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THE EFFECT OF FAT LEVEL ON TEXTURAL CHARACTERISTICS OF LOW-FAT EMULSION TYPE MEAT PRODUCTS.

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Background

The development of low fat meat products presents a number of difficulties because the fat has a considerable influence on both textural and sensory characteristics of the product. In addition, the quality attributes of low fat products depend not only on the amount of fat present but also on the level of protein. Preliminary investigations revealed little correlation between fat level and many of the parameters measured when fat was replaced with added lean. For example, there was no obvious relationship between fat level and water holding capacity or cook loss. Other workers (Claus *et al.*, 1989) found that the protein had a more significant role than the fat or added water.

Objectives

Our initial objective was to examine the effect of varying fat level on the textural characteristics of emulsion-type meat products while keeping the protein constant. The fat levels were varied by replacing the fat with water. No added ingredients (other than salt and phosphate) were used in the formulation. The textural characteristics were determined using an Instron Universal Testing Machine. Results obtained for a commercial brand of frankfurter are also included for comparative purposes.

Methods

The emulsion-type products were prepared with lean pork, lean beef, pork back fat, ice, salt and phosphate. The fat, protein and moisture contents of the lean meat, pork and back fat were calculated and five different formulations were prepared using these values. Predicted fat levels were, 5, 12, 18, 23 and 30% fat and the predicted protein level was 12.5%. Twenty-five kg of each formulation was prepared and filled into cellulose casings using a VEMAG Vacuum filler. These were then cooked to an internal temperature of 70°C.

The moisture and fat contents of the raw and cooked products were estimated using a CEM fat/moisture analyzer. Protein was determined by LECO protein analyzer. The pH values of the blended products were recorded and the internal colour of the cooked emulsion type meat products was measured by the CIE LAB system with a tristimulus colorimeter (Hunterlab D-25, Fairfax, VA). The ability of the uncooked emulsion type product to retain moisture was measured. The water holding capacity was calculated as described by Miller *et al.* (1968). Cook loss was also determined. Emulsion stability was estimated by recording the total fluid (g) released by the raw meat products following heating and centrifugation. A total of twenty five 1.25 cm x 2.0 cm cores (five from each of 5 cooked products) were sheared with a Warner-Bratzler cell attached to an Instron Universal Testing Machine. Maximum peak height (Peak Force, N) and area under the curve (Energy, J) were recorded for each sample. The settings for the test were as follows : Load Cell = 0.5 kN; Cross Head Speed = 150 mm/min. The Kramer Shear Test was carried out on five replicates which were cut into 6.5 cm lengths and placed in the Shear Cell perpendicular to the shear blades. Initial Yield Force (N) and Maximum Load (N) were determined. The settings were as follows : Load Cell = 2.0 kN; Crosshead speed = 100 mm/min. For Texture Profile Analysis a total of thirty 2.5 cm x 2 cm cores (6 from five cooked products) were compressed to 50% of their original height according to Bourne (1978, 1982). Hardness, cohesiveness, springiness, gumminess and chewiness were computed using the following Instron settings : Load Cell = 500 N; Crosshead Speed = 100 mm/min. The results of all experiments were compared using one-way analysis of variance (ANOVA). When ANOVA revealed significant differences between means (at the 5% level) the means were compared using a least significant difference test. Correlation between fat levels and the measured parameters were examined using the software Statgraphics.

Results and Discussion

The fat levels in the raw products were close to the predicted values and were 4.2, 11.5, 16.8, 20.8 and 28%. These values remained unchanged when cooked except at the 23% level where there was a small but significant increase in fat level on cooking. The protein levels were also as predicted, i.e., 12.5% and did not vary between formulations. Moisture levels varied between batches and ranged from 56.6% to 79.9%. These levels decreased slightly on cooking but this was only significant in the case of 12, 18 and 23% fat. One commercial frankfurter brand examined had similar protein, fat and moisture contents to our high fat emulsion-type product. It was shown to contain 28.3% fat, 11.7% protein and 54.3% moisture.

There was a slight increase in pH as the fat level increased and generally the pH of the cooked products was higher. However this difference, although significant, was less than 0.2 units in all cases. The pH values ranged from pH 6.04 to 6.32 and these are close to that recorded for the commercial brand (pH 6.2). A pH value of 6.01 for pork/beef frankfurters was reported by Mittal and Barbut (1994). As expected, differences in colour were observed between formulations. 'L' values, which are an indication of the lightness of the product, increased as the fat level increased. Correlation between fat level and 'L' values was high ($p \leq 0.001$). The values ranged from 53.6 to 63.6 and compare well with the commercial brand ('L' value = 58.2). Marquez *et al.* (1989) reported a similar decrease in the 'L' values of frankfurters when the fat is reduced.

Correlation between fat level and water holding capacity was high ($p \leq 0.001$). The water holding capacity increased gradually as fat level increased. At the 5% level, water holding capacity was 58.36% whereas at 30% fat this value increased to 74.81%. Correlation between fat level and cook loss was also high ($p \leq 0.001$). Cook loss was highest at the lowest fat level. This decreased significantly at the 12% fat level but no further decrease was observed at fat levels greater than 12%. Other workers such as Claus *et al.* (1989) also observed greatest cook loss in 5% fat products when they substituted added water for fat in bologna. It should be noted however that the cook loss, even at 5% fat, is low, when compared with other published data. Mittal and Barbut (1994) reported a cook loss of 3.8 and 4.3% for their high and low fat frankfurters compared with a maximum of 1.5% for our products. The differences in cook

loss between formulations are probably due to alterations in the functionality of the salt and phosphate. At the 5% fat level, an increase in added water may cause a decrease in the total effective salt concentration. Therefore a larger portion of the myofibrillar structure would be retained resulting in less possibility of water binding. In addition, as fat is hydrophobic, moisture diffusion out of a product is less at higher fat levels. The emulsion type products were relatively stable and the volume of total fluid released was small. Correlation between fat level and emulsion stability was high ($p \leq 0.001$). The emulsion was least stable at the 5% fat level with similar volumes of fluids released at 12, 18, 23 and 30%.
By keeping the protein constant, cook loss, water holding capacity and emulsion stability, over the range of fat levels examined, have been improved compared with initial studies. As mentioned previously, these studies involved the replacement of fat with added lean meat and, as a result, protein levels varied in each formulation. The results of the present study imply that it is important to keep the protein constant when the fat level is reduced.

When the protein was maintained at approximately 12.5% correlation between most of the textural parameters measured and fat level was good. In general, the TPA parameters (hardness, chewiness, cohesiveness and gumminess) increased with increasing fat level. Correlation between fat level and most of the measured parameters was excellent ($p \leq 0.001$). However, there was no obvious relationship between springiness and fat level. At the 5% fat level, hardness was measured as 11.43 N which increased gradually to 27.79 N at 30% fat. This is almost identical to the hardness value of 27.88 N obtained for the commercial brand. Chewiness also increased from 45.10 to 129.39 N/mm as fat level increased from 5% to 30%. Again, the commercial brand was of similar chewiness to our 30% fat product (i.e., 119.43 N/mm). Cohesiveness increased from 0.52 at the 5% fat level to 0.60 at 18% fat. Above this fat level there was no further increase in cohesiveness. Cohesiveness in the commercial brand was measured as 0.58 which is similar to our high fat product. Gumminess increased with increasing fat level. At 5%, the value was 5.90 N/mm^2 and at 30% it had increased to 16.28 N/mm^2. The latter is similar to the gumminess value obtained for the commercial brand (16.04 N/mm^2). In general, the TPA parameters increased with increasing fat level. Other workers (Claus *et al.*,1989; Claus *et al.*, 1990; Gregg *et al.*, 1993 and Cavestany *et al.*, 1994) also reported an increase in TPA parameters and water binding properties with increasing fat level when the protein is constant. In contrast, Marquez *et al.* (1989) reported a decrease in these parameters as fat content increased. However the latter workers had increased protein levels and increased added water as the fat decreased and therefore the results are not comparable.
Using the Kramer Shear attachment it was found that the initial yield force was highest at the 5% fat level. The correlation between fat level and initial yield force was good ($p \leq 0.0021$). The forces ranged from 201 N to 161 N. These values are considerably higher than the commercial brand (initial yield force = 55 N). Maximum load was highest at the low fat levels and decreased to a minimum at the 30% fat level. As with initial yield force, correlation between the fat level and maximum load was good ($p \leq 0.0061$). The values ranged from 239 N to 196 N and as with the initial yield force were higher than the commercial brand (maximum load = 56 N).
A decrease in shear stress with increasing fat level has been reported previously. Marquez *et al.* (1989), for example, used a double shear blade device and found a significant decrease in shear stress between 12%, 20% and 29% fat. Hand *et al.* (1987) also showed greater Kramer peak force in low fat compared with high fat frankfurters.
In the present study, no relationship between peak force or energy and fat level was found when the Warner Bratzler attachment was used.

Conclusions
The moisture, fat and protein contents of the emulsion-type meat products were close to the predicted values. They were stable with relatively high water holding capacities and low cook losses. Fat level influenced colour, water holding capacity, cook loss and emulsion stability. It also affected textural characteristics. Maintaining protein at 12.5% revealed correlations between the measured parameters and fat level which had not been obvious when the protein content was variable. Therefore it is important to keep the protein constant when the fat content is lowered in order to identify the role fat plays in the texture of meat products.

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