EFFECT OF MEAT pH AND THE AMOUNT OF ADDED NITRITE AND NITRATE ON COLOUR UNIFORMITY OF DRY-CURED HAMS

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INTRODUCTION

Colour, its uniformity and its stability are important sensory characteristics of dry-cured ham when it is sliced. Both nitrite and nitrate are used to obtain a desired red colour in dry-cured hams. Nitrite plays an important role in colour development and as a preservative, exerting an anticlostridial effect in cured meat. Nitrate is transformed to nitrite mainly by *Micrococcaceae*. The reduction of nitrite to nitric oxide increases as pH decreases and the reduction of nitrate to nitrite increases with pH (Wirth, 1984). The evolution of nitrate and nitrite in Spanish hams cured with nitrate was studied in three different depths by Huerta (1986) and in 11 muscles of PSE and normal hams by Arnau et al. (1995)). Even though the maximum residual amount of nitrate and nitrite in meat products is fixed by law (Presidencia del Gobierno, 1997), the added amount of this substances needed to obtain the desired colour could be affected by pH, particularly in blocky dry-cured ham, where long diffusion distances exist.

The main aim of this study was to evaluate the effect of different amounts of added nitrite and nitrate on colour uniformity in dry-cured ham from low and high pH hams.

MATERIAL AND METHODS

1. Meat pH effect

Ham selection

Hams weighing between 9 and 10 kg were selected according to their pH. The pH was measured at 45 min (pH_{45}) and at 24 h *post mortem* (pH_{24}) in *Semimembranosus* (SM) muscle, with a combined electrode (Ingold 406, Ingold, Urdorf, Switzerland) attached to a portable pH-meter (Crison 507, Crison Instruments SA, Barcelona, Spain). Hams with a $pH_{45}<6.0$ were rejected. Hams with a $pH_{24} \leq 5.6$ were considered of low pH (LpH) and those with $pH_{24} \geq 6.2$ were considered of high pH (HpH).

Processing

Thirty-six hams were refrigerated for 2 days at 1-3 ^{0}C and then nitrified with a dry salt mixture containing 10 g NaCl per kg of ham mixed with different amounts of curing substances. A 2x2x3 factorial randomized block design was used. The factors were meat pH (LpH, HpH), the amount of added nitrate (0.1 and 0.5 g/kg of ham) and the amount of added nitrite (0, 0.1 and 0.5 g/kg of ham). Hams were covered with salt and were processed in the same way as Arnau et al. (1995). After six months, hams were cut through the middle perpendicularly to the femur and colour uniformity was visually evaluated.

2. Nitrite effect at low pH

Three independent experiments were carried out in order to evaluate the red ring and the paler core formation. Since, in the previous experiment the central red ring was observed only in LpH hams, the following experiments were carried out in those hams with $pH_{24} \leq 5.6$ in SM muscle.

2.1. Effect of the added nitrite

Three hams per batch were treated with different amounts of sodium nitrite: 0.1, 0.2, 0.3, 0.4 and 0.5 g per kg of ham and 0.5 g potassium nitrate and 10 g sodium cloride per kg of ham. Then the hams were processed, sampled, and evaluated as in part 1.

2.2 Different nitrite applications

2.2.1 Three carcasses were selected. Right hams were treated with 0.5 sodium nitrite per kg of ham. Half nitrite was applied to the rind and half to the lean tissue surface. Left hams were kept as controls. After three days left and right hams were cut through the middle and cooked at 100 ^{0}C to an internal temperature of 75 ^{0}C in order to evaluate the cured area.

2.2.2 Three carcasses were selected. Left hams were placed in independent 250 l tumblers. A beaker containing 0.1 g sodium nitrite, 0.5 ascorbic acid and 5 g of ice per kg of ham was placed inside the tumbler avoiding any contact with hams. Afterwards a 90 % vacuum was carried out and the hams remained there for 4 hours. Right hams were kept as control. After three days both left and right hams were cut through the middle and cooked in the same way as in 2.2.1 in order to evaluate the cured area.

RESULTS AND DISCUSSION

1. Meat pH effect

HpH hams treated with only 0.1 g of potassium nitrate per kg, presented zones inside the hams which were not cured. Nevertheless, there was no red rings. LpH hams treated only with 0.1 g KNO_3 , and HpH and LpH treated with only 0.5 g of potassium nitrate per kg of ham, presented an homogenous colour. Nitrate is reduced to nitrite due to nitratereductase activity of *Micrococcaceae.* These microorganisms grow quicker at high pH, and at the external part of ham not covered by fat (Carrascosa et al. 1988). In high pH meat, nitrate is transformed to nitrite faster than at low pH (Wirth, 1984), which could be causing the colour differences observed. All the HpH hams treated, both with nitrate and nitrite showed a uniform colour.

LpH hams treated with 0.1 g of nitrite, even though they were cured, presented a red ring and a paler core, in both cases when 0.1 and 0.5 g nitrate were added. LpH treated with 0.5 g nitrite presented a uniform color without red ring and paler core. Red ring has been atributed to microbial or biochemical origins (Lautenschläger, 1995). However, according to our results it seems to be related with the available nitrite. At low pH, nitrite is more easily transformed to nitric oxide, which in its turn would react with meat components. In HpH hams nitrite is less reactive and could migrate to the center of the product. The concentrical ring suggests that a curing substance migrates through skin and fat at a similar rate as through lean tissue. If ring formation was controlled by nitrite diffusion, a concentrical ring would not have been expected, since nitrite is more soluble in lean tissue. A liposoluble low molecular weight such as nitric oxide could justify the ring observed. The core, even though was cured, presented an slightly paler aspect. This may be due to a later curing produced by the nitrite coming from the bacterial reduction of nitrate. Since nitrite is depleted after several weeks (Lautenschlager, 1995; Kemp and Fox, 1977), nitrate could act as a reserve of nitrite during the postsalting period when the water activity inside the ham is still higher than 0.95.

2. Nitrite effect at low pH

The addition of increased amounts of nitrite decreased the ring size. After 0.4 g of nitrite per kg rings disappeared. This shows how the available amount of nitrite is responsible for the red ring. When hams are dry-cured, part of the nitrite is lost with the brine which is formed in the surface. The addition of 0.5 g sodium nitrite per kg of ham produced a concentrical cured area of about 4 centimeters when was cooked three days after the treatment. When nitrite reacts with ascorbic acid, nitric oxide is released. Part of the NO reacted with residual oxygen of the tumbler producing brown $NO2$ which gave a green colour. The remaining NO could penetrate into the ham producing a concentrical cured area of 3 centimeters, when the ham was cooked. This suggests that NO or a related substance could be the agent which diffuses both through lean and fat tissue.

To sum up, red ring seems to be present when the amount of absorbed nitrite is low, when a long difusion distance exists, or when the pH of the meat is low. No explanation has been found in order to explain the increased red colour of the ring when compared to the outside part, more accesible to nitrite.

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REFERENCES

- Arnau, J., Guerrero, L., Casademont, G. and Gou, P. (1995). Physical and chemical changes in different zones of normal and PSE dry-cured ham during processing. Food Chem., (52): 63-69.
- Carrascosa, A.V., Marin, M.E., Avendaño, M.C. and Cornejo, I (1988). Cambios microbiológicos y fisicoquímicos durante el curado rápido de jamón serrano. Aliment., (194): 9-12.
- Huerta, T. (1986). Aspectos fisico-químicos y microbiológicos del jamón curado por via seca. Tesis doctoral. Universidad de Valencia. Valencia.
- Kemp, J.D. and Fox, J.D. (1977). Producing boneless dry-cured hams with different amounts of curing ingredients. J. Food Sci. (42): 1487-1488.
- Lautenschläger, R. (1995). Diffusionverhalten der Pökelsalze und Wertung von Technologien beim Pökeln von rohen Fleischerzeugnissen. Mitteilungsblatt der Bundesanstalt für Fleischforschung. Kulmbach. 128: 151-156.
- Presidencia del Gobierno (1997). Lista positiva de aditivos distintos de colorantes y edulcorantes para su uso en la elaboración de productos alimenticios, así como sus condiciones de utilización BOE num 70: 9378-9418.
- Wirth, F. (1984). Pökeln- Farbbildung, Farbhaltung. In: Technologie der Brühwurst. Institut für Technologie der Bundesanstalt für Fleischforschung. 123-143.