# MEAT BATTER RIGIDITY CHANGES DURING COOKING

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## SUMMARY

A cylindrical shaped thermal scanning rigidity monitor (TSRM) was used to determine shear rigidity modulus of meat batters during cooking. A meat fat-protein of 1.8, moisture content of 62%, and 8.6% filler were used. The fillers were butter-milk powder, corn starch, micro-crystalline cellulose, modified corn starch, modified wheat flour, soy-protein concentrate and whey-protein concentrate. Plots of rigidity modulus versus product-temperature showed two major thermal transitions. The first and most important transition (53 to 61°C) was due to myosin gelation. The second transition (64 to 69°C) was ascribed to the collagen softening. The maximum rigidity-temperature slopes of 0.60 to 1.02 kPa/°C occurred after the first transition.


## INTRODUCTION

Meat induced gelation of muscle proteins is largely responsible for the physical and chemical stabilization of fat and water in comminuted meat products (Ziegler and Acton 1984). The inclusion of ingredients which possess an ability of form gels enhance gelation and contribute to the hardness of the cooked product. Patana-Anake and Foegeding (1985) used a U-shaped thermal scanning rigidity monitor (TSRM) to obtain shear rigidity modulus of meat batters. For different fillers, there was a decline in the modulus in the temperature range 20 to 40°C, attributed to fat melting. Beyond 55°C there was a steep rise in the modulus due to the actomyosin gelation. This paper describes the changes in shear rigidity modulus of meat batters containing various fillers during smokehouse cooking.

## METHODS AND MATERIALS

### *Meat batter preparation:*

Fresh batters were prepared before each experiment. Lean beef composition was: Protein (21.1%), fat (6.7%), moisture (71.3%) and ash (0.9%). Uncooked meat batter composition was lean beef (59.5 or 49.1%), pork fat (20 or 15.2%), filler (0 or 8.6%), salt (1.66%), soluble spice mix (0.48%), nitrite mix (0.3%), and ice (18.1 or 28.8%). The first number in the brackets is for control (no filler) and second for treatments with fillers. The compositions of the fillers were: butter milk powder ( 44, 34, 5, 6), corn starch (90, 0, 10, 0), micro-crystalline cellulose (94, 0, 6, 0), modified corn starch (90, 0, 10, 0), modified wheat flour (47, 45, 8, 0), soy-protein-concentrate (26, 67, 6, 0.5), and whey-protein concentrate (53, 35, 4.5, 5). These numbers represents carbohydrate, protein, moisture and fat contents in percentages, respectively. A batch of 1.5 kg meat batter was prepared in a smaller chopper (Edward Mueller, type MTZ 10/70). Vacuum tumbling was used to reduce the number of large air pockets in the batter.

### *Thermal scanning rigidity monitor:*

Figure 1 shows the cross - sectional view, which is a modification of Montejano et al. (1984) device, of the TSRM. The assembly process consisted screwing the inner water jacket to the base plate. The bottom and top guides were then placed on the base plate, and outer cylinder was placed on the guides. This created 8 mm gap between inner and outer cylinders. Meat batter was then inserted in the annular space with a spatula, upto 15 mm below the top of the outer cylinder. The outer cylinder cap was then screwed, as well as bottom guide stud. An

Table 1: Kinetic parameters of shear rigidity modulus (G) changes during smokehouse cooking of meat batters.

| Fillers | Kinetic parameters ΔS, kJ/(kgmol.K) | Kinetic parameters ΔH, MJ/kgmol | degrees of freedom for error | mean sum of squares of error($x10^{-7}$) |
|---|---|---|---|---|
| Control | -333 | -9.9 | 8 | 3.76 |
| BMP | -323 | -6.9 | 6 | 2.88 |
| CS | -336 | -10.2 | 6 | 2.01 |
| MCC | -324 | -7.8 | 7 | 6.46 |
| MCS | -337 | -10.7 | 7 | 1.85 |
| MWF | -299 | -1.9 | 7 | 4.02 |
| SPC | -331 | -9.0 | 7 | 2.41 |
| WPC | -333 | -9.8 | 7 | 2.23 |

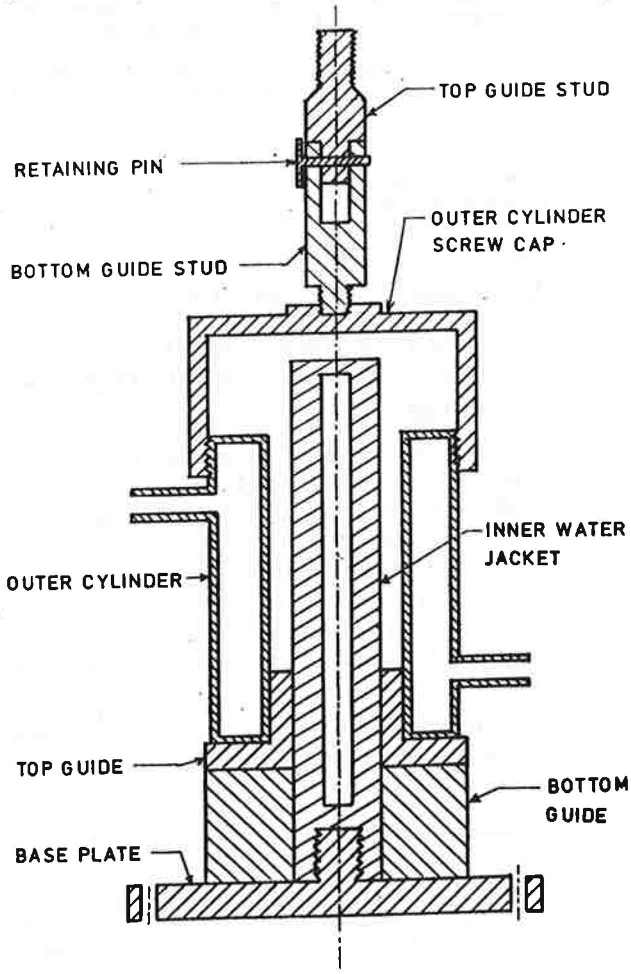



Figure 1: A sectional view of the thermal scanning rigidity modulus apparatus

Figure 2: Rigidity modulus profiles of the meat batters during cooking. 1= modified corn starch; 2= corn starch; 3= micro-crystalline cellulose; 4= modified wheat flour

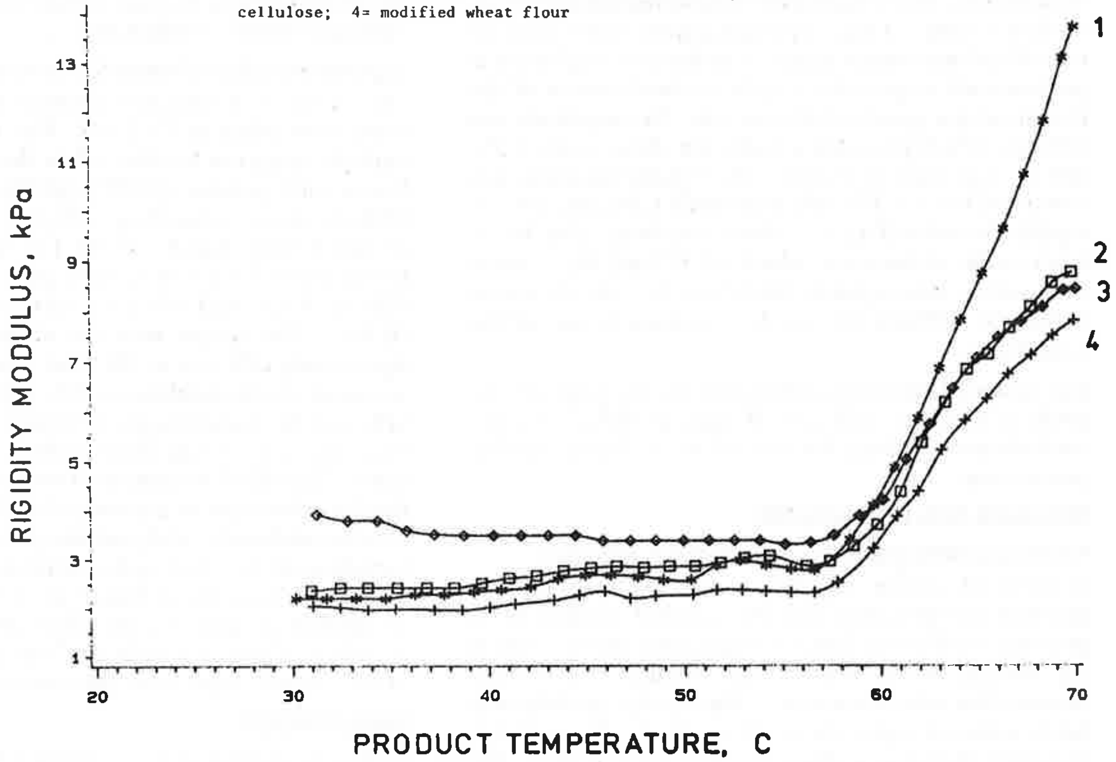
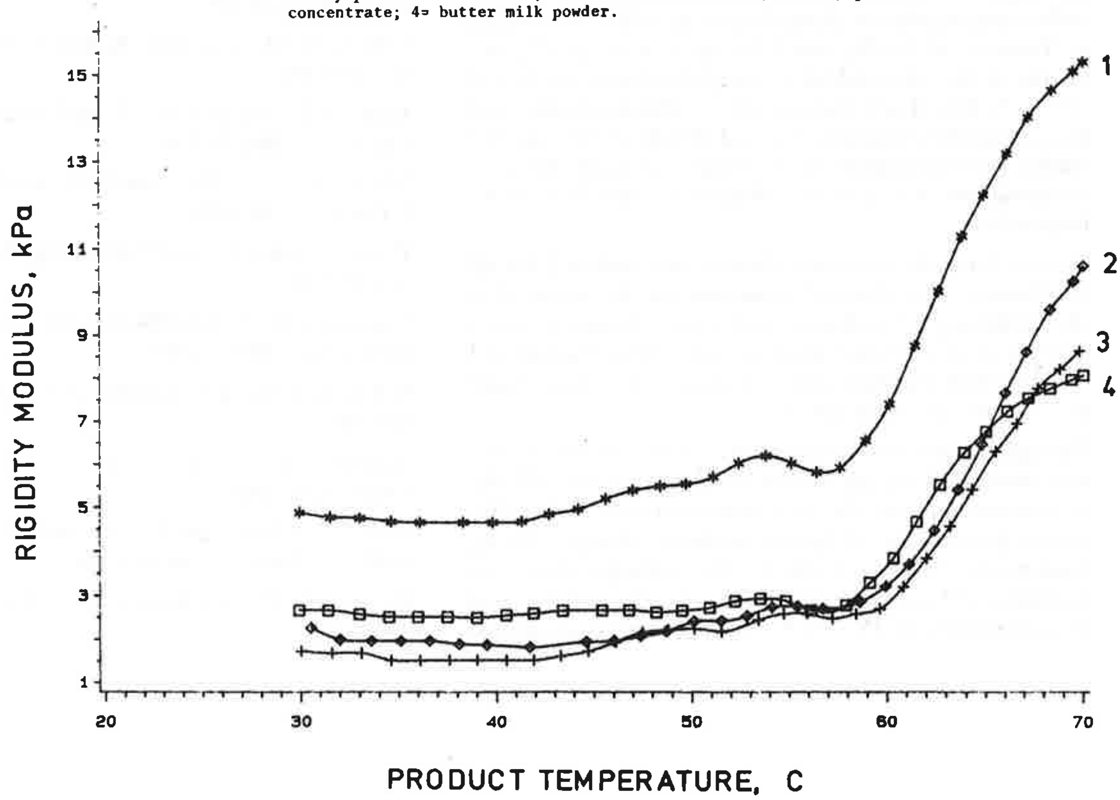



Figure 3: Rigidity modulus profiles of the meat batters during cooking. 1= soy-protein concentrate; 2= control (no filler); 3= whey protein concentrate; 4= butter milk powder.




Instron universal testing machine (model 4204) with a 1 kN load cell was used to measure shear force. The base plate of the TSRM was fastened to the machine base, and top guide was attached to the load cell. The bottom and top guide studs were then removed.

A water bath recirculated water through the inner and outer cylinders to maintain uniform temperature in the meat batter. The temperature was increased at the rate of 0.66°C/min. T-type thermocouples were used to record various temperatures. The Instron machine was programmed to provide a cyclic vertical motion of the crosshead at a speed of 0.48 mm/min. The amplitude was 0.24 mm, which provided a maximum shear strain of 3% and a cycle time of 2 min. The rigidity modulus was computed by $G = F.\ln(R_2/R_1)/(4.628.L.D)$, where G = rigidity modulus (Pa), F = force amplitude (N), $R_2$ = inner radius of the outer cylinder (0.023 m), $R_1$ = outer radius of the inner cylinder (0.015 m), D = displacement amplitude (0.00024 m), and L = average length of the sample (m).

For cooking kinetics modelling, refer to the paper by the authors entitled "Effects of various fillers on the smokehouse cooking kinetics of meat batter" in this proceeding.

## RESULTS AND DISCUSSION

### *Kinetic parameters of rigidity modulus changes:*

A plot of shear rigidity modulus (G) versus product-temperature for the control treatment is presented in Figures 2 and 3. Each point on the curve is the average of two replications. Similar results were obtained for other treatments. The rigidity modulus was fairly constant upto about 55 to 58°C. Beyond this transition there was a sharp increase in the rigidity. The first thermal transition for all the treatments occurred in the range of 54 to 61°C. This transition can be attributed to the myosin gelation (Samejima et al. 1976). According to Yasui et al. (1979) and Ishioroshi et al. (1979) the degree of myosin gelation is completed between 60 and 70°C). Schweid and Toledo (1981), Patana-Anake and Foegeding (1985), and Barbut and Mittal (1988) reported similar thermal transitions for meat batters of different compositions at 57 to 67°C, 54 to 57°C, and 54 to 58°C, respectively.

A second transition occurred between 64 and 69°C for all treatments. This thermal transition can be assigned to the softening of collagen and sarcoplasmic protein (Wright et al. 1977, and Findlay et al. 1986). Barbut and Mittal (1988) reported similar transition between 65 and 69°C for poultry meat batter.

The rigidity-modulus versus product-temperature profile was modelled by an exponential model for all the treatments between the first transition and 70°C. The kinetic parameters of rigidity modulus changes during cooking are shown in Table 1. The enthalpy change of activation ( H) and entropy change of activation ( S) were linearly related as $H = A.S + B$. The regression analysis of the data provided A = 334K, and B = 101.6 MJ/kg mol with $R^2 = 0.98$. However, the tests suggested by Krug et al. (1976) failed to provide a truly linear thermodynamic enthalpy-entropy relationship.

### *Rigidity modulus of meat batters cooked to 70°C:*

The analysis of variance showed filler effect but no replication effect at 5% level. Results of the Duncan's multiple range test for filler effect showed: control (8.1c), Butter-milk powder (BMP) (10.6b), corn starch (CS) (9.0bc), mycro-crystalline cellulose (MCC) (8.4 bc), modified corn starch (MCS) (13.7a), modified wheat flour (MWF) (7.9C), soy-protein concentrate (SPC)(15.3a), and whey protein concentrate (WPC) (8.7bc). The means with the identical letters are not significantly different at 5% level. The values in brackets are mean rigidity modulus at 70°C in kPa. This shows that SPC and MCS treatments provided more rigid product than others, due to the fillers ability to form strong gels in water. The BMP treatment provided significantly more rigid product than in the control and MWF. The ability of poly-saccharides and proteins, present in the fillers, to form firm and resilient gels contributed to the formation of a more rigid meat batter at 70°C. Greater water absorption property of the fillers also provided firmer meat batter gels. Similarly, the better emulsifying ability of the fillers formed more rigid meat batter.

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