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THERMO-RHEOLOGICAL PROPERTIES OF SAUSAGE BATTERS AS AFFECTED BY DIFFERENT LEVELS OF FAT AND ADDED WATER

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BACKGROUND

The existing trend towards low-fat and low-calorie comminuted meat products (CMP) such as bologna and frankfurters has led the industry to develop products that account for these consumer concerns. CMP are complex meat systems comprising mainly fat and protein in a dispersed phase. When fat levels are decreased in CMP, other, usually nonmeat ingredients sometimes are added to the formulation. The nonmeat ingredients could be starches, nonfat protein dairy products, plant proteins, and more added water. Thermo-rheological behavior of meat batters can be utilized to predict the physical response of sausage batter under various conditions of stress and strain. Rheological properties of sausage batters can be correlated with textural characteristics of finished products, such as softness and firmness. These properties are related directly to the consumer's perception of quality.

OBJECTIVE

The objective of the study was to examine the effects of various levels of fat, and added water on rheological properties of sausage batters and the rate of structure development during thermal gelation using dynamic oscillatory measurements in different batters.

METHODS

Fresh boneless beef round (94% lean) and pork picnic (50% fat/50% lean) were used. The meats were ground through 9.38 mm and 4.69 mm plates. Proximate analysis was done using AOAC methods (AOAC, 1990). The batters were formulated to contain fat levels in the range of 15% to 27%. Water added was at levels in the range of 18% to 35%. The meats were mixed in a Hobart mixer with salt (2.5%) and 1/3 of the water for 2 min. Prague powder (0.34%) containing 6.25% sodium nitrite and ascorbic acid (0.1%) was added with another 1/3 water and mixed for 2 min. Bologna seasoning (0.5%) and dextrose (2.0%) along with the remaining 1/3 water were added and further mixed for 2 min. The mixture was comminuted through a Mincemaster Emulsion Mill with a 1.7-mm plate. The control batter (F15W24) contained 15% fat and 24% added water. Thermo-rheological properties of raw batters were assessed by small amplitude dynamic oscillatory tests using a Bohlin VOR computer-controlled rheometer. Samples were loaded in a 1.0 mm gap between two stainless steel parallel plates. The sample perimeter was covered with a thin layer of high temperature-resistant silicone grease to prevent dehydration of the sample edge. The entire gelling unit was enclosed in an insulated shell to minimize heat loss. After initial equilibrium at 22^{O}C for 5 min, the sample was heated at 1^{O}C/min continuously to 80^{O}C, while dynamic oscillatory measurements were made at a fixed frequency of 1.0 Hz with a maximum strain amplitude of 0.0265. Storage modulus (G') and viscosity were measured in triplicate.

RESULTS AND DISCUSSION

The major changes in the batters tested were the values of G' and viscosity at 55^{O}C and 63 to 70^{O}C. Initially, G' and viscosity of batters F15W24, F15W30, F18W18, F18W30, F18W27, and F18W21 (Fig. 1a, b, c, d, e, f), started to decline gradually. A steeper decline (Fig. 1b) was observed from 22 to 45^{O}C. This was followed by small increases in the form of peaks at 48^{O}C and 53^{O}C. Declines in both G' and viscosity occurred from 56 to 60^{O}C, after which increases in G' and viscosity occurred from 62 to 80^{O}C, with maximum G' and viscosity reaching 18.30 KPa and 2.94 KPa, respectively, for batter F15W24 (Fig. 1a) at 75^{O}C. The maximum increases in G' and viscosity (8.91 KPa and 1.43 KPa) for batter F15W30 (Fig. 1b) occurred at 78^{O}C. Batters F18W18 and F18W30 showed maximum G' and viscosity increases of 18.70 KPa and 3.00 KPa (Fig. 1c) and 16.00 KPa and 2.57 KPa (Fig. 1d), respectively at 80^{O}C. Batters F18W27 and F18W21 showed maximum G' and viscosity increases of 15.60 KPa and 2.50 KPa (Fig. 1e) and 15.30 KPa and 2.62 KPa (Fig. 1f), respectively at 80^{O}C. Declines occurred in G' and viscosity in the temperature range from 22 to 45^{O}C for batters F21W24, F21W30, F27W21, F24W24, F27W24, and F27W35 (Fig. 2a-f), with no major structure development. Small increases in G' and viscosity occurred around 48^{O}C and 55^{O}C, followed by declines in G' and viscosity from 58 to 60^{O}C. Final increases in G' and viscosity occurred from 62 to 80^{O}C, with maxima at 15.70 KPa and 2.52 KPa for F21W24 (Fig. 2a) and 11.80 KPa and 1.89 KPa for F21W30 (Fig. 2b), respectively at 75^{O}C. Maximum G' and viscosity of 11.10 KPa and 1.87 KPa for F27W21 (Fig. 2c) and 12.10 KPa and 1.95 KPa for F24W24 (Fig. 2d), respectively occurred at 75^{O}C. Batter F27W24 showed maximum G' and viscosity at 10.20 KPa and 1.64 KPa (Fig. 2e) and batter F27W35 at 11.40 KPa and 1.82 KPa (Fig. 2f), respectively at 80^{O}C. Experimental data collected using a highly sensitive rheometer demonstrated pronounced changes in the thermo-rheological properties of the various batter formulations. The gelation of muscle proteins during heat treatment is largely responsible for developing the characteristic texture of CMP without the release of fat or water. The decline in G' and viscosity from 22 to 34^{O}C may have been related to melting of pork fat. At temperature ranges from 43 to 50^{O}C, and 55 to 60^{O}C, the declines in G' and viscosity were due to denaturation of myosin and it subfragments. The sharp increase in G' from 63 to 70^{O}C shows final gelation of the meat protein and the formation of a strong-gel end product. Differential scanning calorimetry showed that denaturation of myosin and it subfragments occurred via endothermic processes at 45^{O}C, 55^{O}C, and 63^{O}C (Wright and Wilding, 1984). Our results were within this temperature range. Rheological thermograms showed minimum G' and viscosity occurring between 57 to 60^{O}C. This temperature range of thermograms may vary with differences in batter composition.

CONCLUSIONS

The storage modulus (G') and viscosity tests of batters showed variations in structure formation at various temperature points. From the thermograms, it was evident that G' and viscosity patterns of the sausage batters differed according to the batter composition, i.e., content of fat, protein, and water. The thermograms showed that fat and added water had greater effects on the thermo-rheology than the protein content, probably because of the dilution of protein by fat and water. The heights of the thermogram peaks depended on the percentages of fat, and added water. The control batter (F15W24) had the highest G' and viscosity at 70^{O}C. Therefore, fat content greater than 27% and added water greater than 24% may produce frankfurters with a soft texture that may not be desirable to most consumers.

PERTINENT LITERATURE

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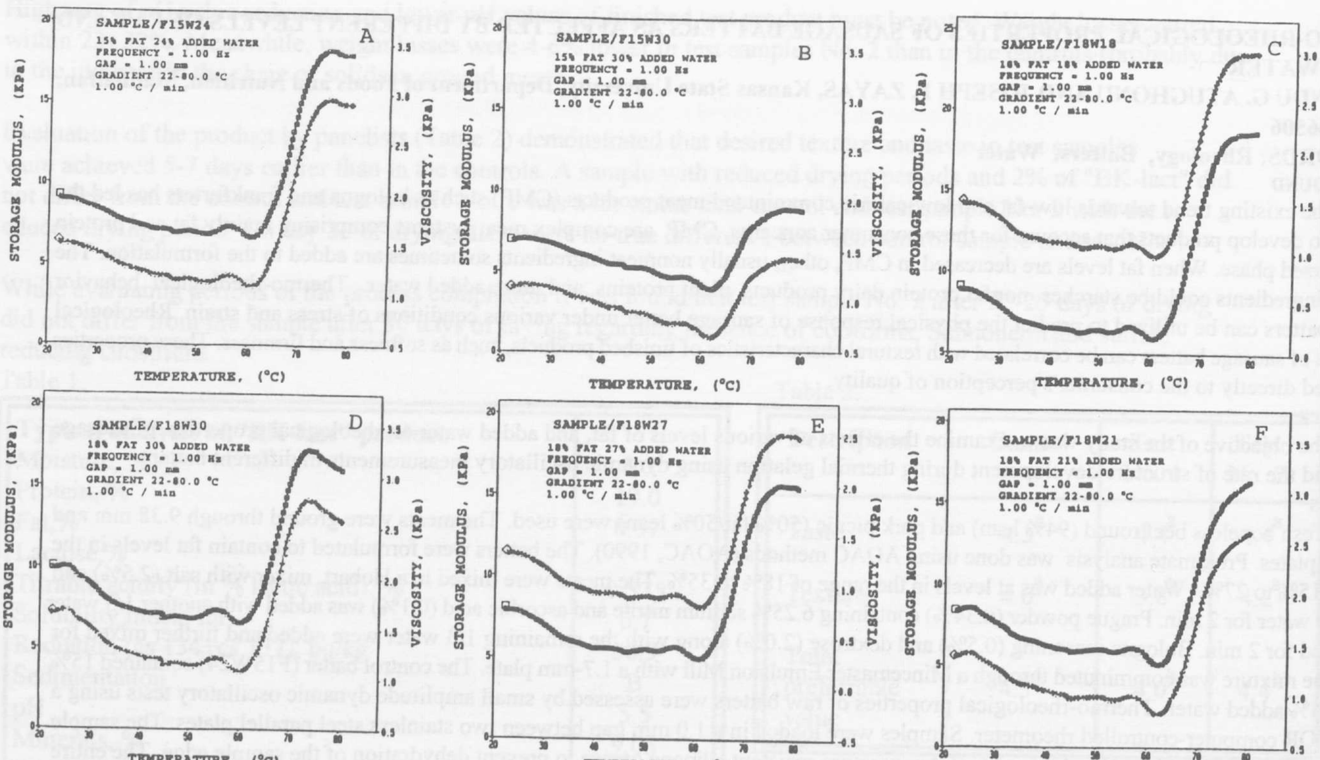

FIG. 1. EFFECTS OF FAT, ADDED WATER AND PROTEIN CONTENT ON THE STORAGE MODULUS (□□□□) AND VISCOSITY (◊◊◊◊) OF DIFFERENT BATTERS DURING THERMAL GELATION WITH BOHLIN VOR RHEOMETER.

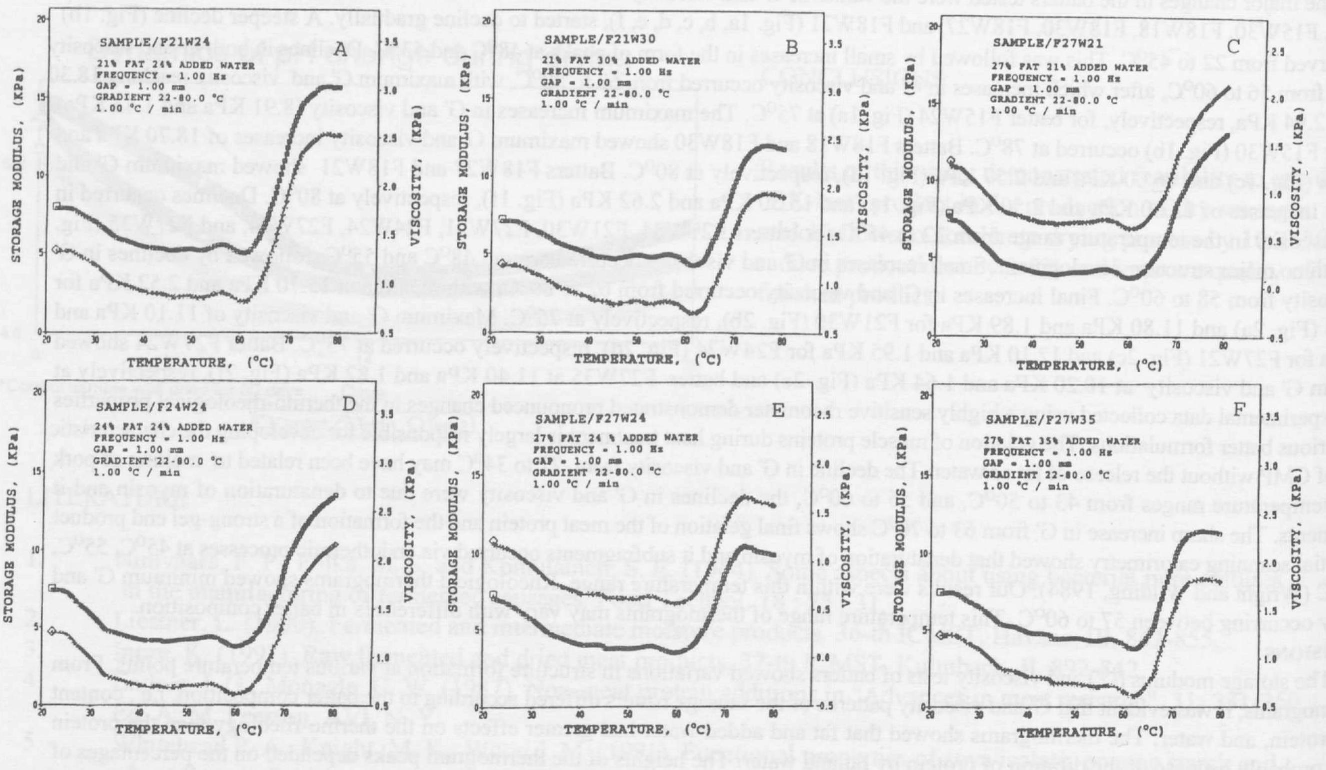

FIG. 2. EFFECTS OF FAT, ADDED WATER AND PROTEIN CONTENT ON THE STORAGE MODULUS (□□□□) AND VISCOSITY (◊◊◊◊) OF DIFFERENT BATTERS DURING THERMAL GELATION WITH BOHLIN VOR RHEOMETER.