COMPARISON OF CONTINUOUS AND OSCILLATORY HIGH PRESSURE IN MEAT BATTERS MADE WITH DIFFERENT RAW MATERIAL

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Background

Frozen meat is commonly used in the meat industry as raw material for numerous products. Depending on a number of factors (species, storage conditions, etc.) freezing and frozen storage can cause chemical and structural changes in meat, essentially in protein characteristics, which reduce their functionality and thus negatively affect the quality of the final processed products.

The use of high pressure (HP) causes changes in the proteins which can be used to modify the functionality of the meat protein and hence the quality of the meat for processing. It has been found that protein functionality of meat raw material induced by freezing and frozen storage influenced the effect of pressure (300 MPa) (Carballo et al., 2000). However, information on varying cycles, oscillatory or step-pulsed high pressure on foods is very limited. There have been studies to inactivate spores (Hayakawa et al., 1994) and enzymes in fish products (Hurtado, 1999) or reduce microbial populations in fruit juices (Aleman et al., 1998) but there has been nothing published on meat products.

Objective

The aim of the present study was to analyze the consequences of applying different high pressure conditions (400 MPa in continuous and in discontinuous form), to pork batters formulated with meat raw material in which there have been changes in protein characteristics induced by frozen storage (1 and 75 days).

Methods

Meat raw material, treatment and freezing were similar to those reported to Carballo et al. (2000). Frozen meat was stored at -18 °C for 75 days. For meat batters preparation, the meat was thawed in a chill room at 2°C for 17h, to reach 0 ± 2 °C, in one case after one day (1D) and in the other after 75 days (75D). The batters (after 1 day and 75 days' frozen storage) were prepared as described by Fernández et al. (1998). Meat protein was adjusted to 17% in all formulations.

Thermal behavior of the fresh and the thawed meat was determined by differential scanning calorimetry (DSC) as described elsewhere (Fernández-Martín et al., 1997).

Pressure treatment was applied as described by Carballo et al. (2000). Three HP treatments were assayed: 32 min continuous pressurization at 400 MPa (P); pressurization (400 MPa) in two 16-min cycles (P2C); and pressurization (400 MPa) in four 8-min cycles (P4C). There was a time lapse of 15 sec between cycles. Pressurizing took place in a high pressure pilot unit ACB model AGIP No 665 (GEC, Alsthom, France) For each meat raw material a nonpressurized control (NP) sample was made by heating under the same conditions as the pressurized samples. After pressurizing, the samples were stored for 18 h at 0-4 °C for analysis.

Texture profile analysis (TPA) was performed in a Universal Testing Machine (model 4501 Instron Engineering Corp., Canton, MA) as described by Bourne (1978). Samples were prepared following the procedure described by Carballo et al. (2000).

Two-way analysis of variance with an F test, and least squares differences by Statgraphics 5.0 (STSC Inc., Rockville, MD) were used for comparison of means and to identify significant differences ($P<0.05$) among treatments.

Results and discussion

DSC traces normalized to the unit of dry mass are shown in Figure 1. Fresh (unfrozen) and consecutively frozen/thawed samples (1 day) (curve not shown) presented practically the same DSC profile. Curve M is typical for fresh pork mince meat, basically consisting in three endothermal effects assigned to myosin (onset and maximum temperatures at ~54.3 and 62.2 °C respectively), myosin, connective and sarcoplasmic proteins (~70.9 °C) and actin (~81.7 °C). Enthalpy of thermal denaturation was 17.5 J/g (dry matter). Curve F corresponds to the sample frozen and stored at -18 °C for 75 days. Three endothermal zones were also observed, but at maximum temperatures of ~59 °C (onset at 52.4 °C), 66 °C and 81.7 °C. Total enthalpy of thermal transition was 14.7 J/g . It seems that actin was practically unaltered (same temperature and height of the peak) while sarcoplasmic proteins and mainly myosin (meromyosin) underwent some denaturation. Changes observed in F with respect to M were apparently the consequence of some protein denaturation undergone by sample M in the course of frozen storage rather than of freezing/thawing operations.

Textural properties of meat batters, particularly hardness and chewiness, were influenced by frozen storage (Table 1). Prolonged storage of meat raw material produced batters with lower ($P<0.05$) values of hardness and chewiness. Similar results have been reported by other authors (Miller et al., 1980; Verma et al., 1985; Jiménez Colmenero et al., 1995). These behavior patterns are associated with changes in the state of the myofibrillar proteins resulting from freezing and frozen storage (Fig. 1) .

The hardness, chewiness, cohesiveness and springiness of gel were lower ($P<0.05$) in samples heated under pressure conditions than in those heated at atmospheric pressure (NP) (Table 1). This could be related to pressure-induced restructuring, denaturation and/or aggregation, which could limit the heat gelation process in meat batters (Cheah and Ledward, 1996; Carballo et al., 1996). Frozen storage of meat raw material did not influence textural properties of pressurized samples, unlike control samples (NP) (Table 1).

The pressurizing conditions (continuous vs. discontinuous) had no effect ($P>0.05$) on textural parameters, irrespective of the time the meat raw material has been in frozen storage (Table 1). Oscillatory or step-pulsed pressurization seems to be more effective

for microbial inactivation (Hayakawa et al., 1994; Aleman et al., 1998) than for inducing changes in muscle texture (Hurtado, 1999) or influencing gel texture properties (Table 1)

Conclusions

Protein denaturation induced by frozen storage influenced textural properties of meat batters, decreasing hardness and chewiness. Heating under pressure conditions (pressurization at denaturing temperature) gave rise to structures with lower values of hardness, chewiness, cohesiveness and springiness. The time the meat raw material had been in frozen storage had no observable on pressure effect. Likewise, a comparison of continuous and oscillatory high pressure treatments revealed no effect on the texture of meat batters.

Table 1. Texture profile analysis of meat batters

Samples[1]	Hardness (N)		Cohesiveness		Springiness (mm)		Chewiness (N x mm)	
	1D[2]	75D	1D	75D	1D	75D	1D	75D
NP	$67.8^{a}{}_{1}$	$54.4^{a}{}_{2}$	$0.64^{a}{}_{1}$	$0.63^{a}{}_{1}$	$7.21^{a}{}_{1}$	$7.12^{a}{}_{1}$	$312.9^{a}{}_{1}$	$244.0^{a}{}_{2}$
P	$24.9^{b}{}_{1}$	$25.2^{b}{}_{1}$	$0.54^{b}{}_{1}$	$0.53^{b}{}_{1}$	$6.50^{b}{}_{1}$	$6.55^{b}{}_{1}$	$87.4^{b}{}_{1}$	$87.5^{b}{}_{1}$
P2C	$24.3^{b}{}_{1}$	$26.3^{b}{}_{1}$	$0.55^{b}{}_{1}$	$0.53^{b}{}_{1}$	$6.52^{b}{}_{1}$	$6.56^{b}{}_{1}$	$87.1^{b}{}_{1}$	$91.4^{b}{}_{1}$
P4C	$26.7^{b}{}_{1}$	$27.5^{b}{}_{1}$	$0.53^{b}{}_{1}$	$0.52^{b}{}_{1}$	$6.23^{c}{}_{1}$	$6.37^{b}{}_{1}$	$88.2^{b}{}_{1}$	$91.1^{b}{}_{1}$
SEM	0.7	1.1	0.00	0.00	0.03	0.02	2.9	3.0

[1] NP= nonpressurized; P= 32 min continuous pressurization at 400 MPa; P2C= pressurization 400 MPa in two 16-min cycles; P4C= pressurization 400 MPa in four 8-min cycles; 1D= 1day frozen storage; 75D= 75 days frozen storage; SEM= Standard error of the mean.

[2] Different letters in the same column or different numbers in the same row indicate significant differences ($P<0.05$).

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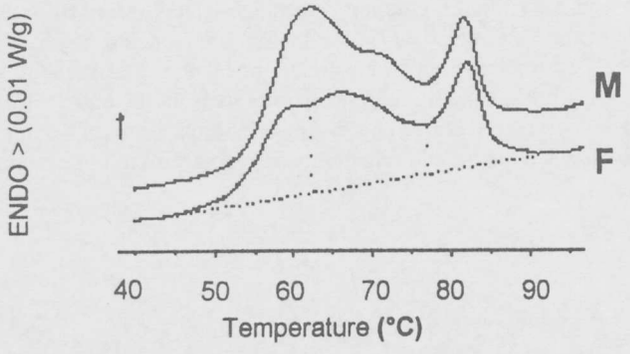

Fig.1 DSC normalized (dry basis) traces of fresh pork meat (M) and pork frozen-stored for 75 days (F).