COOKED PORK MEAT BATTERS PRESSURIZED UNDER NON-THERMAL AND THERMAL DENATURATING CONDITIONS.

S. Cofrades, P. Fernández, J. Carballo and F. Jiménez-Colmenero. Instituto del Frío (CSIC). Ciudad Universitaria. 28040-Madrid. Spain.

BACKGROUND

Pressurization and heat treatment conditions and the type of myosystem to which they are applied are important factors influencing the gelling of myofibrillar proteins and hence the properties of meat products.

Pressurization at non-denaturating temperatures (<40°C) causes protein denaturation (Fernández-Martín et al., 1997). The consequences of this after the heating process appear to depend on the type and the composition of the meat protein system (Suzuki and Macfarlane, 1984; Ikeuchi et al., 1992; Jiménez-Colmenero et al., 1997).

Heating (70 °C) under pressure conditions limits the gelling process so that resulting structures are weaker than gels made by heating (non-pressurized) although they have better water binding properties. This behaviour appears in principle to be linked to two different effects. The first is preservation of batter proteins with middle thermal stability from denaturation (Fernández-Martín et al., 1997). The second is myosin molecule breakdown, causing the formation of various molecular fragments which increase the proportion of salt soluble protein (Jiménez-Colmenero et al., 1998). To gain a better understanding of how high pressure works, it would be useful to determine whether such phenomena occur when pressurization is applied at non-denaturing temperatures (i.e., prior to the heating process). This paper is one of a serie of such studies and examines the way that pressurization under non-thermal and thermal denaturating conditions affects pork gel characteristics such as water binding properties, texture and salt-soluble proteins.

MATERIALS AND METHODS

Fresh pork (M. *biceps femoris*, M. *semimenbranosus*, M. *semitendinosus* M. *gracilis* and M. *aductor*) was obtained from a local meat market. Preparation of pork meat batters (with 1.5 % NaCl) and the pressure and/or heating conditions were carried out as Fernández et al. (1998). The following processing conditions of meat batters were studied: C - control, non-pressurized and unheated; P - Pressurized at 400 MPa at non-thermal denaturing temperature, 10 °C; H - Heated at 70 °C; P/H - Pressurized at 400 MPa at non-thermal denaturing temperature (10 °C) prior to heating at 70 °C; HUP - Heating (at 70 °C) under pressure (400 MPa). After thermal and/or pressurizing treatments the batters were stored at 0-4 °C for 18 h for analysis.

Moisture, protein, fat, ash, pH and weight loss (WL, %) were determined (in triplicate at least) as Fernández et al. (1998). Weight loss could only be assessed in heated samples. Rheological assessment was based on a penetration test (10 mm) performed (in quintuplicate) as Fernández-Martín et al. (1997). The following parameters were assessed: penetration force (PF) (N), apparent elasticity (E_a) (N/cm^2) and gel strength (GS) (J). A Universal Testing Machine (Model 4501, Instron Engineering Corp., Canton, MA) was used in conjunction with a Vectra ES/12 computer (Hewlett-Packard Co., Avondale, PA). Protein solubility in 0.6 M NaCl (salt-soluble protein) was carried out as described by Cofrades and Jiménez-Colmenero (1998). The results are expressed as the percentage of solubilized protein with respect to total protein of the samples.

One-way analyses of variance were performed using a computer statistical package (Statgraphics, STSC Inc., Rockville, MD). The differences of means between pairs were resolved by LSD test to obtein the confidence intervals. Level of significance was set for $P<0.05$.

RESULTS AND DISCUSSION

Moisture content ranged from 80.6 to 79.5 % in raw meat batter and P/H respectively (Table 1). Protein content was higher ($P<0.05$) in heated than in unheated samples, while the mean values for fat and ash content were similar ($P>0.05$) in all samples. Water binding properties were greater in samples heated under pressure than in samples pressurized prior to heating (Table 1).

Pressurization of raw meat batter (P) caused an increase ($P<0.05$) in PF and E_a (Table 1). Of the heated samples, the ones pressurized prior to thermal treatment (P/H) had higher ($P<0.05$) PF, E_a and GS than H samples; the latter in turn exhibited higher ($P<0.05$) texture parameters than HUP. The gel structure produced by heating of meat batter under pressure conditions (HUP) had similar ($P>0.05$) rheological properties to those of the gel produced only by pressurization (P).

In unheated samples, pressurization caused a reduction ($P<0.05$) of salt-soluble protein (Table 1). Heating at 70 °C (H) caused pronounced protein denaturation. Protein solubility was influenced by the conditions in which combined pressurization/heating was applied; in the P/H sample per cent solubility was similar ($P>0.05$) to that induced by heating (H), so that there was no appreciable influence of pressurization under non-thermal denaturing conditions. At denaturing temperature the result was quite different: the proportion of salt-soluble protein was greater ($P>0.05$) in the HUP than the P/H sample (Table 1).

These results indicated that the pressurization conditions determine gelling behaviour during heating. Pressurization at non-denaturing temperature (10 °C) causes some alterations in the protein matrix. This was evident both as changes in the rheological parameters and as a measure of protein denaturation caused by the reduction of salt-soluble protein. In these conditions heating (P/H) favoured greater protein-protein interaction, so that the gel structure was more ordered and complete than in sample made by heating only (H). This suggests that pressurization prior to heating favoured the formation of stronger, more elastic gel structures with poorer water binding properties but with protein solubility on a level similar to that of sample heated at 70 °C (H).

However, behaviour was different when pressurization was applied at denaturing temperatures (70 °C, HUP). High pressure

cut down the decrease of protein solubility induced by the thermal treatment, resulting in gel structures which had better water binding properties but were weaker than in samples that were only heated (H) or were pressurized prior to heating (P/H). This confirms that in such conditions there is some limitation on the gelling process during heating (Fernández-Martín et al., 1997; Jiménez-Colmenero et al 1998).

ACKNOWLEDGMENTS

This research was supported by the Comisión Interministerial de Ciencia y Tecnología (CICYT) under projects ALI97-0684, ALI97-0759.

LITERATURE

Cofrades, S. and Jiménez-Colmenero, F. (1998). Protein molecular interactions involved in formation of frankfurters: Effect of fat level and heating rate. Meat Sci., (in press)

Fernández-Martín F., Fernández, P., Carballo, J. and Jiménez-Colmenero, F. (1997). Pressure/heat combinations on pork meat batters: Protein thermal behavior and product rheological properties. J. Agric. Food Chem., 45, 4440-4445.

Fernández, P., Cofrades, S., Solas, M.T., Carballo, J. and Jiménez-Colmenero, F. (1998). High pressure-cooking of chicken meat batters with starch, egg white and iota carrageenan. J. Food Sci., 63, (in press).

Ikeuchi, Y., Tanji, H., Kim, K. and Suziki, A. (1992). Mechanims of heat-induced gelation of pressurized actomyosin: Pressure-induced changes in actin and myosin in actomyosin. J. Agric. Food Chem., 40, 1756-1761.

Jiménez-Colmenero, F., Carballo, J., Fernández, P., Barreto, G. and Solas, M.T. (1997). High-pressure-induced changes in the characteristics of low and high-fat sausages. J. Sci., Food Agric., 75, 61-66.

Jiménez-Colmenero, F., Cofrades, S., Carballo, J., Fernández, P. and Fernández-Martín, F. (1998). Heating of chicken and pork meat batters under pressure conditions: protein interactions. J. Agric. Food Chem., (submitted).

Suzuki, T. and Macfarlane, J.J. (1984). Modification of the heat-setting characteristics of the myosin by pressure treatment. Meat Sci., 11, 263-274.

Table 1. Proximate analysis (%) , weight loss (WL), pH, penetration force (PF), apparent elasticity (E_a), gel strength (GS) and salt-soluble protein (S) of samples[1].

Samples	Moisture	Protein	Fat	Ash	WL (%)	pH	PF (N)	E_a (N/m^2)	GS (mJ)	S (%)
C	80.6^{a}	15.3^{a}	2.1	2.0	-	6.0^{a}	0.15^{a}	5.0^{a}	1.33^{a}	42.8^{a}
P	80.5^{a}	15.1^{a}	2.4	1.9	-	6.1^{b}	0.39^{b}	20.0^{b}	1.58^{a}	27.7^{b}
H	79.7^{bc}	16.0^{b}	2.4	1.9	5.4^{a}	6.2^{c}	1.55^{c}	68.8^{c}	5.65^{b}	5.5^{c}
P/H	79.5^{c}	16.3^{c}	2.1	2.0	7.7^{b}	6.2^{c}	2.43^{d}	85.6^{d}	9.28^{c}	5.0^{c}
HUP	80.3^{ab}	15.9^{b}	1.9	1.9	0.8^{c}	6.2^{c}	0.41^{b}	17.4^{b}	1.57^{a}	11.8^{d}
SEM	0.2	0.1	0.2	0.1	0.1	0.0	0.04	0.8	0.04	0.3

[1] Different letters in the same column indicate significant differences ($P < 0.05$), SEM: standard error of the mean. C: non-pressurized and unheated meat batter; P: pressurized at 400MPa (10 °C); H: heated at 70 °C; P/H: pressurized at 400 MPa (10 °C) prior to heating to 70 °C; HUP: heated (at 70 °C) under pressure (400 MPa).