THE SENSORY, STRUCTURE AND FRACTURE PROPERTIES OF HEATED SAUSAGE BATTERS

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SUMMARY

Tensile strength measurements on emulsion sausages with varying microstructure, were performed because they generate a well-defined stress-strain pattern compared to the more commonly used penetrometer. For comparison, the texture was also evaluated with a penetrometer and by sensory analysis, using a trained expert panel. The microstructure of the heated sausage batters was studied by examining stained thin sections in a light microscope. A comparison of the different attributes of the sausages showed a close relationship between the fracture strain, the microstructure and the sensory attribute overall acceptability, i.e. sausages with a high degree of extension had a dense network and were more acceptable to the taste panel. The texture measured with the penetrometer reflected the sensory evaluated hardness, whereas no relationship with the microstructure was found.

INTRODUCTION

A number of instrumental methods have been used to measure the textural properties of processed meat, e.g. punch-and-die, penetrometer, compression, shear and tensile strength measurements. Tensile strength measurement in a uniaxial mode is one of the methods generating a well-defined stress-strain pattern as well as fractures that can easily be followed, compared to the others. This enables us to determine the more fundamental physical properties in relation to the sensory attributes and the microstructure of the sausage. Tensile measurements have mostly been used to evaluate the binding strength of the junction between two meat pieces in coarsely ground meat products (MACFARLANE et al. 1977; SIEGEL & SCHMIDT. 1979a,b; DONNELLY & PURSLOW. 1987; PURSLOW et al. 1987, SAVAGE et al. 1990). In this study, tensile strength measurements were evaluated on fine comminutes, such as emulsion sausages, using a mould suitable to produce a dumb-bell shaped specimen, according to LANGLEY et al. (1986).

MATERIALS AND METHODS

Materials: The sausage batters were prepared from pork or beef meat, rindless pork fat, nitrite salt and water. To generate different structures 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 also varied in this 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 in a 20 l Müller bowl chopper with 6 knives at a speed of 1400/2800 rpm. The batch size was 7 kg. The ingredients were added and disintegrated at low speed in the chopper in the following order; meat (20 s), nitrite salt (10 s), water/ice (60 s) and fat (20 s). The speed of the chopper was then increased and comminution was continued for 130 s to a final temperature of 8-12°C. The batter was then stuffed into 47 mm casings using a sausage filler machine (Vemag Robot 500, type 128). The sausages were then heat-treated, according to the following procedure; 40 min at 60°C (60% RH), 10 min drying at 70°C (<20% RH), 45 min smoking at 70°C (60% RH), 30 min cooking at 78°C (100% RH) and 60 min cooling.

Tensile strength measurements: The test moulds producing a dumb-bell shaped specimen were filled with the sausage batters, using a syringe with a pressure of 1.5 kp/cm². For each batter, four test moulds were filled. The moulds were then placed in a water bath, using a temperature programme designed to imitate the heating rate in a smoke-house. After cooling, the tensile strength was measured in a uniaxial mode using an Instron Universal Testing Machine (4301). Measurements were performed at a cross-head speed of 6 mm/min.

This speed was chosen so that the fracture could easily be followed in a reasonable time. The breaking load (N), the fracture stress (breaking load divided by cross sectional area at fracture, N/m^2), the stiffness or elastic modulus (Pa) (initial slope) and the fracture strain (%) of the sausage gel were registered.

Penetrometer: The texture was also evaluated with the more frequently used conic (40°) penetrometer. For each sausage, ten samples with a height of 3 cm were evaluated. The maximum force to penetrate a sample was registered for each sausage.

Sensory analysis: Sensory analysis was carried out on fried (160°C) slices (10 mm) of the sausages. 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), juiciness (1=none, 9=very juicy), flavour (1=very poor, 9=very good) and texture and overall acceptability (1=dislike, 9=like very much).

Microstructure: Samples of the sausages were frozen in liquid nitrogen and cryosectioned (Leitz cryostat 1720). The microstructure of the heated sausage batters was studied by examining thin sections (8μm) stained with aniline blue and orange G according to TORNBERG and PERSSON, 1988. The stained sections were examined in a light microscope (Nikon Optiphot) at a magnification of 27x and 134x. Photographs were taken and then evaluated ocularly using a profile of 1 - 5, 1 standing for a poor meat protein network and 5 standing for a dense network with small pores.

RESULTS AND DISCUSSION

Microstructure: The different recipes gave rise to varying protein networks in the heated sausage batter. The structure was characterized by variation in porosity and/or different degrees of muscle disintegration. The structure profile 1 could stand for a protein network built up of coarsely disintegrated muscle fibres or aggregated proteins, where both these types of structure give rise to a poor network. Instead, the structure profile 5 stands for a sausage with a more dense protein network and few whole muscle fibres (see Figure 1).

Tensile strength measurements: The forms of the stress/strain curves of the different sausages in the tensile strength measurements were similar, typical examples can be seen in Figure 1. An almost linear increase in tensile strength with increasing strain was registered, until a maximum in tensile strength was reached, whereafter fracture occurred and the stress was abruptly lost. This behaviour is typical of an elastic gel, which suggests that the texture of the sausages was dominated by the elastic protein network. The variation in fracture stress for the different sausages was between 5 and 40 kPa.

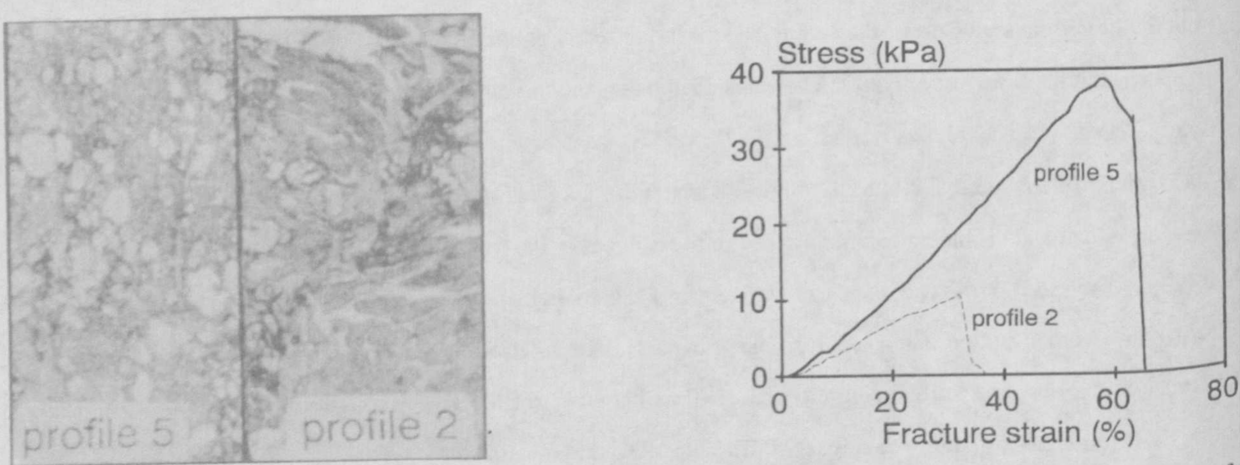

Figure 1. Micrographs of sausages with the structure profiles 5 (left) and 2 (right) at a magnification of 50x. Stress (kPa) as a function of strain (%) of heated sausage batters having the microstructure profiles of 2 nad 5, respectively.

The different parameters calculated from the stress/strain curves, i. e. breaking load, fracture stress, fracture strain and stiffness, were correlated to the microstructure profiles. The fracture strain gave the highest correlation (r=0.70***). This means that as the protein network became denser the heated sausage batter became more extensible.

Penetrometer: The maximum force measured with the penetrometer varied between 0.9 and 6.1 N. However, these parameters did not correlate very well with the microstructure (r=0.31). Instead, the penetration force was best correlated with the amount of connective tissue (r=0.61***) in the sausage. This relationship suggests that the penetration force is more susceptible to dense regions in the sausage, probably consisting of non-disintegrated pieces of connective tissue than to the elasticity of the surrounding protein network.

Table 1. The inter-relationships between sensory attributes, parameters evaluated from penetration and the tensile strength measurements and microstructure profiles of the different sausages expressed as correlation coefficients of linear regression analysis.

	SENSORY ATTRIBUTES				
Parameter (n=27)	Hardness	Juiciness	Flavour	Texture acceptability	Overall acceptability
Penetration force	0,91***	0,25	0,36	0,31	0,39*
Breaking load	0,77***	0,48*	0,43*	0,42*	0,50*
Fracture stress	0,77***	0,51*	0,47*	0,44*	0,54**
Fracture strain	0,59**	0,72***	0,64***	0,61**	0,74***
Stiffness	0,55**	0,03	-0,10	0,08	0,07
Structure profile	0,45*	0,83***	0,85***	0,81***	0,81***

Significance level: $p \leq 0.05$*, $p \leq 0.01$**, $p \leq 0.001$***

Sensory analysis: The sensory attributes registered varied on average between 2.6 and 7.1. In Table 1, these sensory attributes are correlated to the instrumental texture measurements and the microstructure profiles of the sausages. From the Table, it can be deduced that the sensory evaluated hardness (soft-hard) was best correlated with the penetration force and at the same time not influenced so much by the structure of the protein network.

In Figure 2, the relationship between the hardness and the penetration force is presented, where the different structure profiles are indicated.

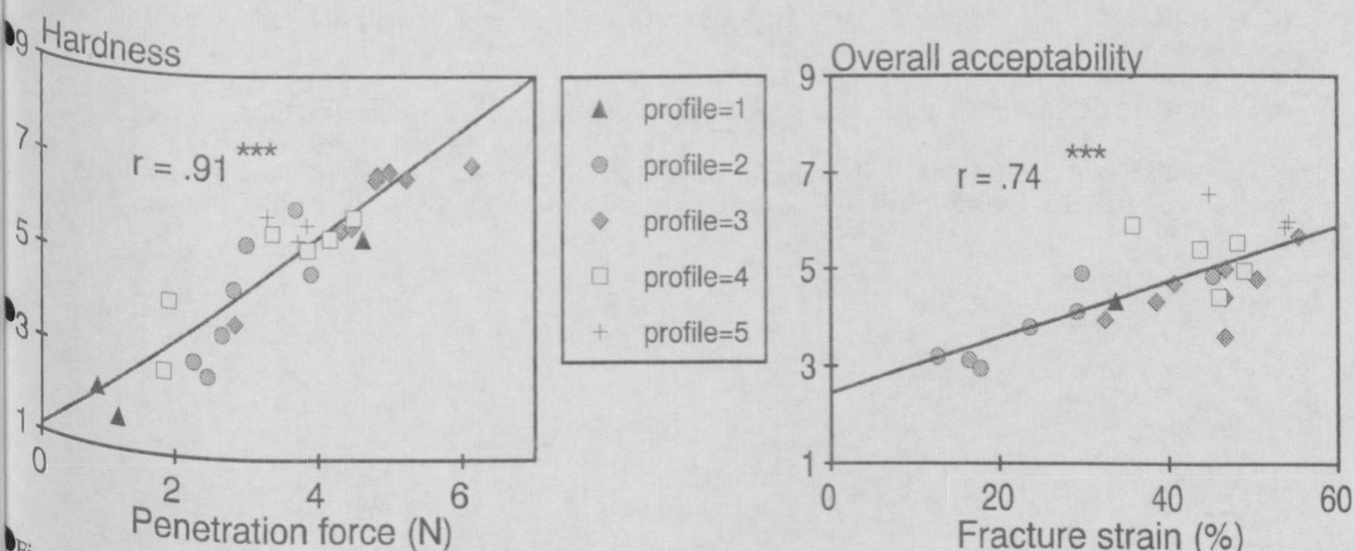

Figure 2. Hardness of the sausages as a function of the penetration force (N) and the overall acceptability of the sausages as a function of the fracture strain (%) with the different structure profiles indicated.

From the Figure, it can be seen that the sausages giving rise to the highest penetration force were the hardest sausages to chew, but the microstructure profile was only 3. The sausages with a poor protein network (profile=1 and 2) had a large variation in this type of texture measurement. They could be very soft as well as quite hard.

The other evaluated sensory attributes, i.e. juiciness, flavour, texture and overall acceptability, all showed a relatively high correlation with the microstructure (r= 0.81***- 0.85***). There was also rather a good relationship between the sensory evaluated overall acceptability (dislike-like very much) and the fracture strain during tensile measurements (see Figure 2). As the fracture strain increased, the sausages became more acceptable to the taste panel and these sausages also had the most dense protein network. For two of the sausages with a very poor microstructure (profile 1) it was impossible to perform any tensile measurements, because a fracture had occurred already, due to the gravity of the specimen. However, these two samples registered the lowest overall acceptability.

CONCLUSIONS

1. The sensory evaluated overall acceptability of an emulsion sausage was mostly governed by the structure of the protein network. The texture measurement that best reflected these properties was the fracture strain in tensile strength measurements.
2. The texture measured with the penetrometer reflected more the sensory evaluated hardness, whereas no relationship with the microstructure was found. The maximum penetration force and hardness were more related to the amount of connective tissue, where large amounts gave rise to high scores in hardness and penetration force.

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