						
G"	0.92***	1.00					
Phase angle	-0.65***	-0.36	1.00				
Hardness	0.78***	0.55**	-0.85***	1.00			
Rubberiness	0.62***	0.36	-0.78***	0.82***	1.00		
Texture acceptability	0.46*	0.34	-0.49**	0.50**	0.10	1.00	
Overall acceptability	0.49**	0.31	-0.60***	0.56**	0.22	0.95***	1.00

Significance level: p≤0.05*, p≤0.01**, p≤0.001***

The overall acceptability was mainly dominated by the texture acceptability of the sensory attributes, and less by the rubberiness and hardness, which, however, were highly correlated to each other. The relatively poor linear correlations between rubberiness and hardness to the texture acceptability might depend on the non-linear behaviour, see Figure 1. The correlation coefficients between the texture acceptability and the hardness and rubberiness increased from 0.50** and 0.10, respectively to 0.74*** and 0.53* for the non-linear characteristics. This means that as the sausage became harder or more rubbery only up to a certain level (≈ 5), the sausage became more acceptable to the taste panel. Subsequently increased hardness gave rise to a less acceptable product.

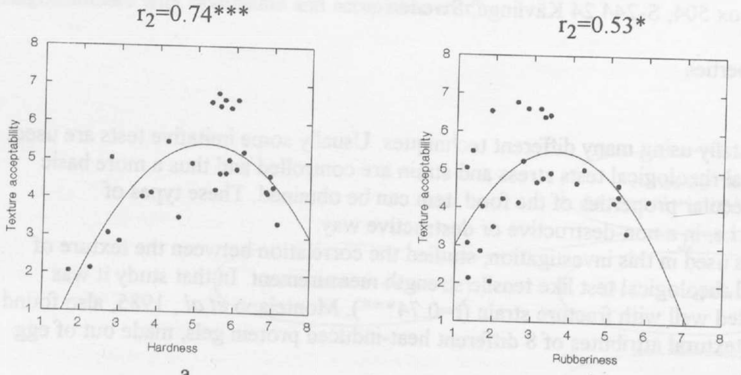

Figure 1. Texture acceptability of the sausages as a function of hardness (a) and rubberiness (b). The correlation coefficient, r_2, is valid for the model $y=a+b*x+c*x^2$.

The storage modulus was found to constitute 99 % of the complex modulus (i.e. G'/G*=0.99). The loss modulus (G") had a high relationship with the storage modulus (r=0.92***), whereas the phase angle was not that well correlated to the loss and storage moduluses. According to Table 1, it was the phase angle among the viscoelastic parameters of the sausages that was best correlated to the sensory parameters, where hardness (r=-0.85***, Figure 2a) and rubberiness (r=0.78***) gave the highest correlation coefficients. This means that neither the elastic (Fig 2b) nor the viscous component of the sausage can best describe the sensorially evaluated hardness. Rather it is the phase angle, which is the relationship between the viscous and the elastic parameters expressed as tan δ = G"/G', that determines this property.

The linear relationships between the storage and loss moduluses with texture and overall acceptability were relatively poor (r=0.31-0.49**). However, the phase angle was best related to the texture acceptability in a non-linear way, which is a consequence of hardness having a non-linear relation to texture acceptability, see Figure 2c. The correlation coefficient increased from -0.49** for the linear regression to 0.69*** for the non-linear one. The best evaluated texture acceptability was achieved at a phase angle of 9-10 degrees.

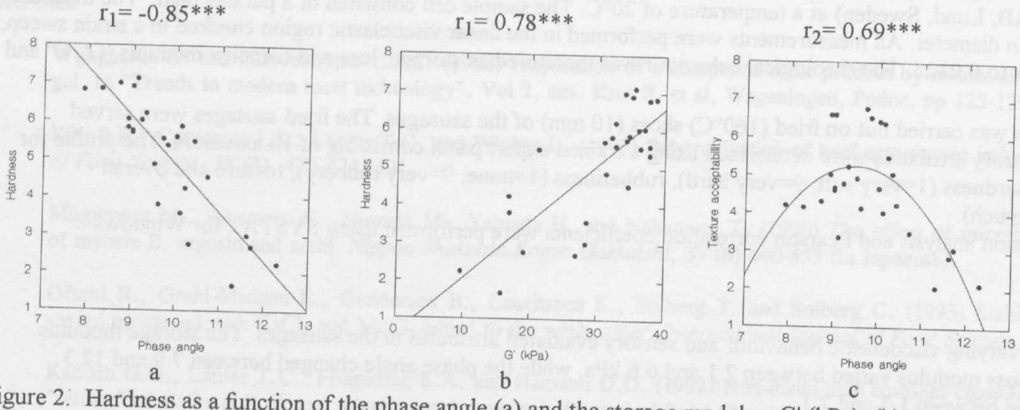

Figure 2. Hardness as a function of the phase angle (a) and the storage modulus, G' (kPa), (b) together with the texture acceptability as a function of the phase angle (c). The correlation coefficients, r_1 and r_2, are valid for the models $y=a+b*x$ and $y=a+b*x+c*x^2$, respectively.

Conclusions

The sensorially evaluated overall acceptability of emulsion sausages was mainly governed by the texture impression (r=0.95***). This texture acceptability, however, increased with hardness and rubberiness only up to a certain level, whereafter the sausage became a less acceptable product with greater hardness and rubberiness.

Among the viscoelastic parameters of the sausage measured it was the phase angle that was best correlated to the sensory properties. Hardness and rubberiness gave the best linear correlation coefficients, r=-0.85*** and r=-0.78***, respectively, whereas texture acceptability was non-linearly (quadratic) related to the phase angle. The most acceptable product was achieved at a phase angle of 9-10 degrees.

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