HIGH HYDROSTATIC PRESSURE TREATMENT OF RAW MATERIAL: EFFECT ON PHYSICOCHEMICAL AND TEXTURE PROPERTIES OF BEEF PATTIES

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Abstract

In this study was evaluated the effect of pressure level and holding time on the raw material for the manufacture of beef patties. It was analyzed the changes of technological, physicochemical and texture parameters of the patties. A statistical design with two factors: pressure level (0.1, 150 and 300 MP) and holding time (1 and 5 min) was applied. Cooking weight loss was modified by the pressure level and holding time interaction. The highest value of CWL was obtained for treatment 300MPa-5min. The pH values of the patties before and after cooking significantly increased with the pressure and the holding time. Regarding the chromatic parameters of raw patties, L* increased significantly due to interaction of pressure level and holding time. Concerning raw patties, the parameter a* decreased and b* increased as pressure increased up to 300 MPa. In addition, the parameter a* of raw samples decreased as holding time increased. Regarding colour parameters of the cooked patties, only pressure level affected them. The pressure level changed significantly the shear force and the work of shearing of cooked patties, decreasing these parameters.

I. INTRODUCTION:

High pressure processing (HPP) allows the cold pasteurization of food, assuring safety and extending the shelf life of the foods, while preserves their sensory and nutritional properties. In addition, HPP causes physicochemical changes in meat proteins, such as depolymerization of F-actin, dissociation of actomyosin, solubilization of myofibrillar proteins and even their aggregation at pressures between 100 and 300 MPa [1]. Those changes, which depend on the characteristics of the system and the conditions of processing, improve meat binding properties and partially compensate the reduction of NaCl and STPP concentrations [2]. Several authors studied the application of HPP (100-350 MPa), before or after the manufacture of low sodium content meat products [2-5].The aim of this study was to perform the HPP of raw material (minced beef), analyzing the effect of pressure level and holding time on technological, physicochemical and texture properties of beef patties.

II. MATERIALS AND METHODS:

Materials:

Fresh beef shoulder clods (muscles *infraspinatus*, *triceps brachii*, *supraespinosu*s) with 48 hours post-slaughter were obtained from a local market Muscles were defatted, and fat was conserved for patty preparation. After that, the pH of the pieces was measured and those with normal pH (5.4 to 5.7) were selected. The salts used for the manufacture of patties were: NaCl (Dos Anclas, Argentina, Argentina) and sodium tripolyphosphate (STPP, N 15-16 Chemische Fabrik Budenheim RA Oetker, Budenheim). The composition of patties is shown in Table 1.

Table 1 Composition of the beef patties

Ingredients	Concentration (%, w/w)
Lean beef	78.75
Fat	10
Cold Water (10 °C)	10
NaCl	1
STPP	0.25

Patties manufacturing:

To prepare the patties, pieces of meat and fat were minced separately using a 4 mm plate in a meat grinder Hobart (Hobart Corp., Troy Ohio, USA). Then the minced beef was vacuum-packed in Cryovac BB2800 bags (Sealed Air, Buenos Aires, Argentina), containing 1.5 kg of minced beef each one. Then, the bags were treated a High Pressure System Stansted Fluid Power Ltd. model Iso-Lab FPG9400:922 (Stansted, UK), with a vessel of 2 dm^3 (maximum working pressure: 900 MPa; temperature range: -20 to 120°C). For the HPP of minced beef two pressure levels were used: 150 and 300 MPa and two holding times: 1 and 5 min. Pressurization rate applied was 300 MPa min^{-1}. Conditioning temperature of vessel and initial temperature of compression fluid were 5 °C. The adiabatic heating induced an increase of fluid temperature that reached a maximum (10 °C) at 300 MPa As control treatment, minced beef non-pressurized (0.1 MPa) was used. Then, minced beef and minced fat were mixed in the proportion set (Table 1) and the mixture was minced again in a meat grinder (Hobart, Corp., Troy Ohio, USA). Then, STPP (dry powder) was added and manually mixed for 5 min. Finally, NaCl (previously dissolved in water at 10 °C) was incorporated and the mix was mixed by hand for 5 min. Then, the batter was stuffed into collagen casings (diameter 50 mm) and they were frozen at -20 °C for 12 h. After that, patties (diameter 50mm, thickness 15mm) were obtained from the frozen casings cutting them with a meat cutter (Berkel Rotterdam type 834) Then, some patties were stored at 1±1 C ° for 24 h and then analyzed. The rest of patties were stored at -40 °C until cooking. Patties were put in aluminum trays and cooked in a grill (George Foreman, USA) at 165-180°C, until reach a temperature of 72 °C at the centre of the sample (end of cooking).

Sample analysis:
Raw and cooked patties: pH (electrode Thermo Orion model 8102BN ROSS and pH-meter Thermo Orion model 710A +, Beverly MA, USA) and CIEL*a*b* color parameters (Minolta colorimeter model CR400 D65 illuminant, 2° observer angle),
Cooked patties: Cooking weight loss (CWL) was determined by weighing patties before and after cooking and the parameter was calculated with the following equation: CWL=(m1-m2)/m1*100, where m1 is the mass of the patty before cooking (after HPP) and m2 is the mass of the patty after cooking Shear force and work of shearing were determined using a Kramer cell with 10 blades attached to a texture analyzer (Stable Micro Systems model TA.XT*plus*), equipped with a load cell of 50 kg. The following speed conditions were applied: pre-test 1 $mm.s^{-1}$, test 1 $mm.s^{-1}$, and post-test 10 $mm.s^{-1}$. The results were expressed as $N.g^{-1}$ (force per gram) and $J.g^{-1}$ (work per gram).

2.1. Experimental Design:

A 3x2 factorial design was used: The first factor (pressure) with three levels (0.1, 150, 300 MPa) and the second factor (holding time) with two levels (1 and 5 min) and combinations of the levels. ANOVA and Tukey Multiple Comparison procedure were applied ($P < 0.05$). The SPSS® Inc. Statistics V12 for windows was used for the data analysis.

III. RESULTS AND DISCUSSION:

3.1. Cooking weight loss

Cooking weight loss was significantly affected ($P < 0.05$) for the pressure level-holding time interaction (Table 2). A highest value of CWL was obtained for treatment 300MPa-5min, which was significantly different from treatment 300MPa-1 min, treatments at 150 MPa and controls 0.1 MPa-(Table 2). Ferrari et al. (2012) applied HPP on prepared beef patties, which differ from the present study, where HPP was performed on raw material [4]. Nevertheless a similar effect was observed in both studies. Those authors reported that CWL of beef patties was significantly increased as pressure level increased in the range 100 to 300MPa. Crehan et al. (2000) applied HPP to raw material (beef and pork) for sausage manufacture [3]. However, they not found a significant effect of HPP (300 MPa-5min) on CWL of sausages.

3.2. pH

The pH was significantly affected ($P < 0.05$) by the pressure level and the holding time in raw and cooked patties (Table 2). In raw patties, the pH increased 0.13 units as pressure level increase up to 300 MPa. Szerman et al. (2011) found similar results in raw beef patties treated at pressures between 100 and 300 MPa [5]. The increment of pH could be attributed to the reduction of free protons due to increased ionization that occurs in

myofibrillar proteins at high pressures [6]. The pH values of cooked patties (pH cooked) were higher than those from raw ones, for each pressure level or holding time (Table 2). Thermal denaturation of meat proteins increases pH values as a consequence of the exposure and ionization of the buried groups that took place during heating [7]. Holding time significantly increased the "pH cooked". However, "pH cooked" of patties treated at 150 was not significantly different from "pH cooked" of patties treated at 300 MPa. Szerman et al. (2011) observed no change in the pH of patties treated between 100 and 300 MPa and subsequently cooked at 72ºC – end point at the slowest heating point [5].

3.3. Shear force and work of shearing

The pressure level affected significantly (P <0.05) the shear force and the work of shearing of cooked patties, decreasing these parameters (Table 2). The holding time significantly (P <0.05) reduced shear force but not affected the work of shearing. Previous studies [4,5], in which HPP was applied on frozen or fresh beef patties, observed an opposite effect of pressure level and holding time on texture parameters. They observed an increment of shear force and work of shearing when pressure level and holding time were increased. In the present study, the high pressure treatment of raw material (fresh beef) would have changed the conformation of myofibrillar proteins. This effect may have reduced the interaction of meat particles when patties were manufactured. Consequently, a reduction of texture parameters should be expected.

Table 2 Cooking weight loss (CWL), pH values of raw (pH raw) and cooked (pH cooked) patties. Shear force and work of shearing of cooked patties.

PARAMETER	PRESSURE-TIME INTERACTION (P*T)					MODEL			
	0.1 MPa	150 MPa		300 MPa		CME	PRESSURE	TIME	P*T
		1 min	5 min	1 min	5 min				
CWL (%)	31.6 d	33.1 cd	35.3 c	39.2 b	44.9 a	13.29	0.0001	0.0001	0.0004

PARAMETER	PRESSURE (MPa)			TIME (min)		MODEL			
	0.1	150	300	1	5	CME	PRESSURE	TIME	P*T
pH raw	5.967 c	6.032 b	6.103 a	6.014 b	6.054 a	0.00307	0.0001	0.0366	0.3105
pH cooked	6.111 b	6.184 a	6.226 a	6.156 b	6.191 a	0.00183	0.0001	0.0192	0.2107
Shear force (N/g)	29.67 a	27.08 b	21.33 c	26.73 a	25.33 b	6.431	0.0001	0.0483	0.2475
Work of shearing (mJ/g)	0.088 a	0.075 b	0.056 c	0.074	0.071	0.00011	0.0001	0.2411	0.5123

Note: Means in the same row with different letters indicate significant differences (P<0.05).

3.4 Chromatic Parameters

Raw patties prepared with beef treated at 300 MPa-5min showed L* values significantly (P<0.05) higher than patties from beef treated at 300MPa-1min (Table 3). Moreover, these samples exhibited L* values significantly different (P<0.05) from patties prepared with beef treated at 150 MPa and control patties -0.1 MPa-. The parameter a* of raw patties decreased, and b* increased as pressure increased up to 300 MPa. Moreover, the parameter a* of raw samples decreased as holding time increased (Table 3). These results are in agreement with previous studies [4,8]. Ferrari et al. (2012) reported that L* of raw patties increased as pressure level increased in the range 100 to 300 MPa [4]. Carlez *et al*. (1995) observed significant increments of that L* in the range 200-350 MPa, turning meat colour to "pink" [8]. According to the authors this whitening effect was due to globin denaturation and/or heme group displacement or release.

Regarding cooked patties, samples prepared from beef treated at 150 MPa did not differ from control patties -0.1 MPa- for any of the parameters evaluated. However, when pressure level was increased up to 300 MPa, cooked patties showed an increase in L* and b* and a decrease in a*. Similar data were found in beef sausages [2] and pork sausages [9].

Table 3 CIEL*a*b* parameters of raw and cooked patties.

PARAMETER	PRESSURE-TIME INTERACTION (P*T)					MODEL			
	0.1 MPa	150 MPa		300 MPa		CME	PRESSURE	TIME	P*T
		1 min	5 min	1 min	5 min				
L* raw	43.52 c	44.30 c	44.79 c	49.12 b	53,37 a	3.404	0.0001	0.0028	0.0019

PARAMETER	PRESSURE (MPa)			TIME (min)		MODEL			
	0.1	150	300	1	5	CME	PRESSURE	TIME	P*T
a* raw	17.41 a	16.37 a	13.37 b	16.39 a	15.05 b	2.8176	0.0001	0.0051	0.103
b* raw	11.19 b	11.33 b	12.60 a	11.59	11.78	0.3011	0.0001	0.2111	0.5808
L*cooked	53.02 b	53.25 b	55.99 a	54.02	54.17	1.4924	0.0001	0.6555	0.255
a*cooked	10.16 a	10.52 a	8.78 b	10.01	9.64	2.3193	0.003	0.3846	0.6672
b*cooked	12.17 b	11.95 b	12.85 a	12.34	12.31	0.2047	0.0001	0.774	0.4982

Note: Means in the same row with different letters indicate significant differences, (P<0.05).

IV. CONCLUSION

Application of high pressure treatments on raw material for manufacture of patties had a positive effect on the shear force and work of shearing of cooked patties, but showed a negative effect on cooking weight loss and chromatic parameters, particularly in the samples treated with 300 MPa. Treatment at 150 MPa had a lesser effect than treatment at 300 MPa on the parameters evaluated. In general, the application of HPP to the raw material had a similar effect on quality of patties than that observed when HPP is applied directly on patties.

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