Pressure/temperature processing of low- and high-fat frankfurters: Denaturation effects on the proteins

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BACKGROUND AND OBJECTIVES

Meat products have been pressurized to produce a general improvement in the gel-forming capabilities of meat proteins and consequent enhancement of the textural properties of processed meat (Macfarlane, 1985; Cheftel and Culioli, 1997). In combined high-pressure/heat treatments applied to pork meat batters, it has been reported (Fernández-Martín et al., 1997) that the mechanism whereby the product's properties are altered is based on the fact that the net pressure-temperature effect is an interdependent phenomenon, so the pressurization process preserves the protein from thermal denaturation during gelation. The persisting protein nativeness limits the formation of gel structures and is responsible for the different textural properties of pressurized relative to nonpressurized meat batters; hence, in order to achieve complete denaturation, the pressurized batters would have to be heated above the normal cooking temperature of 70 °C. This preserving effect has been also observed in the case of chicken batters (Fernández-Martín et al., 1998b). Obviously, in addition to the processing parameters there exists a series of product parameters like meat source, fat and additive levels, that can condition the results of these kinds of treatment (Jiménez Colmenero et al., 1998). A similar pressure protecting effect on subsequent thermal denaturation of myosin has been also observed in a given pressure/temperature treatment of blue whiting mince (Fernández-Martín et al., 1998a), which ocurred simultaneously to the entire denaturation of the actin component by a pressure antogonistic effect.

The present work will deal with frankfurter formulations from beef and pork meat mixtures, with either low or high fat content. They will be subjected to two hydrostatic pressures (200 and 400 MPa) and different temperatures (50 to 70 °C) in order to determine the protein denaturing effect of the different combinations. This effect on the meat proteins will be monitored by differential scanning calorimetry (DSC).

METHODS

Beef and pork meats trimmed of visible extramuscular fat and pork back fat were mixed at 50% w/w, and then combined with 2.5% NaCl, 0.18% of sodium tripolyphosphate (TPP, food grade), and chilled water to produce low-fat (~9.5%, LF) and high-fat (~25%, HF) formulations of given composition. Comminution was carried out at 10 °C, under reduced vacuum, in a Stephan Universal Machine UM5 (Stephan u. Söhne GmbH & Co., Hameln, Germany). The batters were packaged in flexible plastic jars and then subjected to high hydrostatic pressures of 200 and 400 MPa in combination with different temperatures (50, 60, and 70 °C) for 30 min in a pilot machine (Model HP900, GEC Alsthom, Nantes, France), as reported elsewhere (Fernández-Martín et al., 1997). After depressurization at the processing temperature, the samples were transferred to a cool room at 4 °C overnight untill analysis. Batters heated alone at 70 °C were prepared for control purposses.

Water, protein, and ash content were determined in triplicate by common methods (AOAC, 1984); fat content was calculated by difference.

Thermal properties (DSC)

A calibrated Perkin Elmer Differential Scanning Calorimeter DSC7 (Norwalk, CT, USA) was used. The samples, of around 15 mg (±0.002 mg by a Perkin Elmer AD4 autobalance), were capsuled into aluminum pans, then hermetically sealed. Six samples of each class were scanned from 5 to 90 °C at 10 °C/min under dry nitrogen purge of 30 mL/min, and a subsequent second heating was occasionally run to check that all proteins were already irreversibly denatured in the first. The samples were then desiccated into the pan (lid punctured by a pinhole) at 105 °C for water content determination. Average temperatures, t(°C), and enthalpies of thermal denaturation, ΔH(J/g), are reported within 0.8 °C and 8%, respectively.

RESULTS AND DISCUSSION

The composition (%) of the batters resulted: moisture, 73.9 (60.5); protein, 13.6 (13.5); fat, 9.5 (23.0); ash, 2.8 (2.9); figures between brackets referring to HF samples.

The processed batters exhibited a smooth and sticky texture with a high capacity for water+fat retention.

DSC traces of the raw meats from beef (B) and pork (P) and the LF and HF batters are shown in Fig. 1. Samples B and P presented similar profiles, with three main transition regions centered at around 52(myosin), 62-64(myosin, sarcoplasmic and connective proteins), and 74 -75°C(actin). The transition enthalpies were ~13.8 and 14.2 J/g (in dry bases hereafter) respectively, in good agreement with literature data. DSC curves of LF and HF batters exhibited two main endothermal zones separated by the 40 °C mark. The first zone corresponded to pork back fat melting (Barreto et al., 1996), with areas proportionally related to the respective fat contents. The second zone, from 40 °C upwards, recorded the denaturation enthalpy of those proteins remaining in non-denatured condition after batter processing. Qualitatively, the effect of comminuting with salt and TPP was very similar in both batters, clearly detected by the practical disappearance of the myosin and actin zones in LF and HF curves, with most of the protein transitions at ~64 °C. The associated enthalpies were ~6.3 (LF) and 3.7 (HF) J/g, representing ~11 and 24% denaturation of the respective mixture proteins. Fig. 2 shows the thermal behaviour of pressurized LF batters. DSC patterns were very similar to each other but progressively decreasing in enthalpy change as tempeature and pressure increased. HF batters behaved likewise except those pressurized at 70 °C (Fig. 3). Control, unpressurized samples (T) are also shown in the respective Figs 2 and 3 exhibiting a small and broad endotherm (65-80 °C, ~0.4 and 0.3 J/g, respectively), which denoted a somewhat low temperature for batters cooking.

Enthalpy data measured by DSC in the processed batters were normalized to the respective initial fresh batter. The results were then substracted from 1 (assuming 100% non-denatured condition for the corresponding reference batter), so the final figures represented

the fraction of proteins denatured by the processing (process denaturation index, DI, dimmensionless), as illustrated in Fig. 4. DI was generally higher in HF than in LF batters, clearly increasing with pressure. Within each pressure level, DI increased smoothly with temperature increase. However, some of the 200/70 and 400/70 (MPa/°C) combinations presented a lower denaturation power than at previous temperature. Moreover, they yielded exceptionally low protein denatured fractions (~0.5) in comparison to the control samples (~0.95). As a consequence, pressurized batters required higher heating temperatures (80 °C) than cooked-alone batters to achieve equivalent levels of protein denaturation (but poorer in texture, Jiménez Colmenero et al., 1998).

CONCLUSIONS

Batter preparation caused around 15% bigger denaturation in HF than in LF formulations (higher effective additive levels).

Cooking at 70 °C was not enough to produce proper denaturation/aggregation of the system proteins.

The denaturing character (DI) of the pressure/heat combinations was much lower than the corresponding heating-alone processes. According to DSC data, pressurization of comminuted low- and high-fat batters of beef+pork meats may efficiently preserve protein from subsequent thermal denaturation.

High-pressure/high-temperature combinations caused strong structuration effects, yielding smooth textured products with high water+fat binding properties, which may be of technological interest.

These data confirm previous results obtained by the authors on different meat and fish myosystems.

LITERATURE

AOAC. Official Methods of Analysis, 14th ed.; AOAC: Washington DC, 1984.

Barreto, G., Carballo, J., Fernández-Martín, F., Jiménez Colmenero, F. *Z. Lebensm. Unters. Forsch.* **1996**, *202*, 211-214.

Cheftel, J.C., Culioli, J. Effects of high pressure on meat: A review. *Meat Sci.* **1997**, *46*, 211-236.

Fernández-Martín, F., Fernández, P., Carballo, J., Jiménez Colmenero, F. *J. Agric. Food Chem.* **1997**, *45*, 4440-4445.

Fernández-Martín, F., Pérez-Mateos, M., Montero, P. Pressure/heat combinations on blue whiting (*micromesistius poutassou)* mince: Thermal and mechanical properties. *J. Agric. Food Chem.* **1998**a, submited.

Fernández-Martín, F., Fernández, P., Carballo, J., Jiménez Colmenero, F. Thermal behaviour of batters subjected to pressure/heat treatment: Influence of meat source, salt and fat level, and processing parameters. *Meat Sci.* **1998**b, submited.

Jiménez Colmenero, F., Fernández, P., Carballo, J., Fernández-Martín, F. High-pressure-cooked low-fat pork and chicken batters as affected by salt levels and cooking temperature. *J. Food Sci.* **1998,** in press.

Macfarlane, J. J. High pressure technology and meat quality. In *Developments in Meat Science-3*; Lawrie, R., Ed.; Elsevier Applied Science Publ.: London, 1985.

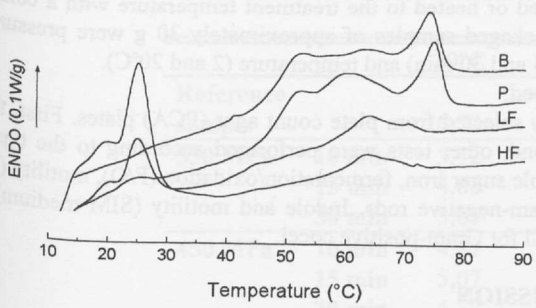

Fig. 1.- DSC traces of raw meats: B, beef; P, pork; and frankfurters: LF, low-fat; HF, high-fat.

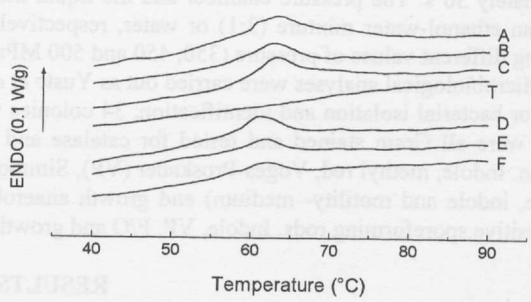

Fig. 2.- DSC traces of LF frankfurters: A, 200/50; B, 200/60; C, 200/70; D, 400/50; E, 400/60; F, 400/70; T, 70.

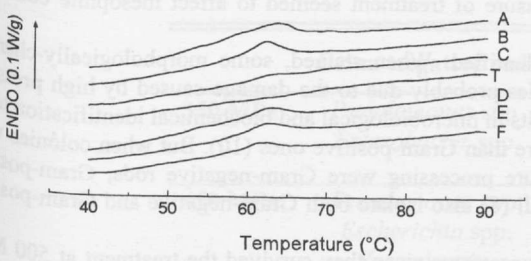

Fig. 3.- DSC traces of HF frankfurters: A, 200/50; B, 200/60; C, 200/70; D, 400/50; E, 400/60; F; 400/70; T, 70.

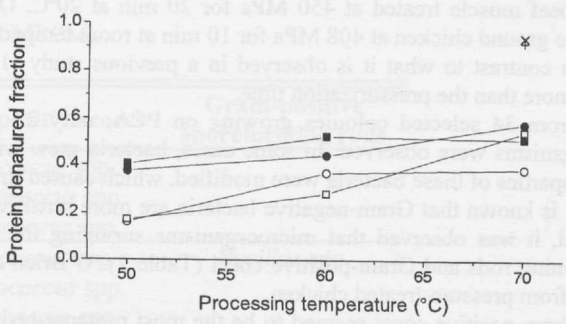

Fig. 4.- Denaturation Index as a function of processing parameters: Open symbols, 200 MPa; Solid symbols, 400 MPa; Circles, LF; Squares, HF; +, Control LF; x, Control HF.