EFFECT OF HIGH PRESSURE AT DIFFERENT TEMPERATURES ON TEXTURE OF DRY–CURED HAM WITH DIFFERENT TEXTURAL CHARACTERISTICS

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Abstract – Pastiness and softness are the most common texture defects in dry–cured ham. The application of high pressure treatments to eliminate pathogenic microorganisms and extend shelf-life can affect product characteristics (colour, texture and flavor). However, in some cases, this effect may reduce incidence and/or intensity of some texture defects. In this study, the effect of HP treatments at different temperatures on samples with different textural characteristics was evaluated. HP treatments produced changes on textural properties showing an increase of hardness (F_0) and a decrease of softness/pastiness (Y_2 and Y_{90}). Increase of F_0 was more pronounced in non–defective samples than on defective samples, producing a higher correction action in those samples that do not need it.

Key Words – Corrective actions, pastiness and texture defects.

I. INTRODUCTION

Dry-cured hams are appreciated by consumers because of its flavor and texture characteristics. The main texture defects in dry-cured ham are excessive softness and pastiness which are related to raw material, process characteristics, proteolysis and other factors. High pressure (HP) treatments are currently being used to eliminate pathogenic microorganisms and extend the shelf-life. However, pressure treatments can affect quality characteristics such as texture, colour, appearance and, potentially, the aroma and taste.

It has also been previously described that HP can also reduce the incidence and the intensity of the previously mentioned defects [1]. Nevertheless, the effect of HP could be different depending on the physicochemical and textural characteristics of the treated samples and the used HP processing conditions. The aim of this work was to study the effect of HP processing at different temperatures on instrumental and sensory texture of samples with different initial texture characteristics. The usefulness of HP treatments as a corrective action for defective samples was also discussed.

II. MATERIALS AND METHODS

A hundred and sixty–four hams were elaborated following an elaboration process in which an intense proteolysis was prone to occur. At the end of process, hams were cut and boned and the cushion part which contains *Biceps femoris* (BF) muscle was excised and sampled. An initial evaluation which consisted of a sensory evaluation, an instrumental texture (stress relaxation test) and a physicochemical characterization (pH, moisture content, salt content, non-protein nitrogen content, total nitrogen and proteolysis index (PI)) was performed.

Hams were classified in three texture level groups: non-defective (ND) (samples with sensory pastiness < 0.5 and PI < 33.0), medium defective (MD) (samples with sensory pastiness between 0.5–2.0 and PI between 27.0–40.0) and high defective (HD) (samples with sensory pastiness > 2.0 and PI > 36.0–48.0). Then, hams from the different groups were equally distributed into different HP temperature treatments: 7ºC (HP7), 20ºC (HP20) and 35ºC (HP35) in experiment 1 and -7ºC (HP-7), 0ºC (HP0) and 12ºC (HP12) in experiment 2. All samples were submitted to 600 MPa during 6 min at the previously mentioned temperatures.

Stress relaxation test after HP temperature treatments on BF muscle using parallelepipeds with the exact same dimensions (2 cm x 2 cm x 1.5 cm) was performed. Initial force F_0 (kg) (representing hardness) and force decay at 2 s (Y_2) and 90 s (Y_{90}) were calculated as previously described [2]. A sensory analysis to evaluate pastiness, adhesiveness and saliva viscosity was also carried out by a three-member expert panel trained following American Society for Testing and Materials standards [3]. During each session, three pairs of samples, corresponding to three of the following comparisons: CT vs. HP-7, CT vs. HP0, CT vs. HP7, CT vs. HP12, CT vs. HP20 or CT vs. HP35, were evaluated by all the panellists.

In order to evaluate the effect of HP temperature treatments on instrumental and sensory texture of dry-cured ham samples with different textural characteristics, an analysis of variance was performed for each experiment. HP temperature treatment, texture level group, and their interaction were included as fixed effects in the model. Sample was also included as a block effect nested to texture level group. Differences between mean values were tested by means of Tukey's test.

III. RESULTS AND DISCUSSION

Initial physicochemical and sensory characteristics of BF muscle samples, from both experiments showed no significant differences for salt and water contents ($p>0.05$) between the different texture level groups (Table 1). In contrast, a decrease of initial force (F_0) and an increase of the force decay (Y_2 and Y_{90} values) with the increase of the defective level was observed, which agrees with Morales et al. (2007) [2]. Moreover, an increase of proteolysis index, sensory pastiness, adhesiveness and saliva viscosity perception with the increase of the defective level was observed.

Table 1: Physicochemical and sensory characteristics (Mean±standard deviation) of BF muscle according to the texture level group.

	ND	MD	HD
Experiment 1: Room temperature treatments			
n	30	30	30
Chemical analysis			
NaCl (%)	4.80 ± 0.72	4.83 ± 0.93	4.71 ± 0.87
Moisture (%)	59.0 ± 0.7	58.7 ± 1.0	58.9 ± 1.1
PI (%)	31.5 ± 2.0^{c}	34.2 ± 2.6^{b}	39.8 ± 2.5^{a}
Sensory analysis			
Pastiness	0.22 ± 0.25^{c}	1.71 ± 0.46^{b}	3.70 ± 0.80^{a}
Adhesiveness	0.66 ± 0.46^{c}	2.00 ± 0.94^{b}	3.43 ± 1.18^{a}
Saliva viscosity	1.03 ± 0.22^{c}	2.64 ± 0.25^{b}	3.98 ± 0.32^{a}
Experiment 2: Low temperature treatments			
n	30	30	14
Chemical analysis			
NaCl (%)	4.94 ± 1.04	4.65 ± 0.86	4.72 ± 0.94
Moisture (%)	58.8 ± 1.1	59.0 ± 0.8	59.0 ± 1.2
PI (%)	32.2 ± 2.5^{c}	35.1 ± 2.4^{b}	37.2 ± 2.9^{a}
Sensory analysis			
Pastiness	0.15 ± 0.18^{c}	0.70 ± 0.78^{b}	2.43 ± 0.92^{a}
Adhesiveness	0.61 ± 0.44^{c}	1.26 ± 0.84^{b}	2.64 ± 1.01^{a}
Saliva viscosity	0.92 ± 0.35^{c}	1.64 ± 0.85^{b}	3.36 ± 1.06^{a}

[abc] within rows, means with different letters indicate significant differences ($p<0.05$). ND: Non-defective; MD: Medium defective; HD: High defective.

HP produced a significant decrease of Y_2 and Y_{90} ($p<0.05$) (Table 2 experiments 1 and 2). However, there was not a significant interaction between the HP temperature treatment and the texture level group for experiment 1 or 2. Therefore, high pressure produced a similar correction action of softness/pastiness regardless of the initial textural characteristics of the sample. The decrease of force decay due to HP treatment was similar in both experiments, showing a decrease between 0.5 and 0.7 for Y_2 and 0.4 and 0.6 for Y_{90}.

An increase of F_0 was found in both experiments showing significant differences in all the treatments applied ($p<0.05$) (Table 3). However, in experiment 1, a significant interaction between HP treatment temperatures and texture level groups was found. Increase of F_0 was more pronounced in non-defective samples (showing a mean increase of 1.8), rather than in medium or high defective ones (which shows a mean increase of 1.2 and 0.7, respectively). Although non-significantly different, the same tendency at low temperatures was observed (Table 3, experiment 2).

Table 2: Least Square means of force decay at 2s (Y_2) and 90s (Y_{90}) on BF muscle according to HP temperature treatment.

HP Treatment	n	Y_2	Y_{90}
Experiment 1: Room temperature treatments			
CT	90	0.40^a	0.68^a
HP7	30	0.35^b	0.65^b
HP20	30	0.36^b	0.65^b
HP35	30	0.35^b	0.64^b
RMSE ^{A}		0.020	0.017
Experiment 2: low temperature treatments			
CT	75	0.39^a	0.67^a
HP12	25	0.32^b	0.62^b
HP0	25	0.32^b	0.61^c
HP-7	25	0.32^b	0.61^c
RMSE^A		0.012	0.013

^{abc} within columns, means with different letters indicate significant differences (p<0.05). ND: Non-defective; MD: Medium defective; HD: High defective.
^{A} Root mean square error of the linear model.

Table 3: Initial force (F_0, Kg) Least Square means of BF muscle according to the interaction HP temperature treatment x defective level group.

	HP Treatment	ND	MD	HD
Experiment 1: Room temperature treatments				
F_0	CT	1.76^a	1.04^a	0.53^a
	HP7	3.11^b	1.98^b	1.08^b
RMSE 0.415	HP20	3.35^b	1.91^b	1.12^{bc}
p < 0.01	HP35	4.19^b	2.80^c	1.62^c
Experiment 2: Low temperature treatments				
F_0	CT	1.87^b	1.32^b	0.70^b
	HP-7	3.39^a	2.47^a	1.60^a
RMSE 0.320	HP0	3.19^a	2.54^a	1.60^a
p= 0.14	HP12	3.02^a	2.40^a	1.66^a

^{abc} within columns, means with different letters indicate significant differences (p<0.05). ND: Non-defective; MD: Medium defective; HD: High defective.
^{A} Root mean square error of the linear model.

Therefore, HP produced a mild correction action of softness in those samples with severe texture defects whereas increase of F_0 might be excessive in non-defective samples that already had an acceptable texture before the HP treatment.

It must be remarked that after HP treatments at 7ºC and 20ºC, similar F_0 values to the non-defective control samples were achieved for medium defective samples. In contrast, a temperature of 35ºC was needed for the high defective samples. The more pronounced effect for HP35 treatment in comparison to HP7 and HP20 may be due to the more severe changes in the myofibrillar proteins (protein denaturalization) and collagen shrinkage because of the high temperatures reached [4-6]. A similar tendency when using low temperatures was found. However, in this case, probably due to the different initial characteristics of the samples, the correction effect was possible for high defectives samples in all the HP temperature treatments applied.

A decrease of pastiness perception on medium and high defective texture groups due to HP treatment was found, but no important differences between any of temperatures used were observed (results not shown). Effect of HP temperature treatments on adhesiveness, saliva viscosity, stringiness and other sensory attributes is being studied at this moment.

IV. CONCLUSION

HP temperature treatments produced an increase of hardness (F_0) and a decrease of softness (Y_2 and Y_{90}) and sensory pastiness. Increase of F_0 was more pronounced in non–defective samples than on defective samples, producing a higher correction action in those samples that do not need it.

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