EFFECT OF THE INCLUSION OF CHESTNUTS IN THE FINISHING DIET ON THE CHANGES IN CHEMICAL COMPOSITION DURING THE PROCESSING OF CELTA DRY-CURED HAM

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Abstract –The effect of the inclusion of chestnut in the finishing diet on chemical composition through the manufacturing process of dry-cured Celta ham was studied. For this work, twenty-four hams of each type (from three different diets: concentrate, mixed and chestnut) were used. During the whole curing period, moisture content decreased progressively and significantly (*P*<0.001) throughout the process for all groups, reaching average values of 43.36, 45.47 and 44.35 g/100 g for hams from mixed, chestnut and concentrate diets, respectively at the end of process. The intramuscular fat content increased slightly from an initial average value of 8.96 to 12.65 g/100 g of total solids at the end of the "bodega" stage. Significant differences (*P*<0.01) were only observed among groups after salting and after the first days of drying-ripening. On the other hand, a significant (*P*<0.001) decrease in the protein content was observed during the manufacturing process for the three dry-cured batches studied, from an initial average value of 86.0 to 75.6 g/100 g of TS at the end of the "bodega" stage.

I.- INTRODUCTION

Dry-cured ham is a traditional product whose curing process is characteristic of a particular geographical origin and hence, sometimes, regulated by a protected designation of origin (PDO). These protected hams show specific sensory characteristics of aroma, flavour and texture. The use of local breeds as an alternative pig production system has important advantages, as these breeds are closely related to the environment and they help to maintain biodiversity and sustainable agricultural production, especially in depressed areas. However, the rationalisation of production often leads to strong modifications of these traditional systems, with the risk of losing product quality as well as loss of heritage, social and cultural.

Galicia (NW Spain) is a great production area of chestnuts (*Castanea sativa* Mill.). At the present time, chestnuts are underutilized and this situation contrasts with the high current prices of commercial concentrates for animal feed, so the use of chestnuts in the feeding of the Celta pig breed, in an extensive management system, would allow the reduction of production costs, and putting in the market products of quality, differentiated, and having a high added value and a healthier fat.

Information about dry-cured ham from Celta pig is very scarce and only previous studies [1, 2, 3] have been realised on this breed, but no more knowledge is published in the literature. So, the aim of this study was to evaluate the effect of inclusion of chestnut in the finishing diet on the chemical composition throughout the manufacturing process of dry-cured Celta ham.

II.- MATERIALS AND METHODS

II.1.- Pigs and diets

A total of 36 Celta pigs were used in the study. Piglets were vaccinated and deparasitised following the usual protocols. Animals were suckled until an age of 40 days. All pigs were reared and fattened until the age of 16 months in an extensive regime, with a livestock density of 12 animals per hectare. After weaning, the pigs were fed with a concentrate feeding. At the age of 12 months, the pigs were randomly divided into three different groups of 12 animals: Group A was fed concentrate feeding (3 kg/animal and day) for the 4 months prior to slaughter; Group B was fed a mixed diet (concentrate feeding/chestnuts; 1.5 kg concentrate + 2.5 kg chestnuts per animal and day) for the remaining four months, and Group C was fed a mixed diet (concentrate feeding/chestnuts) until the age of 13 months, and then a diet of chestnuts only (5 kg/animal and day) in the three months prior to slaughter.

II.2.- Samples

Seventy two Celta ham pieces of 13.5±1.4 kg were used (twenty-four per treatment). Raw pieces were salted with an excess of coarse salt. A heap was formed alternating layers of ham pieces and layers of salt. In this way, the pieces were totally covered with salt. Hams were salted during 14 days in a salting room maintaining a temperature between 2 and 5 °C and relative humidity between 80 and 90%. After the salting stage, the pieces were taken from the heap, brushed, washed, and transferred to a post-salting room where they stayed for 70 days at 3-6 °C and around 85-90% relative humidity. After the post-salting stage, the pieces were transferred to a room for ripening where, during 240 days, the temperature was moderately raised up to 30 ºC and the relative humidity progressively lowered to 40% to achieve adequate drying. Then, the hams were left to mature for 9 additional months in a chamber under environmental conditions of temperature ranging from 12 to 24 ºC and relative humidity of 70-80%. From each group, samples were taken from raw pieces, after sating, after post-sating, at 80, 160 and 240 days of ripening, and at 90, 170 and 270 days of bodega step. In each sample point two Celta hams of each group were analyzed.

II.3.- Chemical composition

Moisture, fat, protein (Kjeldahl N x 6.25) and ash were quantified according to the ISO recommended standards [4, 5, 6, 7], respectively. Total chlorides were quantified according to the Carpentier-Vohlard official method [8].

II.4.- Statistical analysis

In order to study significant differences among the groups studied, an analysis of variance (ANOVA) and posterior Duncan´s test with a 0.05 level of significance was performed, using the computer programme SPSS package (SPSS 19.0, Chicago, IL, USA).

III.- RESULTS AND DISCUSSION

The changes in the proximate composition of dry-cured hams from the three finishing diets (mixed, chestnut and concentrate) throughout the manufacturing process are shown in Table 1. The moisture content decreased progressively and significantly (P<0.001) throughout the process for all groups, reaching average values of 43.36, 45.47 and 44.35 g/100 g for hams from mixed, chestnut and concentrate diets, respectively, at the end of process.

Significant differences among the pieces that belonged to the different finishing diets were observed in raw piece (P<0.01), in the first point of drying stage (P<0.05) and in the medium of "bodega" stage (P<0.05). Little differences, however, were observed and in general the trend was similar in the three batches studied. The final mean of moisture contents determined in dry-cured ham was lower than those observed in other dry-cured hams [9, 10].

During the first 14 days of manufacture, there was the most and significant change in the moisture content from the point of view of kinetic's dehydration, due to the exit of fluids during the salting stage, although there was not significant differences (P>0.05) in this stage among groups. In terms of loss of water, the dehydration was more intense during the drying–ripening stage due to both the duration of this stage and the environmental conditions (higher temperature and lower relative humidity) in the chambers where it takes place. In "bodega" stage, the moisture content become stable in the three groups studied.

The intramuscular fat content increased slightly from an initial average value of 8.96 to 12.65 g/100 g of total solids at the end of the "bodega" stage. Significant differences (P<0.01) were only observed among batches after salting and post-salting stage. On the other hand, a significant (P<0.001) decrease in the protein content was observed during the manufacturing process for the three dry-cured batches studied, from an initial average value 86.0 to 75.6 g/100 g of TS at the end of the "bodega" stage. The decrease in the protein content appears to be fundamentally due to the increase in the NaCl content during the salting stage. This decrease was less pronounced in the other stages. Only in the first sampling point of the drying ripening stage significant differences (P<0.01) among groups were observed.

The NaCl and ash contents increased significantly (P<0.01) after the salting stage due to the homogeneous distribution of the salt throughout the whole piece. Significant differences were observed among batches (P<0.05) in the drying-ripening stage and "bodega" stage, although the differences were small. At the end of the process, the statistical analysis of the data revealed the absence of significant differences in the NaCl concentration on a dry weight basis among groups. At this point, the average NaCl content was 7.45 g/100 g of TS. This value at the end of the manufacturing process was lesser than the values (9.29-11.4% of TS) reported by other authors for

dry-cured hams [10, 11]. Other authors reported values even two and three times higher (13–20% of TS) for the salt content in hams [12].

IV. CONCLUSIONS

From the obtained results it can be concluded that that the chemical composition of dry-cured ham from Celta pig is little affected by the inclusion of chestnuts in the finishing diet. However, the utilization "in situ" of this natural resource allows to reduce the feeding costs, and therefore also the final price of this high quality meat product.

Table 1. Evolution of the proximate composition during the manufacture of dry-cured ham from Celta pigs fed with different finishing diets (mixed, chestnut and concentrate)

	Raw	After salting	After post-salting	Drying ripening stage			Bodega stage			SEM	Sig
Days	0	14	84	164	244	324	414	494	594		Time
Moisture (%)											
Mixed	75.22^{a7}	66.79^{6}	63.23^{5}	57.61^{a4}	51.91^{3}	46.78^{2}	44.73^{1}	42.72^{a1}	43.36^{1}	2.16	***
Chesnut	74.83^{a7}	65.81^{6}	62.13^{5}	58.12^{a4}	51.28^{3}	47.89^{2}	43.99^{1}	44.85^{b1}	45.47^{1}	2.01	***
Concentrate	73.94^{b7}	66.34^{6}	62.54^{5}	57.00^{b4}	52.21^{3}	46.65^{2}	44.74^{1}	44.72^{b1}	44.35^{1}	2.10	***
Sig	**	n.s.	n.s	*	n.s	n.s	n.s	*	n.s		
Fat (% DM)											
Mixed	7.27^{1}	$9.44^{a1,2}$	10.38^{2}	10.98^{a2}	11.80^{3}	11.30^{3}	11.42^{3}	12.20^{4}	13.21^{5}	0.37	**
Chesnut	8.55^{1}	15.81^{b5}	11.83^{23}	11.43^{a2}	12.78^{4}	11.52^{2}	12.74^{4}	12.87^{4}	12.03^{2}	0.40	***
Concentrate	11.08^{1}	14.92^{b}	13.55^{3}	15.23^{b4}	13.78^{3}	12.81^{2}	11.89^{1}	11.85^{1}	12.95^{2}	0.32	*
Sig	n.s.	**	n.s	**	n.s	n.s	n.s	n.s	n.s		
Protein (% DM)											
Mixed	87.43^{4}	79.36^{3}	$78.85^{2,3}$	77.70^{a2}	75.99^{1}	$77.01^{1,2}$	75.44^{1}	75.40^{1}	74.23^{1}	0.76	***
Chesnut	85.73^{3}	75.33^{1}	75.54^{1}	76.72^{a1}	75.28^{1}	$77.38^{1,2}$	76.00^{1}	76.02^{1}	76.36^{1}	0.68	***
Concentrate	84.87^{3}	75.72^{2}	75.10^{2}	73.59^{b1}	75.04^{2}	76.21^{2}	76.43^{2}	77.02^{2}	76.32^{2}	0.67	***
Sig	n.s.	n.s.	n.s	**	n.s	n.s	n.s	n.s	n.s		
Ash (% DM)											
Mixed	4.09^{a1}	10.24^{a2}	10.65^{a2}	11.04^{2}	11.50^{3}	11.20^{3}	12.24^{a4}	11.77^{3}	11.74^{3}	0.46	***
Chesnut	4.01^{a1}	9.03^{b2}	12.55^{b4}	11.35^{3}	11.37^{3}	11.21^{3}	10.70^{b2}	11.13^{2}	10.94^{2}	0.46	***
Concentrate	3.65^{b1}	9.01^{b2}	11.25^{a3}	11.70^{3}	10.75^{3}	11.51^{3}	12.51^{a4}	11.17^{3}	11.15^{3}	0.49	***
Sig	*	*	**	n.s	n.s	n.s	**	n.s	n.s		
Chlorides (% DM)											
Mixed	0.44^{1}	7.25^{a2}	7.58^{2}	7.04^{a2}	6.73^{2}	7.32^{ab2}	7.09^{2}	7.36^{a2}	7.42^{2}	0.42	***
Chesnut	0.41^{1}	6.03^{b2}	7.44^{3}	7.34^{a3}	$6.76^{2,3}$	7.68^{a3}	7.66^{3}	$6.97^{a2,3}$	7.50^{3}	0.43	***
Concentrate	0.43^{1}	6.46^{b2}	7.72^{3}	8.02^{b3}	7.42^{3}	6.87^{b2}	7.54^{3}	8.07^{b3}	7.45^{3}	0.44	***
Sig	n.s.	**	n.s	*	n.s	*	n.s	*	n.s		

Significance: *** (P<0.001), ** (P<0.01), * (P<0.05), n.s. (not significant); $^{a-b}$ Means in the same column and parameter not followed by a common subscript letter differ significantly (P<0.05) (differences associated to finishing diet); $^{1-7}$ Means in the same row (corresponding to the same parameter) not followed by a common superscript number differ significantly (P<0.05) (differences among sampling points)

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REFERENCES

1. Bermúdez, R., Carballo, J., Franco, I., Franco, D., García-Fontán, M.C. & Lorenzo J.M. (2011). Efecto de la inclusión de la castaña en las características fisicoquímicas de jamones de cerdo celta. Libro de Actas del VI Congreso Mundial del Jamón, Lugo (Spain).
2. Bermúdez, R., Franco, I., Franco, D., Carballo, J. & Lorenzo J.M. (2012). Influence of inclusion of chestnut in the finishing diet on fatty acid profile of dry-cured ham from Celta pig breed. Meat Science 92:394-399.
3. Lorenzo, J.M., Carballo, J. & Franco, D. (2013). Effect of the inclusion of chestnut in the finishing diet on volatile compounds of dry-cured ham from Celta pig breed. Journal of Integrative Agriculture, 12:2002-2012.
4. ISO (1997). Determination of moisture content, ISO 1442:1997 standard. In International standards meat and meat

products. Genève, Switzerland: International Organization for Standardization.
5. ISO (1973). Determination of total fat content, ISO 1443:1973 standard. In International standards meat and meat products. Genève, Switzerland: International Organization for Standardization.
6. ISO (1978). Determination of nitrogen content, ISO 937:1978 standard. In International standards meat and meat products. Genève, Switzerland: International Organization for Standardization.
7. ISO (1998). Determination of ash content, ISO 936:1998 standard. In International standards meat and meat products. Genève, Switzerland: International Organization for Standardization.
8. ISO (1996). Determination of chloride content—Part 1: Volhard method, ISO 1841-1:1996 standard. In International standards meat and meat products. Genève, Switzerland: International Organization for Standardization.
9. Armenteros, M., Aristoy, M.C., Barat, J.M. & Toldrá, F. (2011). Biochemical and sensory changes in dry-cured ham salted with partial replacements of NaCl by other chloride salts. Meat Science, 90:361-367.
10. Marušić, N., Petrović, M., Vidaček, S., Petrak, T. & Medić, H. (2011). Characterization of traditional Istrian dry-cured ham by means of physical and chemical analyses and volatile compounds. Meat Science, 88:786-790.
11. Moller, J.K.S., Parolari, G., Gabba, L., Christensen, J. & Skibsted, L.H. (2003). Monitoring chemical changes of dry-cured Parma ham during processing by surface autofluorescence spectroscopy. Journal of Agricultural and Food Chemistry, 51:1224-1230.
12. Gou, P., Guerrero, L., & Arnau, J. (1995). Sex and crossbreed effects on the characteristics of dry-cured ham. Meat Science, 40:21-31.