:10 The effect of processing temperature and effective salt concentration on the binding ability of frankfurt type sausages made with and without added fat

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INTRODUCTION

The binding between meat particles in processed meat products is a heat initiated reaction since binding does not occur in the raw state (Schnell et al., 1970). Kotter and Pischer (1975) suggested that heating caused the previously dissolved proteins to rearrange and interact with the insoluble meat proteins and in so doing form a cohesive structure. The protein matrix formed, binds water and fat and determines the textural characteristics of the product (Schmidt et al., 1981).

Studies by Acton (1972) using chicken and Siegel and Schmidt (1979) using beef, found that binding started at 40°C for chicken and 50°C for beef and then increased linearly with temperature to 80°C. These studies were carried out under constant ionic strength and pH conditions. However, studies using differential scanning calorimetry have shown that ionic strength (Quinn et al., 1980) and pH (Stubursvik and Martens, 1980) change the temperature at which denaturation of the major meat proteins occur. Yasui et al. (1980) and Samejima et al. (1981) have shown that, at a given temperature, the gel strength of myosin can be maximized by optimizing both ionic strength and pH. As myosin is the major determinant of meat protein functionality (Macfarlane et al., 1977, Schmidt et al., 1981), these studies indicate that changes in either salt level or pH will produce corresponding changes in the temperature required to produce a meat protein matrix that will effectively bind both water and fat.

Finely comminuted cooked meat products contain approximately 30% fat, but it is not clear as to how this fat is bound in these products. Swift (1961) proposed that meat proteins bind fat by forming true oil in water emulsions. However, Schut (1976) suggested that emulsification plays only a small part in fat binding with most fat being entrapped in a heat set protein matrix. If meat proteins are involved in true emulsification, a change in fat level should cause a change in the amount of water bound. If fat is bound in a true emulsion, reducing the fat level should release water from the emulsion structures. However, if some of the water is bound in an emulsion and some is held within the protein matrix, a reduction in fat level would leave more protein available to bind water. Fat also concentrates added salts in the protein water phase since salts are insoluble in nonpolar fat (Morrison et al., 1972).

The objectives of this study were to: (a) determine if the effective salt concentration altered the temperature at which maximum water binding ability of meat proteins occurred and (b) to observe whether the level of fat in a finely comminuted meat product changed the water binding ability of the meat proteins.

MATERIALS AND METHODS

Meat and Product Formulation: The meat used in the experiment, lean bull meat (6% fat) and pork back fat (94% fat), was ground, mixed, vacuum packed in five kg portions and stored at -30°C until used (approximately three months). All products were formulated to contain 0.01% sodium nitrite, 0.03% sodium erythorbate and a moisture level of four times the protein content plus 10%. High fat products contained 30% fat and low fat products contained 5%. Salt (NaCl) levels used were calculated based on the weight of nonfat ingredients. Five kg batch sizes were used for all treatments.

Treatments, Design and Statistical Analysis: This study was carried out to determine the effect of two fat levels (5 and 30%), four concentrations of salt in the nonfat phase (1.33, 2.13, 2.93 and 3.73%) [which corresponds to concentrations of 1.0, 1.6, 2.2 and 2.8% in the 30% fat products] and four cooking temperatures (56, 64, 72 and 80°C) on the WBA (water binding ability) of frankfurt type products. A complete 2x4 factorial design (two fat levels by four salt levels) with a four way split for temperature was used; a total of 32 treatments. The experiment was replicated twice. The WBA data was analyzed by analysis of variance of a split plot design with two blocks (replicates). When F values were significant, differences between treatment were determined (at the 5% probability level) using Fischers least significant difference (Snedecor and Cochran, 1976).

Processing: The meat was removed from the freezer and thawed at 25°C (12 hours) and then at 2°C until used (2-7 hours). The ingredients were mixed by weighing them into the bowl of a 35 liter Meissner bowl chopper (RMF Steel, Kansas City, MO) and chopping them at a blade speed of 400 rpm for ten bowl revolutions. All treatments were then processed to a constant degree of mechanized work end point: Knife speed 4,000 rpm (6 blades 32 cm diameter), 100 bowl revolutions at 16.7 rpm. After chopping, samples were taken for pH measurement (pH range 5.75 to 5.85) and the product temperature was measured; temperature ranges were 4-8°C for the no fat treatments and 8-14°C for the fat treatments. The products were stuffed into 306x406 cans and closed to a fill weight of 525 ± 2 g. Cans from each treatment were randomly assigned to one of four batches (2 cans per batch) and stored in a 2°C cold room (1 to 5 hours) until cooked.

Cooking was carried out in an air agitated, thermostatically controlled retort (water temperature 2°C ± 0.5°C above the required temperature) until the desired internal temperature was obtained (typically 90 to 100 minutes). The internal temperature was monitored with thermocouples (O. F. Ecklund, Inc., Cape Coral, FL) placed in the center two cans treated similarly to the treatment cans.

After heat processing, the cans were cooled in running tap water (6 to 8°C) until the internal temperature had dropped to 35°C and then stored at 2°C overnight. The products were removed from the cans, dried with paper towel and weighed for WBA determination. Any fat adhering to the product or cans was included as part of the product weight, not as product loss.

pH was determined by blending 50 g of sample with 250 mls of deionized water and measuring the pH of the resultant slurry with a Corning combination electrode and pH meter (Model 125). Moisture, fat and protein was determined on the raw materials using the AOAC (1970) methods. WBA was calculated as the amount of water, meat and salts retained in the product after cooking divided by the amount originally present; expressed as a percentage.

RESULTS AND DISCUSSION

Analysis of variance of WBA (Table 1) showed that fat level had no effect on the WBA of the products, either as a main effect or interaction (P>0.05). The fat level may have had a small effect on WBA, as the error mean square was relatively large (3.6) and differences in WBA greater than 4.0% were required to produce significant differences (P<0.05) between the high fat and low fat treatments, at a given temperature and salt level. However, there was no consistent effect of fat level on WBA. If there was an effect of fat level on WBA, it was small.

Table 1. Analysis of variance of water binding ability

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F	Significance
Whole Plot					
Replication	35.6	1	35.6	3.70	0.096
Fat	8.2	1	8.2	0.85	0.39
Salt	1396.8	3	465.6	48.41	<0.001
Fat by Salt	25.5	3	8.5	0.88	0.49
Error	67.3	7	9.61		
Split Plot					
Temperature	2258.9	3	753.0	206.61	<0.001
Temperature by Fat	9.6	3	3.21	0.88	0.47
Temperature by Salt	557.9	9	62.0	17.00	<0.001
Temperature by Fat by Salt	41.9	9	4.7	1.28	0.299
Error	87.4	24	3.6		
Total	4489.1	63			

This is consistent with the results obtained by Morrison et al. (1971). They showed that reducing the fat level, in model meat products, from 60 to 20% produced only a small increase in cooking loss.

This would indicate that in meat products the production of an oil-in-water emulsion does not play a large role in determining the amount of fat and water bound in cooked meat products. If this was the case, removing the fat from the product should produce a concurrent reduction in the amount of water bound, as both fat and water are required to produce an emulsion. This concept is supported by the work of Meyer et al. (1964) who found that the addition of true emulsifying agents to cooked sausage products had a negative effect on the amount of fat and water bound, and Swasdee et al. (1982) who showed, using microscopy, that fat particles in frankfurters are nonuniform in size and did not show the homogenity of dimensions considered to be representative of 'true emulsions'.

The results of the effect of temperature and salt level (averaged over both fat levels) on WBA are presented in Fig. 1. Increasing the cooking temperature reduced the WBA of the products (P<0.01), with the effect being more pronounced at low salt levels than at high salt levels. When the salt concentration was greater than 2.93%, increasing the temperature produced only a small reduction in WBA, whereas at salt concentrations lower than 2.93%, increasing the temperature produced large reductions in WBA. At a given temperature, the WBA was determined by the salt conentration used, with the greater WBA occurring at the higher salt concentrations. Increasing the salt concentration above 2.93% produced no increase in WBA (P>0.05) at any temperature. All treatments heated above 70°C had WBA values less than 95%, while heating to 65°C produced maximum (P<0.05) WBA at all salt levels except at the lowest salt level, and then maximum WBA occurred only at temperatures below 58°C.

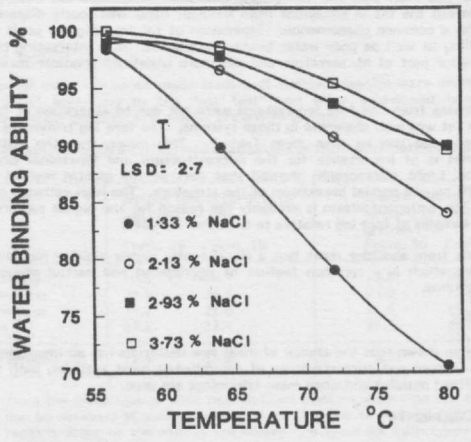

Fig. 1. The effect of temperature and salt level on the water binding ability of frankfurters; averaged over both fat levels.

The salt concentrations used in these products seem high (1.33 to 3.79%), however, these concentrations are expressed as a percentage of the nonfat ingredients. Hence, the salt concentrations used here should be compared to those approximately 30% lower (1.0 to 2.8%), in products that contain 30% fat.

These results indicate that one role of salt in meat products is to increase the temperature at which the products undergo syneresis with a concurrent loss of water. Although differential scanning calorimetry studies have (Wright et al., 1977; Quinn et al., 1980) shown that increased salt concentrations increase the denaturation temperature of meat proteins, it appears that a more important role of salt in meat products is to increase the temperature at which the meat proteins aggregate. Thermally induced reduction in WBA has

been postulated as being due to protein shrinking and aggregation (Hermansson, 1983).

CONCLUSION

The effect of fat level on the WBA of frankfurters was minimal, as there was no consistent effect of fat level over the temperature range and salt levels used. This indicated that very little of the water in these products was bound in a true oil in water emulsion.

The effect of increasing salt level was to permit the products to be cooked to higher temperatures without appreciable reductions in WBA. Increasing the salt level above 2.93% produced no change in WBA. Cooking the products to 65°C or less produced near maximum WBA for all but the lowest salt level, while increasing the temperature above 65°C reduced WBA. At the lowest salt level (1.33%), increasing the temperature above 58°C produced a corresponding large linear reduction in WBA (1.3% per degree centigrade increase in temperature).

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