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A NEW MEASURING SYSTEM TO STUDY THE RHEOLOGICAL PROPERTIES OF MEAT DURING HEATING

BOHLIN, L.*, AUTIO K.**, and PUOLANNE E.***

* Bohlin Reologi Ab, Science Park Ideon, S-223 70 Lund, Sweden
** Technical Research Centre of Finland, Food Research Laboratory Biologinkuja 1, 02150 Espoo, Finland
*** University of Helsinki, Department of Meat Technology, SF-00710 Helsinki, Finland

SUMMARY

Continuous evaluation of storage modulus (G') during heating of meat showed the same general patterns to all samples studied: G' decreases from 30 to 50° C, indicating softening of the sample. In the temperature range 52-55° C, there is an increase in rigidity, followed by a much steeper one above 65° C.

Beef and pork meat presented very similar storage modulus-temperature relationship up to 75° C. Above this temperature the rigidity of beef remained approximately constant while pork still showed increase in rigidity.

The rigidity of meat having pH 6.4 was lower than for meat with pH 5.5. Also the main transition temperature for beef having pH 6.4 was at higher temperature.

INTRODUCTION

A considerable amount of work has been done in examining the influence of cooking on the texture of meat (Bouton and Harris, 1972; Bailey, 1972; Lawrie, 1979; Locker, 1982). Most of these reports are related to the measurement of shear force after cooking samples for different times and temperatures, an approach which may not be as sensitive in detecting transitions as continuous evaluation of the same sample during heating.

The technique of mechnical spectroscopy is well suited to the rheological characterization of a material during a complex time/temperature profile without breaking the structure. It has been used for studying heat-induced gelation of proteins (Egelandsdal et al.,1986; Paulsson et al.,1983), but also for more complicated systems as for the evaluation of structure formation of a cake and ice cream (Dea et al.,1983) and for comminuted muscle systems (Montejano et al.,1984). No published data, however, exist on the usage of the technique for whole meat.

In this paper a new measuring cell for attachment to the Bohlin Rheometer has been designed and the preliminary results on the effect of cooking temperature on the texture of pork meat and beef having different pH-values are reported.

MATERIALS AND METHODS

Muscle samples were obtained from young bull and pig M.longissimus dorsi 20 h after slaughter.

Meat pieces, whilst frozen, were drilled into cylinders (5x20 mm) parallel to the fibres along the muscle. The meat sample was bonded with cyanoacrylate to the lower and upper sample holder (Figure 1). A thermocouple was attached to the measuring cell, which was filled with a low-viscosity silicon oil. The measuring cell was attached to the Bohlin Rheometer (Bohlin Rheology Ab, Lund, Sweden).

In this instrument a small amplitude oscillation is applied to the material and the resulting stress is compared with the strain. The amplitude ratio of the stress to strain gives the complex modulus, G*. The two sine waves will have a phase difference, δ, and this is used to give the storage and loss components; in-phase component being the storage or elastic componant (G'), the quadrature component being the viscous or loss term (G"). This is illustrated in Figure 2. Measurements were made at the strain amplitude of 0.004, frequency of 0.5 Hz and at heating rate of 1° C/min. Each point in the curves is the average of at least 5 measurements.

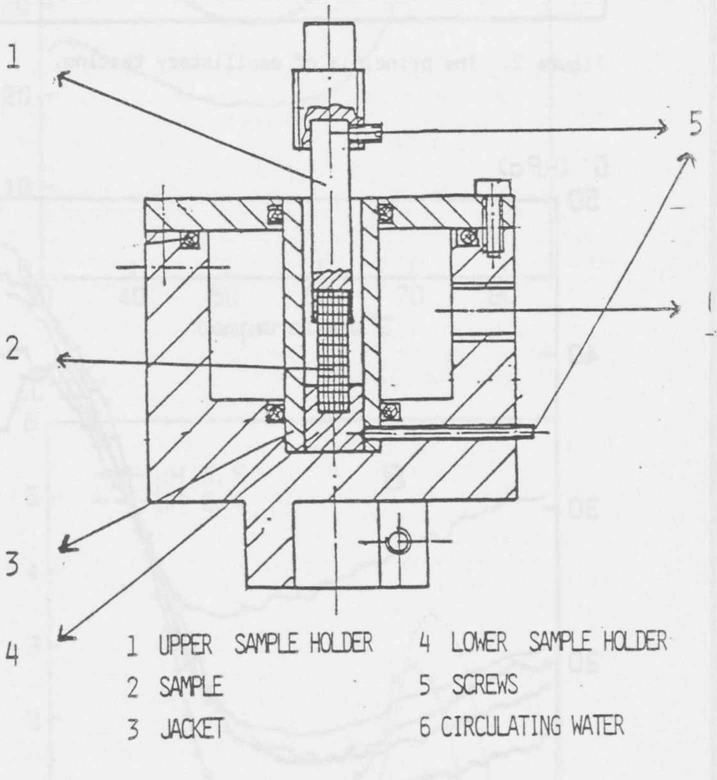

Figure 1. The measuring cell.

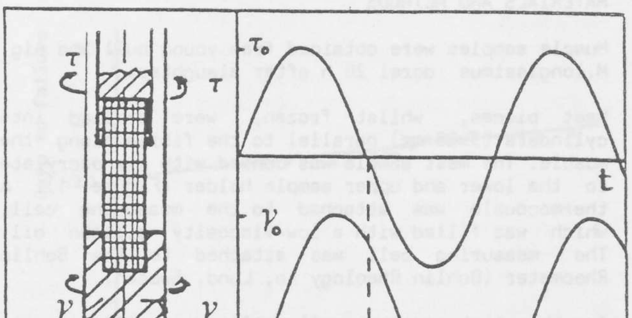

Figure 2. The principle of oscillatory testing.

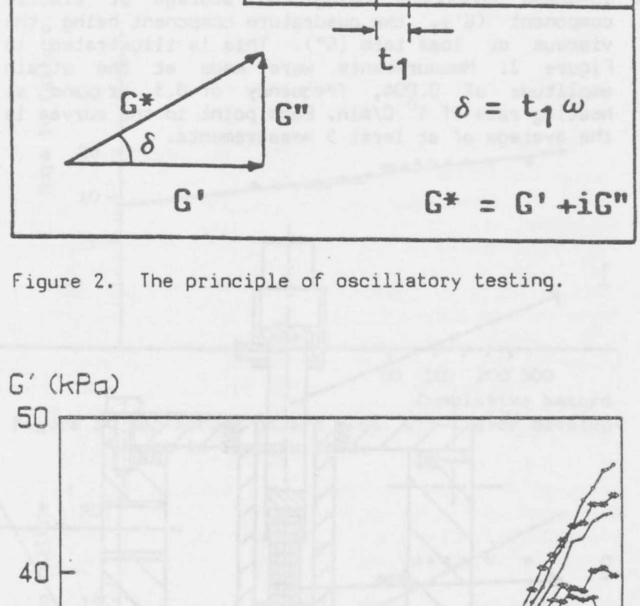

Figure 3. The thermograms of five replicates.

RESULTS AND DISCUSSION

Figure 3 illustrates the profiles of G' plotted against temperature for five replicates. The reproducibility is quite good at higher temperatures taking into account the heteregenous nature of meat. Figure 4 gives storage modulus (G'), loss modulus (G") and phase angle (δ) for pork meat sample. G' is decreased fom 30 to 50° C indicating softening of the meat sample. In the temperature range 50-60° C there is a small increase of G', followed by a much sharper and more pronounced increase above 65° as the stiffening of the sample is increased. Although the magnitudes of G" and δ, varied a lot between replicates, which is expected for highly elastic systems, the curve profiles were the same for all the samples studied. G" decreased from 30 to about 50° C and increased above 65° C, indicating that "fluidity" of the sample is first increased and above 65° C decreased. Phase angle decreased during the heating, as the elasticity of the meat is increased.

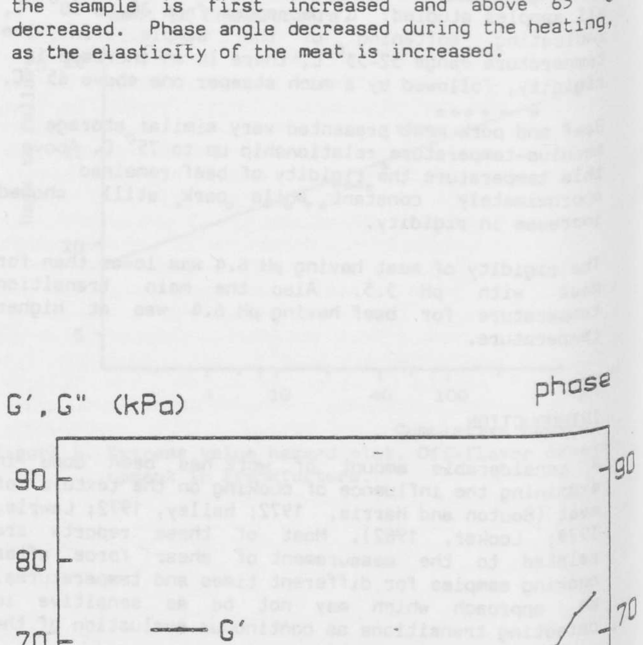

Figure 4. Rheological parameters (G', G",δ) for pork meat during heating.

Figure 5a illustrates the thermograms for beef and pork meat and the results show that above 73^{o} C G' for pork meat is higher than for beef. Since the heat-induced texture change in meat is related to several different factors, such as protein aggregation, collagen shrinkage, cooking losses etc.(Bouton et al.,1981), the derivation of the thermograms with respect to temperature gives more details of the curves; the transition temperatures for major rheological changes (Fig.5b). This figure shows that the increase of G' is composed of several consecutive events and the major transition temperature is higher for pork meat. Figures 6a and b show that the rigidity of meat with pH 6.4 is lower than for meat with pH 5.5 and the main transition temperature for beef with pH-value 6.4 is at higher temperature.

The work is being continued to measure the normal force, as some of the increase of G' results from collagen shrinkage. Present studies include also the effet of heating rate, which is known to have great effect on the tenderness of meat.

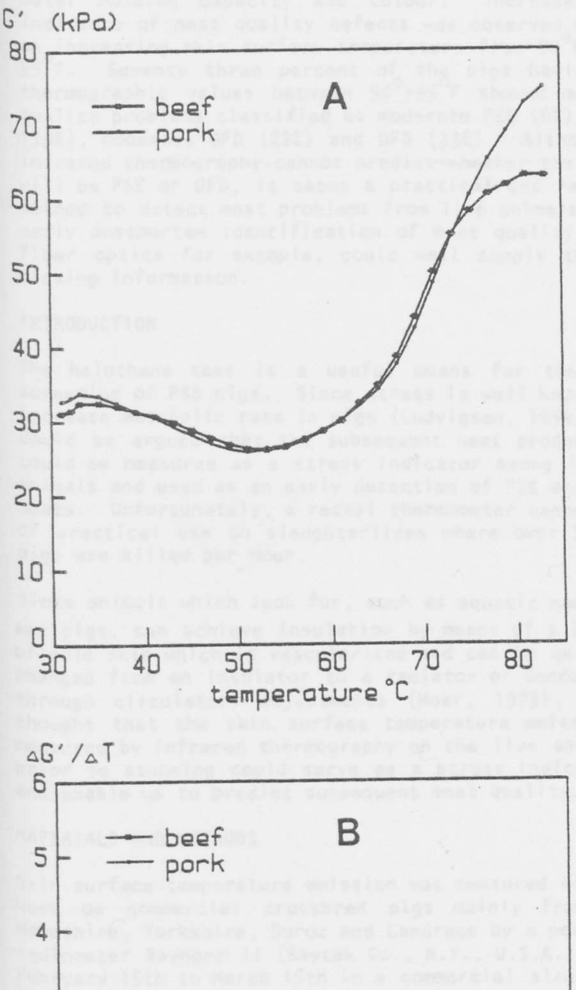

Figure 5. A) A thermogram for pork meat and beef. B) The derivative form of the curve.

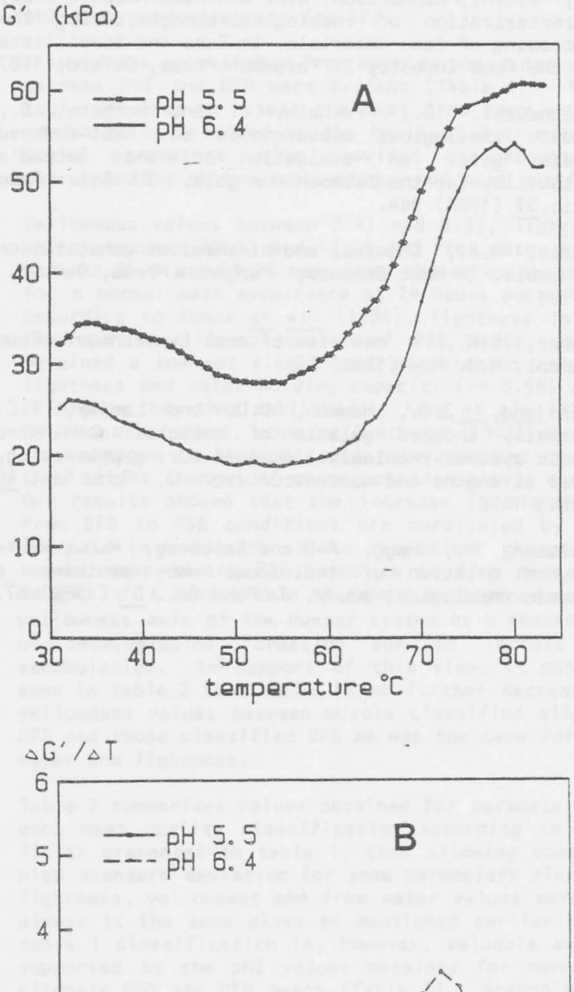

Figure 6. A) A thermogram for beef with pH values 5.5 and 6.4. B) The derivative form of the curve.

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