Mechanically Recovered Poultry Meat Sausages Manufactured with High Hydrostatic Pressure

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ABSTRACT The effect of high pressure processing at high temperature on texture and color of frankfurter-type sausages made with different contents of mechanically recovered poultry meat (MRPM) was evaluated and compared with that of a standard cooking process. Five types of sausages containing 100, 75, 50, 25, and 0% MRPM and 0, 25, 50, 75, and 100% of minced pork meat (MPM), respectively, were manufactured. They were pressurized at 500 MPa for 30 min at 50, 60, 70, and 75 C or cooked at 75 C for 30 min. Pressure-treated sausages were less springy and firm, but more cohesive. Moreover, color of pressurized sausages was lighter and more yellow than that of conventionally cooked sausages. Addition of MPM increased cohesiveness, hardness, and force at 80% compression. Minced pork meat also caused the appearance of sausages to be lighter, less red, and less yellow. Cooked sausages made with MRPM can have an attractive appearance and texture via high pressure processing.

(*Key words*: mechanically recovered poultry meat, poultry meat emulsion, high pressure processing, texture, color)

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INTRODUCTION

Consumption of poultry meat and poultry meat products has grown considerably in the last few years (EC, 1997). For several reasons, people prefer this kind of meat to beef or pork. Thus, new meat products containing different contents of poultry meat are being manufactured.

Mechanically recovered poultry meat (MRPM) is a poultry-derived raw material of high quality. Great amounts of this meat are produced yearly (Froning, 1981; Dawson *et al*., 1988). It is worth using MRPM as an ingredient for some food products, giving MRPM added value. Mechanically recovered poultry meat has very good nutritional and functional properties and is suitable for the formulation of many meat products (Froning, 1981; Field, 1988). It also has some disadvantages, such as color, flavor, and texture (Froning, 1976; Jones, 1988) and the microbial load, which makes it a highly perishable raw material (Gill, 1988). Use of mechanical recovering systems has increased the utilization of poultry meat in further-processed products.

Sensory properties, such as color, flavor, and texture, are very important for consumer acceptance and choice of food products and, consequently, for the manufacturer. For this reason, many studies to optimize and improve these characteristics in various foods are being carried out.

High hydrostatic pressure is an increasingly investigated technology that can be applied as a food processing and preservation method (Hayashi, 1992; Mertens and Knorr, 1992). It does not markedly affect flavor and nutrient content of foods (Cheftel, 1992; Hayashi, 1992; Schöberl *et al*., 1997), but it can change some other characteristics such as structure of proteins and, therefore, functional properties (Okamoto *et al*., 1990; Hayakawa *et al*., 1992; Ikeuchi *et al*., 1992b; Yamamoto *et al*., 1992). Thus, gelation and texturization of minced meat or fish, surimi, mechanically recovered meat, and other muscle proteins can be obtained through pressurization (Cheftel, 1992).

Gels made with high pressure from chicken or rabbit pastes, a sheep myosin suspension, or a rabbit actomyosin suspension have been studied and compared to the same gels prepared with heat treatment, and have shown different results depending on the raw material and the treatment conditions (Suzuki and Macfarlane, 1984; Okamoto *et al*., 1990; Ikeuchi *et al*., 1992a; Yoshioka *et al*., 1992).

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Abbreviation Key: MPM = minced pork meat; MRPM = mechanically recovered poultry meat; TPA = texture profile analysis.

In the present study, high pressure processing at high temperature was applied to frankfurter-type sausages containing different percentages of MRPM and minced pork meat (MPM). The objectives of this work were: 1) to evaluate texture and color of sausages generated by pressurization and to compare them with traditionally cooked sausages and 2) to determine whether high pressure is a useful process to overcome the disadvantages of using MRPM in formulated meat products.

MATERIALS AND METHODS

Sausage Preparation

Mechanically recovered poultry meat,[2] manufactured from meat remaining in carcasses and leftovers originated in poultry processing, and commercial left-over MPM[3] were kept frozen until use. Five different batters were prepared, so that the final products contained approximately 15% protein and 14 to 17% fat, combining 100, 75, 50, 25, and 0% MRPM with 0, 25, 50, 75, and 100% MPM, respectively. Other ingredients and additives were incorporated in the formulated batters (Table 2). Batters were left standing overnight at 2 C. The AOAC official methods of analysis were applied to determine total solid, fat, total nitrogen, and ash contents (McNeal, 1990). Sausage batters were stuffed into cellulose casing[4] (22 mm diameter) and kept under refrigeration until processing.

High Pressure and Cooking Treatments

For high pressure processing, the equipment used was a discontinuous isostatic press.[5] The time needed to achieve the treatment pressure was about 120 s and the decompression time was approximately 30 s. The pressure chamber and the water inside were heated to the treatment temperature with a constant flow of hot water. Refrigerated sausages were allowed to reach the temperature in this chamber before treatment. Pressurization was carried out at 500 MPa for 30 min at four different temperatures (50, 60, 70, and 75 C). A standard cooking process (75 C for 30 min) was applied to the nonpressurized sausages in a water bath. Each treatment was performed twice. After processing, sausages were cooled in running tap water for 30 s and stored at 2 C until analyses were performed.

Texture Analyses

A Texture Analyser[6] with a 25-kg (± 1 g) load cell was used to carry out three different tests: texture profile analysis (TPA), force at 80% compression, and force at cutting. For each treatment, four cylindrical replicates (22 mm diameter and 20 mm height) were analyzed when sausages reached room temperature. Crosshead speed was 1 mm/s. Texture profile analysis was performed as described by Bourne (1978) and was carried out with an aluminum compression platen (10 cm diameter). Two 40% compression deformations were done with an interval of 5 s between them. Force at 80% compression was measured using the same probe as in the case of TPA. Force at cutting was measured by a probe consisting of a standard wire (0.3 mm diameter).

Color Analysis

A portable HunterLab spectrocolorimeter[7] was used to evaluate three color parameters: *L* (lightness), *a* (redness), and *b* (yellowness) values. The spectrocolorimeter was standardized before starting, using, in this order, a black glass and a white porcelain calibrated tile (No. M03793; X 79.8 – Y 84.5 – Z 90.5, D65, 10°). For each treatment, three cylindrical replicates (22 mm diameter and approximately 40 mm length) at room temperature were cut longitudinally to analyze the internal color of sausages. Reference (untreated) samples were also tested. Measurements were done with reference to illuminant *Fcw* (cool white fluorescent) and the 10° standard observer and the light reached the internal sides of sausages through a non-reflecting glass container (63 mm diameter, 2 mm thickness) in which samples had been slightly compressed and flattened.

Statistical Analysis

Treatments (four pressurization treatments and one cooking treatment) were carried out twice per each batter. For each treatment, four, in each texture analysis, or three, in color analysis, replicates were performed. Data were analyzed using ANOVA with the General Linear Models procedure of SAS® software.[8] Level of significance was set for $P < 0.05$. Differences among means from each variable [formulation, temperature of treatment, and type of treatment (pressurization or no pressurization)] were determined using Duncan's multiple range test. Interactions among the three variables were tested (SAS Institute, 1990).

RESULTS AND DISCUSSION

Composition of Raw Materials

Proximate composition of MRPM and MPM is shown in Table 1. Due to the great variability of MRPM composition (Froning, 1981; Jones, 1988), this raw material is not always suitable for formulation of any kind of meat

[2]Agropecuària de Guissona, S. Coop. Ltda., 25210 Guissona, Spain.
[3]Arcadíe España, S. A., 08227 Terrassa, Spain.
[4]Nojax®, Viskase, S. A., 93176 Bagnolet, France.
[5]Division Equipements Industriels, GEC ALSTHOM ACB S. A., 44945 Nantes, France.
[6]Model TA-XT2, Stable Micro Systems, Haslemere, Surrey GU27 3AY, U.K.
[7]Model 45/0 LAV, MiniScan XE™, Hunter Associates Laboratory, Inc., Reston, VA 22090.
[8]The SAS® System for Windows™. Release 6.11. 1989–1995. SAS Institute Inc., Cary, NC 27513.

TABLE 1. Proximate composition of MRPM[1] and MPM[2]

Content	MRPM		MPM	
	$\bar{x}$[3]	SD	$\bar{x}$	SD
	(%)			
Total solids	29.53	0.786	38.25	0.489
Fat	11.82	0.769	20.21	1.006
Total nitrogen	2.61	0.146	2.85	0.054
Ash	1.08	0.026	0.92	0.011

[1]MRPM = mechanically recovered poultry meat.
[2]MPM = minced pork meat.
[3]n = 4.

emulsion. Fat content is important for the batter stability. Initially, a 32% fat MRPM batch was proposed, but it was rejected because the emulsion was not stable and, consequently, substantial amounts of fat were separated despite adding an emulsifier. Thus, another MRPM batch with a lower percentage of fat was used as raw material (Table 1).

Minced pork meat was manufactured from leftovers; therefore, it had a high fat content, almost 8.5% more than MRPM. This difference made necessary, in some cases, the addition of different percentages of lard to adjust fat to approximately 14% (Table 2). Significant differences were caused by the three variables (formulation, temperature of treatment, and type of treatment) and also by the interactions among them.

Texture Analyses

Results are shown in Figures 1 and 2. In general, nonpressurized sausages presented significantly greater springiness than pressurized ones. Okamoto *et al.* (1990) worked with rabbit meat paste and also observed that high pressure reduced springiness compared to a cooking process. In contrast, Carballo *et al.* (1996) and Pérez Mateos *et al.* (1997) stated that this parameter is higher in pressurized pork meat batters and blue whiting muscle protein gels, respectively. Therefore, animal species is a very important factor that, in most cases, determines texture. However, in the present study, similar values of springiness were obtained regardless of the formulation (Figure 1A).

Usually, high pressure processing gave significantly more cohesive sausages than cooking process and, in general, in pressurized samples, the higher the treatment temperature the lesser the cohesiveness. Similarly, Pérez Mateos *et al.* (1997) found higher cohesiveness in pressure- (375 MPa at 38 C for 20 min) than in heat-induced gels. The addition of MPM increased cohesiveness. In this case, the influence of this kind of meat was quite evident: sausages containing 100% MPM generally showed the highest cohesiveness (Figure 1B).

Analysis of adhesiveness presented rather irregular results: neither the type of treatment nor the formulation exerted a clear influence. Samples not pressurized or containing 100% MPM were, in some cases, less adhesive (Figure 1C). Okamoto *et al.* (1990) reported that heat-induced gels from several food proteins are lacking adhesiveness.

Formulation (in particular, absence of MRPM) most influenced hardness; sausages without MRPM were significantly the firmest [(firm is a preferred term to hard) (Jowitt, 1974)], especially those treated at 75 C under pressure or not (2,155.76 and 2,949.93 g × cm/s^2, respectively). Type of treatment was a very important factor. Thus, nonpressurized sausages showed, in general,

TABLE 2. Formulation and composition of batters containing MRPM[1] and MPM[2]

Formulation and composition	100 MRPM: 0 MPM		75 MRPM: 25 MPM		50 MRPM: 50 MPM		25 MRPM: 75 MPM		0 MRPM: 100 MPM	
	(%)									
Formulation										
MRPM	92.02		69.02		46.00		23.01		. . .	
MPM	. . .		21.07		42.10		63.20		84.27	
Lard	3.33		1.79		0.27		. . .		. . .	
Water	. . .		3.47		6.98		9.14		11.08	
Sodium chloride	2.00		2.00		2.00		2.00		2.00	
Emulsifier[3]	1.40		1.40		1.40		1.40		1.40	
Acidificant[4]	1.00		1.00		1.00		1.00		1.00	
Phosphates[5]	0.25		0.25		0.25		0.25		0.25	
	$\bar{x}$[6]	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD
Composition										
Total solids	34.23	0.079	32.40	0.310	32.54	0.202	32.59	0.120	33.66	0.299
Fat	14.62	0.194	14.70	2.662	12.91	0.062	14.40	0.339	15.26	1.367
Total nitrogen	2.36	0.028	2.36	0.052	2.50	0.080	2.41	0.005	2.50	0.040
Ash	3.73	0.023	3.45	0.006	3.46	0.003	3.35	0.009	3.37	0.056

[1]MRPM = mechanically recovered poultry meat.
[2]MPM = minced pork meat.
[3]Citric acid esters of mono- and diglycerides (E-472c). SKW Bio-Systems, S. A., 08191 Rubí, Spain.
[4]Glucono-delta-lactone (E-575). Quimidroga S. A., 08006 Barcelona, Spain.
[5]Triphosphates (E-451) and polyphosphates (E-452). SKW Bio-Systems, S. A., 08191 Rubí, Spain.
[6]n = 4.

high values of hardness (Figure 1D). Okamoto *et al.* (1990), Yoshioka *et al.* (1992), employing chicken meat paste, and Pérez Mateos *et al.* (1997) came to similar conclusions; all of them pressurized at lower temperatures than in the present study. These results are probably due to the larger cooking losses observed in the firmest sausages, particularly in the case of nonpressurized ones (J. Yuste, unpublished data). Other authors (Macfarlane *et al.*, 1984; Nose *et al.*, 1992; Mandava *et al.*, 1994) also found a relationship between high pressure processing and better cooking yields. The lower cooking losses of pressurized samples result in a considerable improvement in sausage manufacturing yield, which is an important economic issue for manufacturers of cooked meat products. Due to cooking losses, nonpressurized sausages, besides being firmer, were slightly brittle and less juicy; these characteristics led to a poorer texture.

In TPA, gumminess is defined as the product of hardness × cohesiveness and chewiness as the product of hardness × cohesiveness × springiness. Therefore, gumminess and chewiness results followed, obviously, a similar pattern to the hardness ones.

The amount of MRPM played an essential role in the sausage resistance to be 80% compressed. In general, the lower the content of MRPM the higher the force required for the compression (Figure 2A).

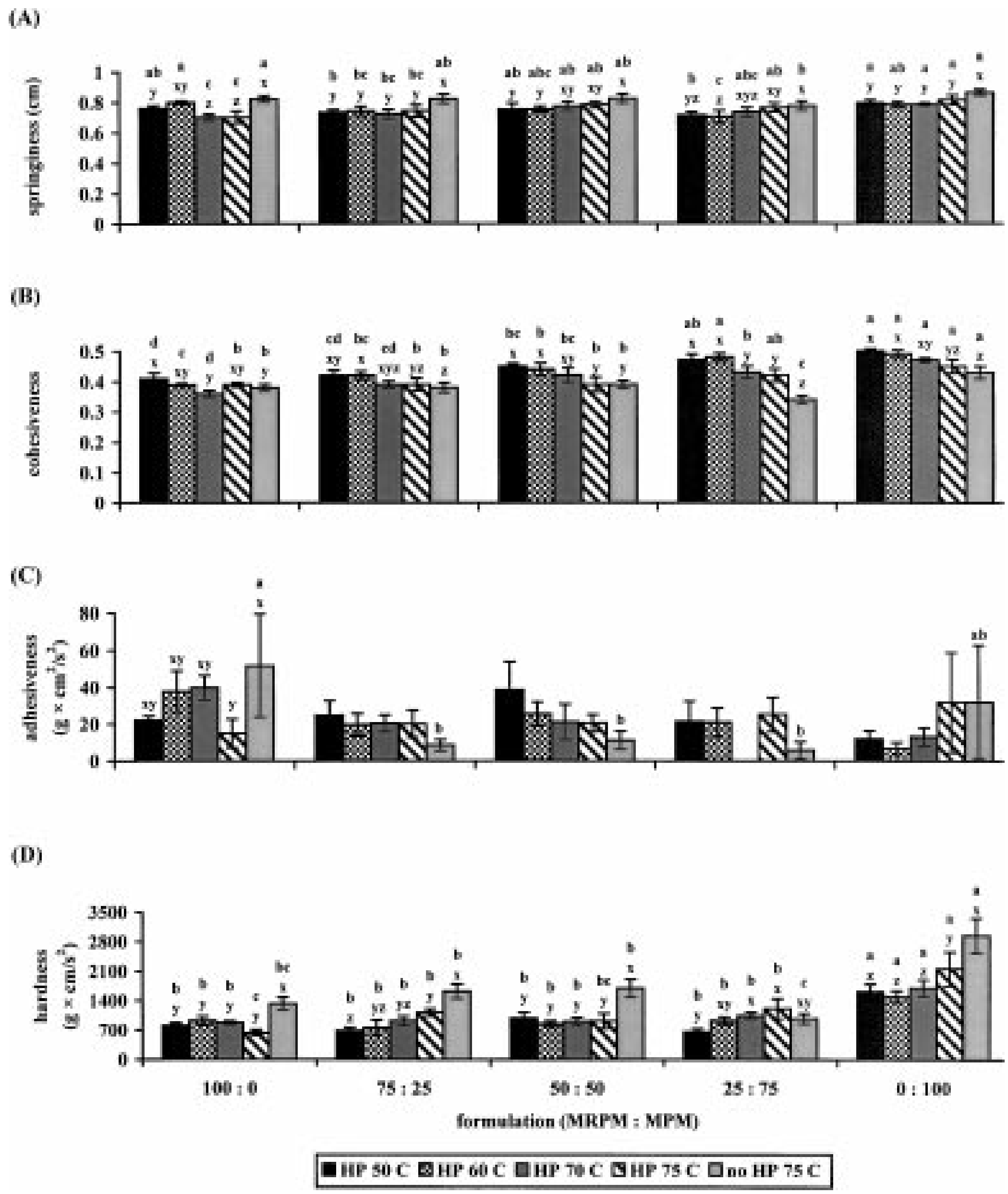

FIGURE 1. Texture profile analysis parameters of sausages containing mechanically recovered poultry meat (MRPM) and minced pork meat (MPM) pressurized (HP) at 500 MPa for 30 min or conventionally cooked (no HP) for 30 min. Results are means from eight replicates. A) springiness; B) cohesiveness; C) adhesiveness; D) hardness. a–d: Means within the same type of bar with no common letter differ significantly ($P < 0.05$). x–z: Means within the same group of bars with no common letter differ significantly ($P < 0.05$).

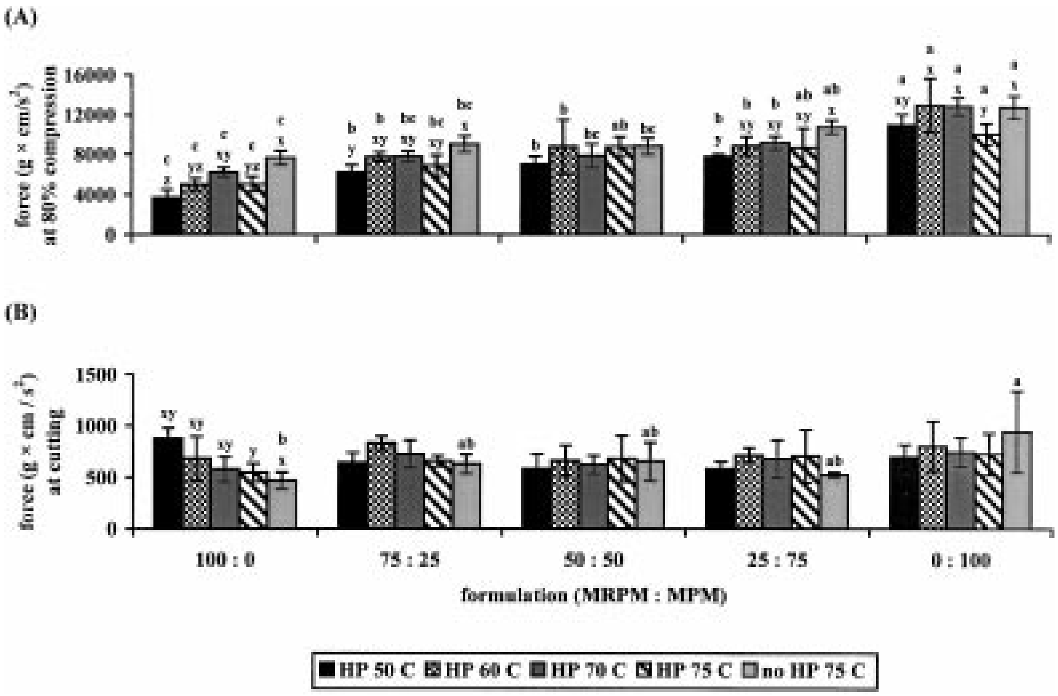

FIGURE 2. Textural parameters of sausages containing mechanically recovered poultry meat (MRPM) and minced pork meat (MPM) pressurized (HP) at 500 MPa for 30 min or conventionally cooked (no HP) for 30 min. Results are means from eight replicates. A) force at 80% compression; B) force at cutting. a–c: Means within the same type of bar with no common letter differ significantly ($P < 0.05$). x–z: Means within the same group of bars with no common letter differ significantly ($P < 0.05$).

Force at cutting showed few significant differences, only between nonpressurized sausages containing the maximum percentages of either kind of meat. Samples with 100% MRPM treated at 70 or 75 C required a lower force. This result is more evident when compared with those made with 100% of MPM, which were firmer and more difficult to cut. Force at cutting depends not only on the firmness but also on proper gelling. The different behavior observed in 100% MRPM sausages treated at lower temperatures (50 or 60 C) was due to the lack of the gelled texture of cooked sausages and the soft texture because of the relatively low temperature of treatment and the 100% content of a pasty raw material such as MRPM. In this case, samples were flattened rather than clearly cut, which resulted in a higher resistance (Figure 2B). Although one of the effects of high hydrostatic pressure is gelation of proteins (Cheftel, 1992), pressurization temperatures of 50 or 60 C were not enough to achieve a suitable texture in sausages, regardless of the formulation. Thus, as Schöberl *et al.* (1997) stated, high pressure processing of minced meat as an alternative process of production of "unheated frankfurter-type sausages" does not seem adequate.

Beilken *et al.* (1990) measured Warner-Bratzler shear force on postrigor beef muscles and reported that cooked ones exhibited higher values than pressurized ones (150 MPa) at high temperatures (up to 80 C). Nose *et al.* (1992), working with beef meat, and Pérez Mateos *et al.* (1997) observed, respectively, lower breaking strength and higher breaking deformation in samples treated with high pressure. Carballo *et al.* (1996) found generally higher penetration force and work of penetration values in cooked batters.

Factors that improve binding among meat particles also markedly influenced hardness, force at 80% compression, and force at cutting. Thus, protein denaturation or aggregation or both induced by high pressure processing (Macfarlane *et al.*, 1984; Okamoto *et al.*, 1990; Hayakawa *et al.*, 1992; Ikeuchi *et al.*, 1992b; Yamamoto *et al.*, 1992) and addition of salt, which helps to solubilize myofibrillar proteins, are other important factors to take into account.

Color Analysis

Results are shown in Table 3. The addition of MPM significantly increased lightness of sausages. Although both processes (high pressure or cooking) gave significantly higher L values than those of reference samples, in general, pressurization caused lighter sausages than cooking.

In contrast, pressurized and nonpressurized sausages showed significantly lower a values than reference samples. In general, the higher the MRPM content the greater the a value; this effect is obvious, taking into account the characteristic dark red color of MRPM (Froning, 1976; Jones, 1988) when the fat content is not excessively high. Reference samples containing 100% MRPM showed a much higher a value than the rest; otherwise, the treated samples with 100 and 75% MPM showed the lowest a values. On the other hand, the lowest *b* values were observed in nonpressurized sausages. Moreover, those with 100% MPM also presented quite low *b* values in most cases.

Similar changes in color parameters of pressurized minced beef meat, beef patties, and pork meat batters were observed by Carlez *et al.* (1993, 1995), Carballo *et al.* (1997) and Jiménez Colmenero *et al.* (1997), respectively. However, the former reported that the *b* value remained constant. These changes were due to denaturation of the globin moiety of myoglobin molecules and to the partial oxidation of ferrous myoglobin into ferric metmyoglobin caused by pressurization (Carlez *et al.*, 1995). In general, MRPM presents substantial amounts of hemoglobin (Froning, 1981; Field, 1988; Jones, 1988). Thus, it is likely that pressure-induced modifications on this molecule could also generate color changes.

Several authors consider changes in color caused by high pressure processing to be a problem, depending on the product that is treated (Murakami *et al.*, 1992; Carlez *et al.*, 1993; Cheftel and Culioli, 1997). In contrast, in the case of MRPM, pressure-induced discoloration and paleness can be considered beneficial.

Summary and Conclusions

Compared to a standard cooking process, high pressure processing at high temperature yielded less springy and firm but more cohesive sausages, which were also lighter and more yellow.

The addition of MPM increased cohesiveness, hardness, and force at 80% compression. It also caused lighter, less red, and less yellow sausages. In this study, formulation influenced textural parameters more than type of treatment; this effect was very clear, particularly in the case of absence of MRPM.

Significant differences were caused by the three variables (formulation, temperature of treatment, and type of treatment) and also by the interactions among them. Thus, pressurization could be a good choice to achieve desirable characteristics in the case of meat products containing MRPM, because two of the main drawbacks of this meat as an ingredient are its appearance (too dark) and texture (too pasty and soft). Texturization of MRPM would possibly increase the range of products prepared from this raw material (Froning, 1976; Jones, 1988). Moreover, a certain amount of MPM can help to solve the disadvantages and to improve the properties of these products, but this raw material should not be added excessively because it could lead to very firm products. Dhillon and Maurer (1975), Froning (1976), Newman (1981), and Radomyski and Niewiarowicz (1987) stated that combinations of MRPM and hand deboned poultry meat gave desirable sensory and functional properties and economic advantages.

From the results obtained, it can be stated, as reported by Cheftel and Culioli (1997), that pressure treatment with previous, simultaneous, or subsequent cooking is the most

TABLE 3. Color parameters of sausages containing MRPM[1] and MPM[2] pressurized (HP) at 500 MPa for 30 min or conventionally cooked (no HP) for 30 min

	100 MRPM: 0 MPM		75 MRPM: 25 MPM		50 MRPM: 50 MPM		25 MRPM: 75 MPM		0 MRPM: 100 MPM	
Parameter	$\bar{x}$[3]	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD
L value										
Reference (untreated)	$43.99^{c,y}$	0.612	$46.78^{b,z}$	0.637	$46.88^{b,z}$	0.916	$52.95^{a,y}$	0.389	$53.07^{a,y}$	0.834
HP 50 C	$48.99^{d,x}$	0.666	$53.34^{c,wx}$	0.544	$54.69^{c,x}$	0.585	$56.46^{b,x}$	0.958	$59.49^{a,vw}$	0.236
HP 60 C	$49.36^{c,x}$	0.502	$53.90^{b,w}$	0.826	$54.22^{b,x}$	0.445	$57.36^{a,x}$	0.690	$58.84^{a,w}$	0.508
HP 70 C	$49.77^{d,x}$	0.225	$53.10^{c,wx}$	0.943	$54.11^{c,x}$	0.428	$56.95^{b,x}$	0.589	$60.59^{a,v}$	1.480
HP 75 C	$49.39^{c,x}$	0.939	$51.87^{b,xy}$	0.834	$54.72^{a,x}$	0.638	$56.06^{a,x}$	0.642	$49.73^{c,z}$	1.959
no HP 75 C	$49.28^{d,x}$	0.577	$50.29^{c,y}$	0.223	$51.87^{c,y}$	0.643	$54.27^{b,y}$	0.427	$56.51^{a,x}$	0.632
a value										
Reference (untreated)	$8.37^{a,w}$	0.298	$5.64^{b,x}$	0.128	$4.68^{c,x}$	0.164	$3.46^{d,x}$	0.202	$4.33^{e,x}$	0.263
HP 50 C	$5.53^{a,x}$	0.129	$3.98^{b,y}$	0.123	$3.40^{c,yz}$	0.048	$2.68^{d,yz}$	0.157	$1.88^{e,z}$	0.040
HP 60 C	$5.28^{a,x}$	0.081	$3.94^{b,y}$	0.195	$3.50^{c,yz}$	0.095	$2.63^{d,z}$	0.102	$2.32^{d,y}$	0.077
HP 70 C	$5.37^{a,x}$	0.101	$4.08^{b,y}$	0.150	$3.62^{c,y}$	0.106	$2.81^{d,yz}$	0.096	$2.30^{e,y}$	0.238
HP 75 C	$4.56^{a,y}$	0.137	$3.94^{b,y}$	0.056	$3.66^{b,y}$	0.072	$2.96^{c,y}$	0.100	$4.56^{a,x}$	1.637
no HP 75 C	$3.89^{a,z}$	0.116	$3.36^{b,z}$	0.101	$3.29^{b,z}$	0.140	$2.60^{c,z}$	0.083	$2.21^{d,y}$	0.103
b value										
Reference (untreated)	$11.17^{ab,wx}$	0.209	$11.67^{a,w}$	0.125	$10.93^{b,x}$	0.395	$10.88^{b,x}$	0.293	$10.01^{c,y}$	0.264
HP 50 C	$10.35^{ab,y}$	0.114	$10.68^{a,xy}$	0.071	$10.43^{ab,x}$	0.127	$9.98^{bc,yz}$	0.369	$9.68^{c,yz}$	0.185
HP 60 C	$10.60^{a,xy}$	0.187	$10.64^{a,y}$	0.107	$10.49^{a,x}$	0.161	$10.43^{ab,xy}$	0.175	$9.85^{b,yz}$	0.240
HP 70 C	$10.59^{a,xy}$	0.163	$10.88^{a,xy}$	0.130	$10.65^{a,x}$	0.142	$10.69^{a,x}$	0.149	$9.53^{b,yz}$	0.782
HP 75 C	$11.27^{a,w}$	0.213	$11.26^{a,wx}$	0.093	$10.81^{ab,x}$	0.172	$10.68^{b,x}$	0.176	$11.27^{a,x}$	1.713
no HP 75 C	9.56^{z}	0.149	9.74^{z}	0.156	9.38^{y}	0.269	9.74^{z}	0.221	9.35^{z}	0.274

$^{a-e}$Means within a row with no common superscript differ significantly ($P < 0.05$).

$^{v-z}$Means within a column with no common superscript differ significantly ($P < 0.05$).

[1]MRPM = mechanically recovered poultry meat.

[2]MPM = minced pork meat.

[3]n = 6.

suitable way of processing fresh whole or minced meat, taking into account the modifications induced by pressurization. Final cooked meat products would be obtained directly from this process.

Cooked sausages containing MRPM with better appearance and texture than the traditional ones can be obtained by means of high pressure processing. Moreover, the ability of pressurization to inactivate microorganisms and, therefore, to enhance the safety and to extend the shelf-life of some food products must be emphasized (Hoover *et al*., 1989; Hayashi, 1991; Ludwig *et al*., 1992; Yuste *et al*., 1998). Thus, high pressure processing is a technique with a promising future in the processing of meat and meat products and, in general, in food technology.

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