EFFECT OF ELEVATED RIPENING TEMPERATURES ON THE CHEMICAL CHANGES DURING SUCCESSIVE AGING PERIODS OF IBERIAN HAM

Lourdes Martín; Juan José Córdoba; Carmen García; María Luisa Timón; Juan Florencio Tejeda and Jesús Ventanas.
Tecnología de los Alimentos, Facultad de Veterinaria, UEX, Avda. Universidad s/n, 10071 Cáceres (Spain)

Keywords: Iberian ham, proteolysis, non-protein nitrogen, free aminoacids, ripening temperature

BACKGROUND

Dry-cured Iberian ham, the most valuable meat product of Spain, is made from very heavy pigs (140-160 Kg liveweight). The processing involves salting with dry salt and drying for about 18 months: during the first 4 months (salting-postsalting) the hams are held under controlled temperatures, followed by a period of increasing temperature in natural dryers during the summertime (temperature ranges between 20°C and 30°C) and finally hams are left to mature in cellar for a period that generally exceed 12 months (temperature ranges between 12°C and 18°C) to let their particular flavor develop.

The regional peculiarities of the curing techniques and the particular climatic conditions are reputed to lead to large differences in the sensory qualities of the products. The hams processed in Extremadura (Montánchez, Olivenza), Guijuelo or Jabugo have attained a high degree of consumer acceptance and have been proposed for a Protected Designation of Origin (PDO). The chemical changes occurring in muscle tissue during processing of Iberian hams have been investigated (Antequera *et al.*, 1992; Córdoba *et al.*, 1994a, b). By contrast, no study has so far been reported on the effects of different ripening conditions on the degradation processes leading to formation of desirable flavor. Although protein changes could be a source of flavor compounds in the Iberian hams, through the involvement of aminoacids in Maillard reactions (Ventanas *et al.*, 1992), insufficient information is available on the modifications taking place during ripening.

OBJECTIVE

The purpose of this study was conducted to follow the time-course of protein breakdown along processing as influenced by ripening temperature.

MATERIAL AND METHODS

Forty-five thighs were obtained from Iberian pigs (160 Kg liveweight) fattened extensively including acorns from *Quercus ilex* and *Quercus suber*, and processed in two different plants located in Olivenza (O) and Montánchez (M). The steps included in the sampling procedure and the number of hams removed for testing at each stage were as follows: 1.- Green state, n=5 common for both process. 2.- Salting-postsalting, O (n=5), M (n=5), 3.- Drying: O (n=6), M (n=6), 4.- Four months cellar: M (n=6), 5.- Eight months cellar: M (n=5), 6.- Fully matured ham: O (n=4), M (n=3).

Samples of *Biceps femoris* were taken and analyzed for moisture, NaCl, non-protein nitrogen (NPN). Free aminoacids were identified and their content measured.

Moisture was determined following the ISO recommended methods (ISO/1442). NaCl was measured as chloride by titration with $AgNO_3$-NH_4CNS (AOAC, 1984). NPN was analyzed in the extracts of muscles made with $HClO_4$ 0.6N following the method of Johnson, 1941. FAA were determined, adding norleucine as an internal standard, by the method of Yang and Sepúlveda, 1985 with minor modifications (Córdoba *et al.*, 1994a).

Statistical methods was performed by the analysis of variance and differences between means were analyzed using the Bonferroni test.

Table 1. Variations of different parameters in *Biceps femoris* muscles during ripening of Iberian hams in Montánchez and Olivenza.

	green ham	postsalting	drying	4 months cellar	8 months cellar	fully ripened
	Montánchez					
moisture (%)	$72.21^{a}\pm0.48$	$63.63^{ab}\pm1.54$	$57.39^{bc}\pm1.51$	$54.73^{cd}\pm0.78$	$49.39^{d}\pm2.02$	$47.28^{d}\pm0.28$
Cl (molal)	$0.00^{a}\pm0.00$	$0.37^{a}\pm0.03$	$0.84^{b}\pm0.06$	$1.05^{bc}\pm0.09$	$1.24^{bc}\pm0.16$	$1.50^{c}\pm0.06$
	Olivenza					
moisture (%)	$72.21^{a}\pm0.48$	$65.22^{b}\pm0.83$	$59.54^{c}\pm1.97$	nd	nd	$49.86^{d}\pm0.73$
Cl (molal)	$0.00^{a}\pm0.00$	$0.26^{a}\pm0.07$	$0.65^{b}\pm0.04$	nd	nd	$1.23^{c}\pm0.12$

Means with different numbers in the same row are significantly different ($P<0.05$).

RESULTS AND DISCUSSION

The most important feature in Figure 1 is that levels of NPN and the overall content of FAA are strongly influenced by temperature of ripening. Marked differences were found between processing groups in the rate of NPN production. In general, an increase of NPN near 6 folds was found during the whole process, rising from 5.23 ± 0.87 mg N/g DM at the beginning to 34.91 ± 1.69 mg N/g DM in Olivenza hams and 25.48 ± 1.08 mg N/g DM in Montánchez hams.

The levels of compounds of protein origin were lower in Montánchez hams after postsalting, being in this plant the rise of temperature delayed with regard to the plant from Olivenza. In contrast, a more intense proteolytic breakdown takes place in the hams held in the dryer of Montánchez, in relation to higher values of temperatures than dryer of Olivenza.

While the hams were kept in cellar the NPN levels continue increasing in Olivenza hams whereas a fairly constant value was found in Montánchez hams. The higher concentration of NPN present in fully matured Olivenza hams is consistent with the superior temperature measured in this processing plant along the complete cellar stage. It is also noteworthy to take account the rise of NPN in Montánchez hams associated to the sudden increase of temperature observed during the six latter months of maturing.

The overall increase of the total FAA content during processing of hams was in close agreement with the previously described for the NPN values. The complete reaction seems to rise almost linearly with temperature. The sudden rise in both NPN and FAA from the heating suggests that the endo and exopeptidases were activated by the temperature increase. The higher temperature during the drying cycle could stimulate the activity of certain proteases as cathepsin D that remain active after 8 months of processing in dry-cured hams (Toldrá y Etherington, 1988), and has been shown to have maximum activity at 33-55ºC (Rico *et al.*, 1990). Also, the relatively high temperatures reached at this stage were more favorable for specific aminopeptidases from muscle tissue, these enzymes showed an optimum temperature around 37ºC (Toldrá *et al.*, 1992). During the latter steps of processing the rate of formation of FAA was less active. This can be attributed to several phenomena. Possibly the exopeptidase activities reduce at the end of processing (Toldrá *et al.*, 1993) due to the inhibitory effect of salt and desiccation at the concentration ranges found in the dry-cured hams studied (Table 1). Second part of the FAA is degraded to volatile compounds as amines and Maillard reaction products (Antequera *et al.*, 1992; Ventanas *et al.*, 1992). When evolution of FAA was compared in the two processes studied, marked differences were found in the levels of the aged hams (3591.33±163.9 mg/100g DM in Montánchez hams, 4106.92±257.9 mg/100g DM in Olivenza hams). The variations of FAA pattern observed because of the distinct conditions of ripening may be involved in the differences of taste appreciated by consumers. The glutamic acid, alanine and lysine were, among the 19 FAA identified, the most abundant in the final product. These FAA have been reported as precursors of sweet, bitter, sour or "umami" taste (Kato *et al.*, 1989). In addition, some of them could contribute to aromatic compounds formed by different pathways as its reaction with reducing compounds in the Maillard reactions (Baines and Mloztiewicz, 1984). The latter possibility is supported by the identification of branched-chain, aromatic and sulfur containing aldehydes or alcohols in the volatile of Iberian hams (García *et al.*, 1991).

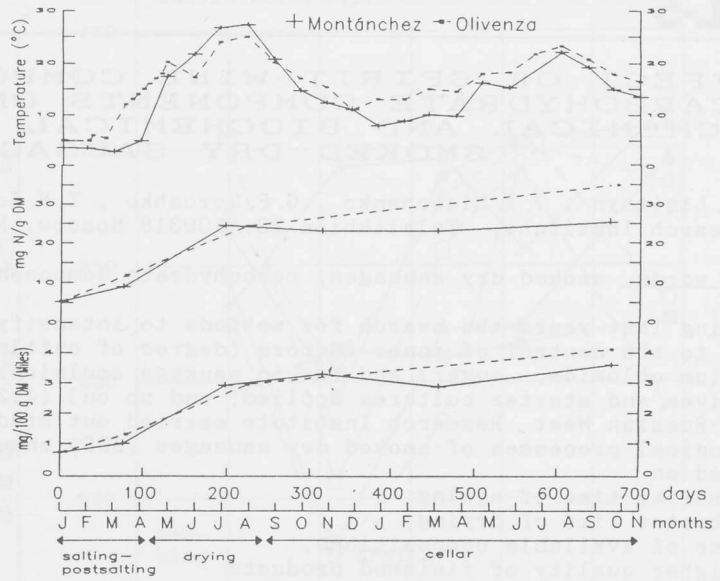

Fig. 1 Enviromental temperature and evolution of NPN (mg N/g DM) and total FAA (mg/100g DM) during the processing of hams in Montánchez and Olivenza.

CONCLUSION

The processing temperature during the ripening of Iberian hams greatly affects the evolution of NPN and FAA concentrations in the final product. Although little is known about the precise conditions that rule the production of flavor actives substances derived from proteolytic breakdown, a high temperature (up to 26ºC) during the drying cycle and a long term stage in cellar (up to 12 months) favours the concentration of FAA at the end of ripening.

REFERENCES

Antequera, T.; López-Bote, C.; Córdoba, J.J.; García, C.; Asensio, M.A. and Ventanas, J. (1992). *Food Chem.* **45,** 105-110.

AOAC (1984). *Official Methods of Analysis* , (3rd edn), 24010, 432.

Baines, D.A. and Mloztiewicz, J.A. (1984). *In: Recent advances in the chemistry of meat* , Ed.: Bailey, A.J. The Royal Society of Chemistry, Cambridge. 118-164.

Córdoba, J.J.; Antequera, T.; García, C.; Ventanas, J; López-Bote, C. and Asensio, M.A. (1994a). *J. Agric. Food Chem.* **42,** 2296-2301.

Córdoba, J.J.; Antequera, T.; Ventanas, J.; López-Bote, C.; García, C. and Asensio, M.A. (1994b). *Meat Sci.* **37,** 217-227.

García, C.; Berdagué, J.J.; Antequera, T.; López-bote, C.; Córdoba, J.J. and Ventanas, J. (1991). *Food Chem.* **41,** 23-32.

ISO (1973). *Meat and Meat Product-Determination of moisture content.* ISO: Geneve, Switzerland, Method 1442.

Johnson, M.J. (1941). *Proc. 3th Int. cong. Microbiol.* Nueva York. 348.

Kato, H.; Rhue, M.R. and Nishimura, T. (1989). *In: Flavor Chemistry.* Ed.: Teranishi, R.; Buttery, R.G. y Shahidi, F. ACS Symposium Series 388. American Chemical Society. Washington D.C. , 158-175.

Rico, E.; Toldrá, F. and Flores, J. (1990). *Z. Lebensm Unters Forsch* **191,** 20-23.

Toldrá, F. and Etherington, D.J. (1988). *Meat Sci.* **23,** 1-7.

Toldrá, F.; Aristoy, M.C.; Part, C.; Cerveró, C.; Rico, E.; Motilva, M.J. and Flores, J. (1992). *J.Food Sci.* **57,** 816-833.

Toldrá, F.; Rico, E. and Flores, J. (1993). *J. Sci. Food Agric.* **62,** 157-161.

Ventanas, J.; Córdoba, J.J.; Antequera, T.; García, c.; López-Bote, C. and Asensio, M.A. (1992). *J. Food Sci.* **57,** 813-815.

Yang, C. and Sepúlveda, F. (1985). *Cromatography* **346,** 413-416.