Texture of Uncooked and Cooked Low- and High-Fat Meat Batters As Affected by High Hydrostatic Pressure

Keywords: *High pressure; meat batters; fat content; texture*

INTRODUCTION

Pressure treatment prior to heating has been reported to considerably enhance the thermal gelation capacity of meat protein in a model system (Suzuki and Macfarlane, 1984; Ikeuchi et al., 1992), favoring an increase in binding strength of meat patties (Macfarlane et al., 1984) and in Kramer shear force of low- and high-fat burgers (Carballo et al., 1996b). However, no such behavior has been detected in studies on the effect of pressurization on meat emulsions (cooked product) with various fat contents (Mandava et al., 1994; Jiménez Colmenero et al., 1996). The lack of any effect of high pressure on these meat systems may have something to do with the type of protein matrix constituting the system. In this system, either high pressure does not influence texture or else it does have some effect on uncooked batters that is lost in the cooking process. It has been reported that pressure-induced cross-linking junctions melt upon heating (Balny and Masson, 1993).

Given the scarcity of literature regarding the effects of pressurizing on meat emulsion characteristics, it would be useful to analyze the influence that pressure treatment has on textural properties of the protein sol matrix which encapsulates or “emulsifies” the fat globules (uncooked product) and on the gel matrix (gel-type emulsion) forming later as a result of heating (Nakai and Li-Chan, 1988). The aim of this experiment was to analyze the way that application of high pressures (100 and 300 MPa for 5 and 20 min) to low-fat (6%) and high-fat (23%) meat batters affects their texture (penetration force, elasticity, and work of penetration) and also the way in which these properties are influenced by subsequent heating.

MATERIALS AND METHODS

Raw materials and preparation of meat batters were as described by Jiménez Colmenero et al. (1995), to give the desired composition: low-fat (LF) sample (6% fat content) and high-fat (HF) sample (23% fat content) with similar protein levels (12%). One part of the batter was not pressurized and served as a control (zero pressure). The rest of the batters were placed in flexible plastic jars (diameter = 5.5 cm) containing 100 ± 0.5 g of sample. Each jar was hermetically sealed and placed in a 8 mm × 30 cm Ultra-Cover latex bag (Amevisa S.A., Madrid, Spain). The bags were filled with cold water (6−8 °C) and hermetically sealed. They were then placed in the pressure vessel (diameter = 10 cm, length = 30 cm), which was filled with cold water (6−8 °C). Next, the meat emulsion was pressurized in the appropriate conditions (Table 2) on a high-pressure pilot unit ACB Model AGIP 665 (GEC, Alsthom, Nantes, France). Cold water (6−8 °C) was used as the pressurizing medium. After pressurization, the jars were taken from the vessel and removed from the latex bags. For each treatment, part of the lot was stored at 0−4 °C for texture analysis (uncooked meat batters). The other part was placed in a water bath at 70 °C for 60 min (cooked meat batters). After this treatment, the samples were cooled at room temperature and stored for 18 h at 0−4 °C and then subjected to texture analysis.

Proximate composition (moisture, protein, fat, and ash) of uncooked meat emulsion was evaluated, in triplicate, according to the procedure of Carballo et al. (1995). Texture analysis was based on a penetration test (run in quintuplicate for each sample), performed once the samples had attained ambient temperature, in the same jars used for the pressure and thermal treatments, following the procedure described by Cavestany et al. (1994). This was performed with a cylindrical stainless steel plunger (diameter = 0.5 cm) attached to a 100 N cell connected to the crosshead of the Instron machine; crosshead speed was 1.0 cm/min. The rheological parameters were measured from the force−deformation curves. The force required to rupture was the penetration force (PF) (in newtons). Elastic behavior was estimated as the distance (*D*) (in millimeters) that the plunger has to travel from the sample surface to the rupture point. Gel strength was taken as work of penetration (WP) (in joules), which was calculated as the area enclosed by the curve from the first moment of contact with the surface until rupture point. A Universal Testing Machine (Model 4501, Instron Engineering Corp., Canton, MA) equipped with an Hewlett-Packard Vectra ES/12 computer (Hewlett-Packard Co., Avondale, PA) was used.

Analysis of variance with an *F* test and least-squares differences were used to compare means and to identify significant differences ($P < 0.05$) among treatments.

Table 1. Proximate Composition (Percent) of Low-Fat (LF) and High-Fat (HF) Meat Batters[a]

sample	moisture	protein	fat	ash
LF	78.6a	12.1	6.2a	3.3
HF	61.9b	12.1	23.0b	3.1
SEM	0.3	0.2	0.5	0.1

[a] Different letters in the same column indicate significant differences ($P < 0.05$). SEM, standard error of the mean.

RESULTS AND DISCUSSION

Fat contents in the meat batters were 6.2% (LF) and 23.0% (HF), close to target levels (Table 1). The fat content of the batters was reduced by increasing the water content, the protein level being the same in both samples (Table 1).

Uncooked Meat Batters. Of the unpressurized batters (LF/NP and HF/NP), PF and WP were lower ($P < 0.05$) in LF than in HF samples, while elasticities were similar ($P > 0.05$) in both (Table 2). These patterns are consistent with the viscous behavior of the system, in that viscosity decreased with increased added water and increased with higher fat content (Carballo et al., 1996a) as a result of the reduced protein/water ratio.

Pressurizing meat batters caused a significant increase in PF and WP (Table 2). In HF samples, the increase was greater the higher the pressure and the longer the pressurizing time. In LF samples, on the other hand, the relationship between the two textural parameters and the pressure treatment was less clear (Table 2). The highest values of PF and WP occurred in samples pressurized at 300 MPa for 20 min (Table 2). These textural changes were probably the result of alterations in the characteristics of the protein matrix that formed. Increased gel strength of pressurized myofibrillar proteins has been associated with increasing hydrophobicity and SH content (Ikeuchi et al., 1992).

Cooked Meat Batters. Of the unpressurized cooked batters, the HF sample (HF/NP) exhibited higher ($P < 0.05$) PF, similar ($P > 0.05$) WP, and lower ($P < 0.05$) elasticity with respect to the LF sample (LF/NP) (Table

Table 2. Influence of Fat Content, Pressure Level, and Pressure Time on Penetration Force (PF, N), Elastic Behavior (*D*, mm), and Work of Penetration (WP, J × 10^{-2}) of Uncooked and Cooked Meat Emulsions[a]

	uncooked			cooked		
sample	PF	*D*	WP	PF	*D*	WP
LF/NP	0.032a	10.05a	0.018a	3.38ab	7.13ab	1.18ade
LF/100/5	0.076bd	10.02a	0.064bd	3.76bcf	7.83bc	1.46bc
LF/100/20	0.055b	7.08b	0.035ac	3.94cf	8.44cd	1.61c
LF/300/5	0.063bd	7.54bc	0.031a	2.93d	8.15c	1.02a
LF/300/20	0.140c	7.98c	0.083d	3.21ad	8.98d	1.30bde
HF/NP	0.082de	10.03a	0.053bc	4.44e	5.88e	1.42bce
HF/100/5	0.100e	10.05a	0.062b	4.11ef	6.26ef	1.21ade
HF/100/20	0.149c	9.87a	0.107e	3.93cf	5.77e	1.11ad
HF/300/5	0.254f	9.63a	0.162f	3.66bc	7.03af	1.24abde
HF/300/20	0.388g	10.01a	0.234g	3.88cf	7.34ab	1.26abde
SEM	0.008	0.28	0.007	0.13	0.27	0.09

[a] Different letters in the same column indicate significant differences ($P < 0.05$). SEM, Standard error of the mean. The first term in each sample denomination indicates fat content: LF, low-fat; HF, high-fat. The second term indicates the pressure applied: NP, no pressure; 100, 100 MPa; 300, 300 MPa. The third term indicates the pressure time: 5 or 20 min.

2). Other authors have described similar results (Cavestany et al., 1994; Jiménez Colmenero et al., 1995). This behavior has been associated with the characteristics of the matrix that forms (Jiménez Colmenero et al., 1995).

Heat-induced texture changes were much more substantial than pressure-induced changes (Table 2). Pressurizing before cooking had no clearly appreciable effect on PF and WP in LF cooked batters or on WP in HF cooked batters (Table 2). In HF samples, pressurizing at 100 MPa for 20 min and at 300 MPa caused a decrease ($P < 0.05$) in PF. Similar results have been reported by Jiménez Colmenero et al. (1996), in the sense that Kramer shear force and Kramer energy of HF emulsions decreased under pressurization (100 and 300 MPa). Pressurizing at 300 MPa caused an increase ($P < 0.05$) in elasticity of the matrix forming in both LF and HF samples (Table 2). A pressure-induced increase in matrix elasticity has also been described by other authors (Okamoto et al., 1990). The observed effect on the texture of cooked product indicates that pressurizing prior to heating did not enhance thermal gelation ability of meat batters. To the contrary, the changes induced in the protein matrix, where PF and WP increased in uncooked product (Table 2), appear to have led to functional deterioration, which was appreciable as a loss of penetration force (Table 2). Pressurization causes protein denaturation and/or aggregation (Okamoto et al., 1990; Yamamoto et al., 1993; Mandava et al., 1994), and these lead to reduction in parameters such as shear force, hardness, or peak force of meat emulsions (Miller et al., 1980; Jiménez Colmenero et al., 1995), much as was found in the present experiment. The pattern of behavior was dependent on fat level, being much more marked in HF products (Table 2) (Jiménez Colmenero et al., 1995).

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