PE4.54 Effects of Salting (NaCl or KCl) and High-Pressure Processing on Instrumental Colour and Texture, and Sensory Attributes of Pork Longissimus Muscle Dried at Different Levels 188.00

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***Abstract*—Potassium chloride as a substitute of sodium chloride and high-pressure processing both are of interest to dry-cured meat product industry. The aim of this work was to evaluate the effects of NaCl or KCl salting and high-pressure processing on the instrumental colour and texture, and the sensory attributes of pork *longissimus* muscle dried at different moisture contents. Pork loins were salted either with NaCl or KCl and dried at different moisture contents. After drying, loin pieces were cut in halves and treated at 600 MPa. Instrumental colour and texture, and sensory analyses were carried out. Salting treatment and high-pressure processing did not affect instrumental and sensory hardness significantly. Redness (a*) was significantly higher in NaCl salted loins, whereas bitterness was higher in KCl salted loins, as expected. High-pressure processing at 600 MPa increased lightness (L*) and fibrousness significantly at moisture contents above 50 %.**

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***Index Terms*—High-pressure processing, Moisture content, Pork *longissimus*, Potassium chloride, Sodium chloride.**

I. INTRODUCTION

SODIUM chloride (NaCl) is an essential ingredient in dry-cured meat products because it decreases water activity and contributes to water-holding capacity, colour and flavour [1]. Potassium chloride (KCl) is one of the additives most frequently proposed as a NaCl substitute. The NaCl substitution by KCl could affect the isotherms of the product surface which could influence the drying kinetics of meat products, and thus their colour and texture characteristics. The relationships between instrumental texture and water content have been studied in dry-cured meat containing NaCl [2], [3], [4], [5]. The use of high-pressure processing on meat products provides additional microbiological safety [6], although their colour and texture characteristics can be affected.

The aim of this work was to evaluate the effects of salting either with NaCl or KCl and high-pressure processing (HPP) on the instrumental colour and texture (TPA), and the sensory attributes of pork *longissimus* muscle dried at different moisture contents.

II. MATERIALS AND METHODS

A. *Sample preparation*

A total of 12 pork loin muscles (*longissimus*) from 6 carcasses were selected in a commercial slaughterhouse. The average pH was 5.55 ±0.07. Muscles were trimmed of intramuscular fat and weighed. Subsequently muscles were cut into 3 pieces of a similar weight. All the loin pieces were salted either with 25 g/kg of NaCl or 31.89 g/kg of KCl (molar equivalent to 25 g NaCl) and subsequently vacuum packed with a poliamide water-permeable bag (Activa Ingredientes Funcionales, SA, Banyoles, Girona, Spain) and kept horizontally at 3 ºC ± 2 ºC and 60 % HR. The loin pieces were turned upside down daily to allow a better salting. Once the salt had diffused inside de muscle and loins were hard enough, they were hung with a plastic net to continue drying. Loin pieces were weighed every 2 or 3 days. Once the loin pieces had reached the target weight loss, the water permeable plastic bags were removed and loins were packed in bags in a N_2 atmosphere and kept at 3 ºC ± 2 ºC for at least one month to allow homogenisation. The loin pieces were cut longitudinally in two parts, vacuum packed and one part was kept as control, whereas the other was processed by high pressure (HPP), at 600 MPa for 6 min (holding time) at 12 ºC in a Wave 6000 equipment of 120 l (NC Hyperbaric, Burgos, Spain).

B. *Instrumental colour and texture measurements*

At seven days after HPP the loin pieces were sliced for sensory (1.5 mm thick) and instrumental texture (10 mm thick) analysis. Instrumental colour was measured on the *longissimus* muscle surface of the remaining piece immediately after cutting each slice (1 cm thick). A colorimeter Minolta Chroma Meter CR-200 was used to measure colour in the CIE-LAB space [7]: lightness (L*), redness (a*) and yellowness (b*). The illuminant used was D65 with 2º standard observer and the specular component included. Each value was the mean of fifteen measurements.

Ten specimens per sample were accurately carved with a scalpel into parallelepipeds of 10 mm × 10 mm × 10 mm (length×width×height). Thereafter, a Texture Profile Analysis (TPA) test was performed on all the specimens. A RT/5 Universal MTS Alliance Texture Analyser (SEM, Barcelona, Spain) with a 150 mm diameter compression plate was used for the instrumental texture analyses. Specimens were compressed twice to 75% of their original height (time = 0 s between the two compression cycles), at a crosshead speed of 1 mm/s and perpendicularly to the fibre bundle direction. Force versus time was recorded and hardness (kg) was calculated. Hardness is defined as 'the maximum peak force during the first compression cycle' [8]. Moisture content was analysed by drying at 103 ± 2 ºC until reaching a constant weight [9].

C. *Sensory analysis*

A total of nine sessions were carried out by a six-member expert panel trained following American Society for Testing and Materials standards [10]. During each session, four pairs of samples, two from each of the following comparisons: NaCl-CT vs. NaCl-600MPa, KCl-CT vs. KCl-600MPa, were evaluated by all the panelists. The sample order within the comparisons was randomized within sessions, blocking the order of presentation and the first-order carry-over effects [11]. Attributes were scored using an unstructured scale from 0 (very low) to 10 (very high).

D. *Statistical analysis*

The statistical analysis for the instrumental colour and sensory attributes, was carried out with the SAS statistical package [12] using the General Linear Model procedure. The model included the salting treatment and the high-pressure processing and their interactions as fixed effects and the moisture content, and moisture content within each main effect were included as covariables. Interactions not statistically significant ($P > 0.05$) were dropped from the model.

III. RESULTS AND DISCUSSION

The relationships between moisture content and instrumental hardness (Texture Profile Analysis, TPA) for NaCl and KCl salted *longissimus* muscle (irrespective of the HP processing) are shown in Fig. 1. Both salting treatments showed similar behaviour. TPA hardness showed a non-linear relationship with a dramatic increase at around 50 % moisture content, which corresponds to a water content of 1 g per g of dry matter. These results are in agreement with those reported by Ruiz-Ramírez et al. [4] in dry-cured loin salted with NaCl. On the other hand, sensory hardness showed a linear relationship, increasing with decreasing moisture content (covariable moisture coefficient β = -0.1209) in both salting treatments (irrespective of the HP processing), as shown in Fig. 2.

Table 1 shows the least-squares means of instrumental colour and sensory attributes of *longissimus* muscle dried at different levels according to the salting treatment (NaCl or KCl) and to the high-pressure processing (Control or 600 MPa). Salting treatment affected redness (a*) significantly. The muscles salted with NaCl showed higher a* values than the ones salted with KCl. This could be related with differences in water content at the same water activity due to differences in the desorption isotherms of the salts used. Concerning the sensory attributes, only bitterness was significantly affected by salting treatment. As expected, the muscles salted with KCl showed higher bitterness than the ones salted with NaCl.

With regard to the high-pressure processing (HPP) effect, samples treated at 600 MPa showed significantly higher lightness values (L*) and lower darkness and redness scores than the control ones. As shown in Fig. 3, lightness (L*) increased with increasing moisture content, and this increase was significantly higher after high-pressure treatment (i.e., covariable moisture × HPP coefficient: β 600 MPa > β CT; Table 1). Higher moisture contents would allow higher protein denaturation, which would explain the L* increase after HP processing. Several authors have reported similar results concerning lightness increase after HPP of dry-cured ham [13], [14], [15] and [16]. Sensory hardness was not affected by HP processing, but 600-MPa samples showed significantly higher fibrousness than control samples at higher moisture contents (i.e., β 600 MPa < β CT; Table 1), as shown in Fig.4. Fulladosa et al. [15] and Tanzi et al [14] also described a significant fibrousness increase in dry-cured hams after high-pressure processing.

IV. CONCLUSION

The high-pressure processing at 600 MPa of dry pork loin salted either with NaCl or KCl increases the product lightness and fibrousness. However, the effects are only significant at moisture contents above 50%.

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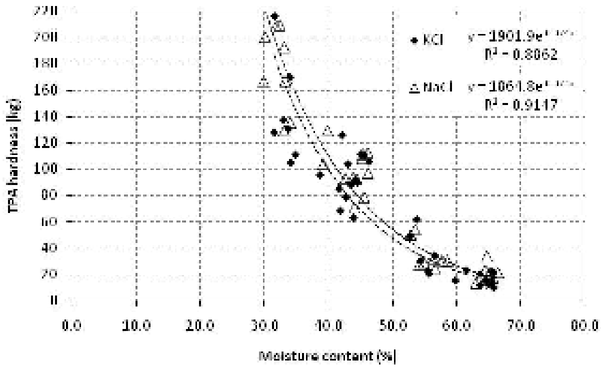

Figure 1. Instrumental hardness (TPA) versus moisture content according to the salting treatment (NaCl and KCl) for *longissimus* muscle (irrespective of the high-pressure processing: Control or 600 MPa).

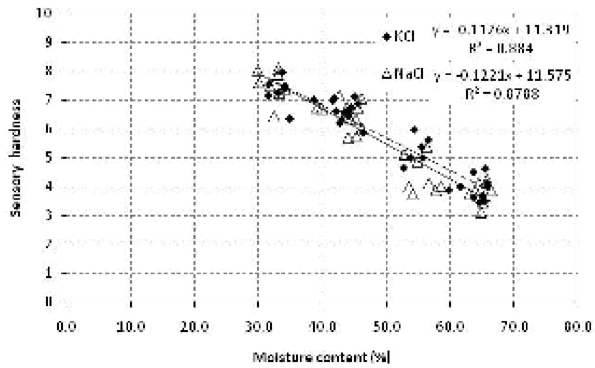

Figure 2. Sensory hardness versus moisture content according to the salting treatment (NaCl and KCl) for *longissimus* muscle (irrespective of the high-pressure processing: Control or 600 MPa).

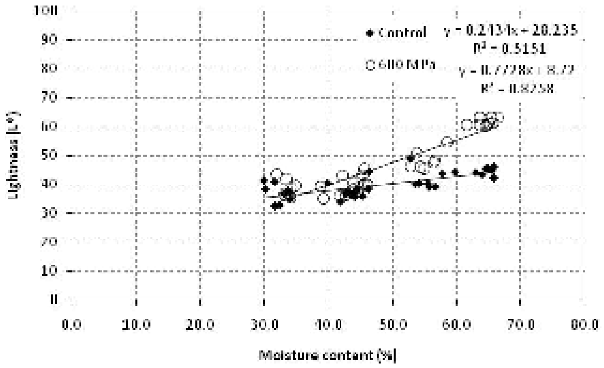

Figure 3. Lightness (L*) versus moisture content according to high-pressure processing (Control and 600 MPa) for *longissimus* muscle (irrespective of the salting treatment: NaCl or KCl).

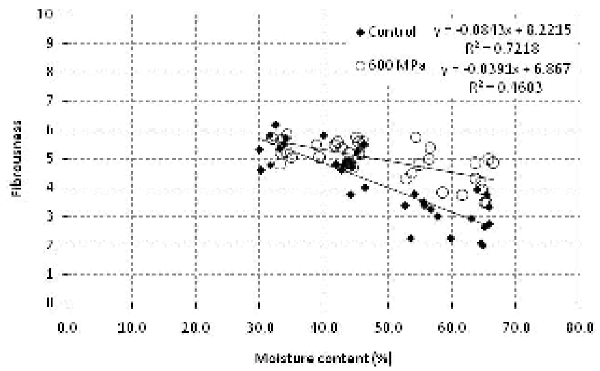

Figure 4. Fibrousness versus moisture content according to high-pressure processing (Control and 600 MPa) for *longissimus* muscle (irrespective of the salting treatment: NaCl or KCl).

Table 1
Instrumental colour and sensory attributes of pork *longissimus* muscle dried at different moisture contents according to salting treatment (NaCl or KCl) and high-pressure processing (HPP) (least-squares means).

	Salting treatment		High-pressure processing		Covariable moisture × HPP (β)		
	NaCl	KCl	Control	600 MPa	Control	600 MPa	RMSE
CIE-LAB colour							
L*	43.21	43.37	40.12[b]	46.46[a]	0.1891	0.7213	3.586
a*	8.50[a]	7.85[b]	7.39	8.96	-0.0260	0.0500	1.533
b*	1.17	1.67	1.01	1.83	-0.1241	-0.0646	1.166
Visual appearance							
Darkness	4.49	4.51	4.60[a]	4.40[b]	-0.0593	-0.1016	0.901
Redness	3.91	4.00	4.23[a]	3.68[b]	-0.0259	-0.0872	1.106
Flavour							
Saltiness	3.03	2.17	2.51	2.69	-0.0541	-0.0293	0.598
Sweetness	1.27	0.55	0.92	0.91	-	-	0.542
Bitterness	0.40[b]	3.80[a]	2.00	2.19	-	-	0.659
Umami	2.16	1.72	1.75	2.13	-0.0425	-0.0134	0.685
Texture							
Hardness	5.61	5.82	5.55	5.88	-	-	0.498
Fibrousness	4.54	4.52	4.11[b]	4.96[a]	-0.0856	-0.0404	0.583
Crumbliness	5.01	4.65	4.98	4.67	-	-	0.773

[ab] Within factor and row, means with a common letter are not significantly different ($P \geq 0.05$).
β: regression coefficient ($P < 0.05$); RMSE: root mean square error.