EFFECT OF TEMPERATURE DURING HP PROCESSING ON COLOUR AND COLOUR STABILITY OF DRY–CURED HAM

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Abstract –High pressure (HP) treatments are used in the industry to ensure safety and extend shelf life of dry–cured ham. However, these treatments can produce changes on the texture and the appearance of dry–cured ham. The aim of this work was to evaluate the effect of HP treatment at different temperatures on colour and colour stability of dry–cured ham samples with different initial texture. Results showed a decrease of a* and an increase of L* in all the used temperature treatments, being the increase of L* higher in non–defective groups rather than defective groups when using room temperatures. Colour stability was similar for all the HP temperature treatments and texture level groups, showing a decrease of a* after 4 days exposure to light in all the cases.

Key Words – CIE-Lab, defective texture, high pressure.

I. INTRODUCTION

Colour is an important attribute which determines quality and consumer's acceptability of dry-cured ham. High pressure (HP) treatment is commonly applied in the industry to ensure microbiological safety but it can produce undesired changes on colour and colour stability [1, 2]. Although the effect of HP treatments on dry-cured ham has been widely described, the effect of temperatures during pressurization was not found in literature. The aim of this work was to evaluate the effect of the HP treatments at different temperatures on colour and colour stability of samples having different initial textural characteristics.

II. MATERIALS AND METHODS

A hundred and sixty–five hams were elaborated following an elaboration process in which 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 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 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 the 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 600MPa during 6 min at the previously mentioned temperatures.

Colour before and after the HP treatments and colour stability in the BF muscle during storage at 6ºC ± 0.5 °C after 0, 4, 7, 11, 22 and 28 days of light exposure were evaluated. Colour in the CIE-LAB space: lightness (L*), redness (a*) and yellowness (b*) with the illuminant D65 with 2° was used.

In order to study the effect of HP on colour after HP processing, an analysis of variance was performed. HP temperature treatment, texture level group and their interaction were included as fixed effects in the model. Besides, in

order to study colour stability, time of exposure to light, texture level group and their interaction for each of the HP temperature treatments were included as fixed effects in the model. In both analysis, sample was included as a block effect nested to texture level group. Differences between mean values were tested by means of Tukey's test ($p<0.05$).

III. RESULTS AND DISCUSSION

a. Effect of HP temperature treatments on CIE Lab on samples with different initial textural characteristics

Initial physicochemical and sensory characteristics of BF samples assigned to the different texture level groups showed no significant differences for salt and water contents, L* (lightness) and a* (redness) ($p<0.05$) in both experiments 1 and 2 (results not presented). However, a slight increase of b* (yellowness) with the increase of the defective level was observed which could be attributed to the variation of the composition.

It must be remarked that there was an important variability of colour, within the same slice due to the presence of nitrification halos. This fact might cause disturbance and high variability inside the same sample before and after the HP treatment. Changes on colour of different nitrification areas of the halos should be analysed more in depth.

In general, after HP treatments, a decrease of a* was observed (Table 1), which was attributed to the protein and pigment denaturalization [3]. A more pronounced decrease of a* in HP35 in comparison to HP20 and HP7 was found (Table 1, experiment 1). This fact can be due to the temperatures reached by the samples during the process (about 53ºC). Besides, interestingly, no significant decrease was found in HP-7 and HP0 (Table 1, experiment 2). Therefore, at industrial level, to avoid colour changes is recommended the use of low temperatures. However, effectiveness of pasteurization using these conditions should be validated.

A decrease of b* was only found in HP35 probably due to the high temperatures reached by the samples (results not presented).

Table 1: Least Square means of a* value on BF muscle according to HP temperature treatments.

HP Treatment	n	a*
Experiment 1: Room temperature treatments		
CT	90	20.72^{a}
HP7	30	19.33^{b}
HP20	30	19.63^{b}
HP35	30	16.80^{c}
RMSE [A]		1.526
Experiment 2: Low temperature treatments		
CT	75	25.18^{a}
HP-7	25	24.24^{a}
HP0	25	23.37^{a}
HP12	25	21.31^{b}
RMSE [A]		1.123

[abc] within columns, means with different letters indicate significant differences ($p<0.05$).
[A] Root mean square error of the linear model.

An increase of L* after HP processing was observed for all the used temperatures according to the previous published studies [1, 4] (Table 2). This fact was attributed to the new arrangement of proteins, caused by coagulation or denaturalization processes during HP processing, which increase the reflected:absorbed ratio [1, 2, 5]. A significant interaction between HP temperature treatment and texture level groups in both experiments was only found for L*. When applying pressure at room temperatures (Table 2, experiment 1), increase of L* was more pronounced in non-defective samples (mean increase of 6) which have a lower proteolysis index and a less damaged structure than medium defectives samples (mean increase of 5) and high defective samples (mean increase of 3.5) samples. The reason could be that effect of pressure is more severe/intensive in those proteins not affected by proteolysis. Similar results for the different temperatures used (7ºC, 20ºC and 35ºC) were found.

At low temperatures (Table 2, experiment 2), this effect was not observed. Low temperatures produced a less intensive action on the denaturalization of the proteins. In must be remarked that, no significant changes when using HP treatment at -7ºC were found in any of the texture level groups.

Table 2: Least Square means of L* value on BF muscle according to the interaction.

	HP Treatment	n	ND	MD	HD
Experiment 1: Room temperature treatments					
	CT	90	38.63[d]	37.44[c]	38.13[c]
RMSE[A] 1.372	HP7	30	41.91[c]	40.18[b]	40.86[b]
P=0.003	HP20	30	47.47[a]	44.40[a]	43.60[a]
	HP35	30	44.89[b]	43.28[a]	42.38[ab]
Experiment 2: Low temperature treatments					
RSME[A] 1.315	CT	75	43.68[a]	43.03[b]	40.24[b]
	HP-7	25	44.30[a]	44.03[b]	41.46[ab]
P=0.035	HP0	25	44.03[a]	44.74[b]	43.25[a]
	HP12	25	44.98[a]	46.53[a]	42.43[a]

[abc] within rows, 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.

b. Colour stability of HP treated samples at different temperatures

No significant changes in L* and b* for any of the texture level groups after 28 days exposure to the light were found in any of the HP temperature treatments (p>0.05). In contrast, a slight decrease of a* during the exposure period, similar for all the texture level groups and HP temperature treatments, was observed (See Figure 1 for HP7 as an example).

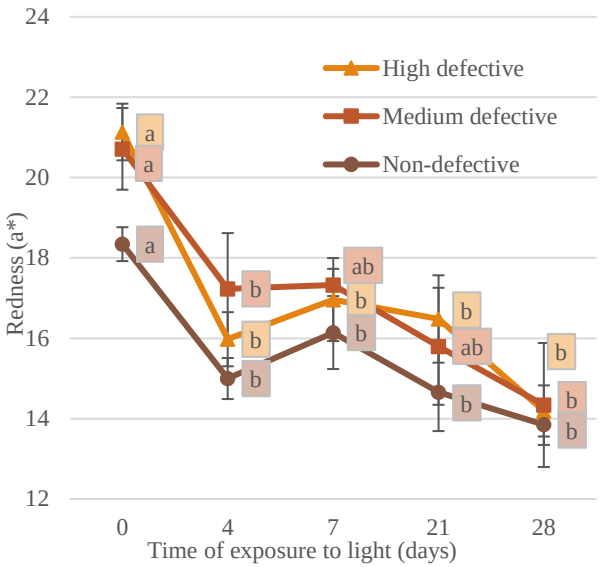

Figure 1: Colour stability of HP treated samples at 7ºC for the different texture level groups.

In all the cases, significant differences were found between 0 h and more than 4 days of exposure to light (p<0.05). However, no differences between 4, 7, 11, 21 and 28 days of exposure were observed. Therefore, neither the texture characteristics of the sample nor the HP temperature treatment influence on the colour stability.

IV. CONCLUSION

A decrease of a* and an increase of L* was found in all the used temperatures. Increase of L* was more pronounced in non–defective groups when using room temperatures. Slight decrease of a* after 4 days of exposure to light for all the temperature treatments and defective level groups was found.

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