SUBSTITUTION OF ANIMAL FAT WITH PEANUT OIL IN A MEAT EMULSION MODEL.

CHRISTENSEN M. and ZEUTHEN P.

Department of Biotechnology, Food Technology, The Technical University of Denmark, Lyngby, Denmark.

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SUMMARY

The acceptability of emulsion products formulated by replacing pork fat with peanut oil at seven substitution levels (15, 30, 45, 60, 70, 80 and 100 %) was studied at two final fat levels (15 and 26 %). 60 % substitution was possible in products containing 26 % total fat before changes in WHC occured. At a total fat content of 15 %, 45 % substitution was possible. Instrumental measurements and sensory evaluation of the texture showed changes in breaking strength even at low substitution levels. Futhermore, the texture of the fat reduced products was so soft, that the products were not acceptable from an eating quality point of view. Storage stability was not affected by substitution level, only the final fat content. No additional fat loss due to oil addition was observed.

INTRODUCTION

The type and total amount of fat in the food supply has emerged as a topic of increasing concern to the consumers. Increasing demand for fat reduced products as well as interest in the proposed relationship between dietary fat, serum cholesterol concentration, and development of coronary heart disease exemplifies this concern (Marquez et al., 1989).

Animal fat is added to meat products for economic reasons, flavour, palatability and texture modification (Rakowsky, 1970). Saturated and monounsaturated fatty acids are predominant in meat fats (with the exception of fish). Most vegetable oils mainly contain mono- and polyunsaturated fatty acids. If vegetable oil to some extend is replaced by animal fat in comminuted meat products, the level of cholesterol and saturated fatty acids will be reduced making the products more desirable from a health standpoint. However, incorporation of high levels of polyunsaturated fatty acids in the diet has recently been reported to promote carcinogenesis in experimental animals (Rhee, 1992). A vegetable oil low in saturated and polyunsaturated fatty acids and high in monounsaturated fatty acids levels should therefore be chosen.

Presently many meat processors are reducing the fat levels in their products. Reducing total fat levels in processed meats cause problems with palatability and texture - the product becomes firmer, more rubbery and less juicy (Park et al., 1990, Claus et al., 1989). Texture problems can be avoided by adding oil and a greater amount of water to the products. Substituting animal fat with vegetable oil, however, may cause changes in the functional properties of the final product, especially the texture, because oils are not surrounded by a sheath of connective tissue (the cell wall) like fat cells. In addition, oils have melting points lower than animal fat.

The objective of the present study was to evaluate the effect on the functional properties and the sensory quality of a meat emulsion produced with different peanut oil and fat levels.

MATERIALS & METHODS

Formulation of sausage model

In order to make use of a model which was as simple as possible, and where only few extra factors from additives could influence the test result, the ingredients of the basic meat emulsion were limited to pork meat, backfat tissue, distilled water/ice and sodium chloride added 0,5 % sodium nitrite. Visible fat was removed from the trimmings to obtain lean meat, with an approximate composition of 19.4 % protein, 74.6 % water and 6.0 % fat. Approximate composition of pork backfat was 4.3 % protein, 14.1 % water and 81.2 % fat. Lean and pork backfat was diced and vacuumpacked in batches of 2000 g and frozen at -20°C for no more than 2 months. Peanut oil (deodorised) was kept under refrigeration at +2°C. Two total fat levels were tried out, 26 % and 15 %. At both levels 15, 30, 45, 60, 70, 80 and 100 % animal fat was substituted with vegetable oil. In order to have a standard of reference to compare the effect of substitution, an unsubstituted control/reference was included at each total fat level, i.e. 26 % and 15 %.

Preparation of model sausages

Lean and backfat was thawed at 2 °C for 24 hrs and the other ingredients were tempered overnight at 2 °C to ensure that the temperature always was uniform from batch to batch. Lean and fat was grinded the following day. The meat emulsion was prepared in a Robot-Coupe R 501 (Robot-Coupe SA, France). Approximate composition of the unsubstituted reference emulsion at the high fat level: 26 % fat, 62.2 % water and 9.6 % protein and of the fat reduced product: 15 % fat 73.8 % water and 9.2 % protein. As the chopper did not work under vacuum a good deal of air was introduced into the emulsion during comminution. This among other factors can lead to a loose and soft final product. The meat emulsions were therefore vacuumpacked in cans (72x65 mm) to remove some of the air. Six to eight sausages were made of each batch. After filling, the emulsion models were heat processed to a final internal temperature of 74 °C in a water bath held at 76 °C and subsequently cooled in cold water for 20 min.. The products were then stored at 2 °C. Half the products of each batch were packed in plastic bags and stored at 2 °C for 2 weeks (after examining for cook loss). Then analyzed for storage loss, centrifugation loss and instrumentally for texture. The other half was analysed at once.

Chemical analyses

Determinations were made of protein, fat, moisture, salt and pH to ascertain the composition of the recipes. The pH measurements were performed the day of productionon on raw mixes. Determination of fat, moisture and pH was made using standard procedures. Protein was determined by the Kjeldahl method (using the conversion factor 6.25) and salt using MERCK Spectroquant 14755.

Instrumental evaluation of texture

Texture analyses were carried out as uniaxial compression until fracture using an INSTRON Universal Testing Machine, model 4301 equipped with a 100 N load cell and a crosshead speed of 50 mm/min. Samples to be tested for texture were cut into 15 mm thick slices. Core cuts with a diameter of 15 mm were cut out from the slices, and these were used for texture measurement. Six samples from each batch were tested. To ensure uniform temperature the samples were held on ice in plastic Petri dishes until measurement. Data for breaking strength were collected on a computer connected to the Instron Machine.

Water-Holding Capacity (WHC)

WHC of the products was expressed as the ability of the heat processed emulsion to retain water, partly following pasteurization, partly when subsequently subjected to pressure in form of centrifugation. The products were analyzed for cook loss, centrifugation loss, and water holding capacity according to Thomsen and Zeuthen (1988). Fat loss and storage loss was also determined by a standard procedure.

Sensory evaluation

The products were evaluated by a 7 member sensory panel using a multiple comparison procedure (Dethmers et al., 1981). The scoring scale was a 170 mm graphic scale which was analyzed by measuring the distance along the line. A high number (maximum 170) equals a high degree of the quality trait in question. The reference sample was a product with a final fat content of 26 % and no oil added. Samples to be evaluated contained 26 % total fat, and 0 % (coded/hidden reference), 35 %, 60 % and 80 % peanut oil respectively. Three cores (15x15 mm) and a slice (2 mm thick) of each sample were placed in coded polystyrene cups with transparent lids. The panel members were asked to score the samples in comparison with the reference sample.

Statistics

The results were analyzed using analysis of variance except for the sensory evaluations which was analyzed by two-sided analysis of variance.

RESULTS & DISCUSSION

Water-Holding Capacity

WHC was significantly affected by the two factors - oil substitution and total fat content.
As it can be seen from Figure 1, 60 % oil substitution was possible at the high fat level (26 % total fat) before significant changes in WHC occurred. When the total fat content was reduced to 15 %, 45 % substitution was possible before a significant drop in WHC was observed. When increasing the oil substitution level the amount of protein in the aqueous phase is reduced. This reduces the strength of the protein gel and its ability to retain water during heat treatment.
Significant ($P<0.05$) differences were found in WHC due to total fat content (Figure 1). Retention of water in meat products require the dissociation of most myofibrillar protein structure (Ziegler & Acton, 1984). This dissociation is affected by salt concentration in the aqueous phase (Hamm, 1986). When formulating the fat reduced models, the water content was increased and fat content decreased. The total effective salt concentration in the emulsion is thereby reduced, thus decreasing WHC of the products.
Storage treatment significantly only influenced the WHC of the fat reduced models. During storage the number of protein-protein bonds in the protein matrix are increased. As the density of the protein structure increases less space for free water is available resulting in loss of water. The greater water loss of the fat reduced products, compared to the "high fat products," is due to the higher amount of free water to be retained during heat treatment.

Texture Measurements

Firmness, expressed as breaking strength (N), decreases significantly ($P<0.05$) with increasing level of substitution and decreasing final fat content (Figure 2). Decreasing breaking strength with increasing substitution level is among other factors due to the decreased connective tissue content in the final product.
Connective tissue elements contribute a great deal towards creating a structure and giving a firm "bite" to the product (Wirth, 1985). By substituting fatty tissue for peanut oil, and thereby reducing connective tissue content in the meat emulsions, the texture becomes softer and less coherent.
The texture is also affected by the mechanical strength of the interfacial protein film. In the process of emulsion formation, the interfacial film is formed as a result of adsorption of myofibrillar proteins on the surface of fat globules (Lee et al., 1981). When adding increasing amounts of oil/fat to the emulsion the protein film around the fat particles becomes thinner, decreasing the mechanical strength and elasticity of the product. As mentioned above, when the final fat content is reduced to 15 %, the breaking strength of the products decreases significantly - no breaking strength could be measured on the Instron at substitution levels above 30 %.
No significant changes in breaking strength due to storage treatment were observed.

Sensory evaluation

Only products containing 26 % final fat were sensory evaluated, the fat reduced samples were too loose in texture.
The colour of the products depends on the reaction between added nitrite and myoglobin in the meat. The samples containing 60 % and 80 % peanut oil were found to differ significantly from the others - their colour was lighter. Colour differences due to content of oil, is to be explained by the better distribution of oil than animal fat during emulsification.

When evaluating the hardness of the products, it was possible for the panel to classify the sausages in three different groups with decreasing breaking strength: The coded reference; 35 % substitution; and 60 % to 80 % substi-tution. When correlating the instrumentally measured breaking strength with the sensory evaluated hardness, a correlation coefficient of $r=0.992$ is found.
Cohesiveness of the products decreases with increasing level of substitution. The oil containing samples differ significantly from the reference.
Only the samples containing above 60 % peanut oil were found to differ significantly from the reference when evaluating fat/oiliness of the products. This means, that it is possible to substitute at least 35 % pork fat with peanut oil, before the product feels greasy and oily in the mouth.

The overall taste of the sausages was not affected by oil substitution at all.

CONCLUSION

The presented results clearly show that the level of substitution has a decisive effect on the functional properties of the meat emulsions.

If the water holding capacity is considered as the only important functional property, substituting 60 % animal fat with peanut oil is possible in sausages containing 26 % total fat before changes occur. In the products with 15 % total fat, only 45 % substitution is possible before changes, compared to the unsubstituted product (at the same fat level) is observed.

However, the instrumental measurements and the sensory evaluation of the texture show that the breaking strength of the products changes significantly, even at low substitution levels. Furthermore, due to the high content of water, the texture of the fat reduced sausages is so soft (even with no oil added) that the products may be considered not acceptable.

Storage stability was not affected by oil substitution, only by total fat content. No fat loss due to oil addition was observed.

The results indicate that it is possible, at the high fat level, to produce sausages containing vegetable oil with satisfactory functional properties.

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