6-25 THE RATE OF PENETRATION OF SALT INTO COOKED MEAT

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INTRODUCTION

The manufacture of traditional bone-in, hot smoked pork joints such as hams and loins has also evolved towards the shortest possible curing times, which even in the case of manual injection can be reduced to 24-72 hours (Kramlich et al.,1973; Andújar et al., unpublished data).

Thus, it is of interest to consider whether the uniformation of the distribution of salt in these products, due to diffusion, continues at an appreciable rate during the storage of the finished products.

There are no reports in the literature on the diffusion of salt in cooked meat, whereas raw meat has been thoroughly studied (Morley,1977), in wet curing (Körmendy and Gantner,1958; Wistreich et al.,1959,1960; Fox,1980) as well as dry-curing conditions (Andújar and Tarrazo, 1981).

It is the cooked meat situation that will be considered in this paper.

MATERIAL AND METHODS

Longissimus dorsi muscles were obtained from pig carcasses, 24-72 hours post-mortem, after they had been chilled to 2°-4°C. All visible fat was trimmed off, taking care not to damage the dorsal layer of epimysial connective tissue.

The intact muscles, wrapped in polyethylene film, were put into a forced convection oven at 160°C, until a core temperature of 70°C was reached.

Meat slabs 30 mm thick X ca. 30 mm X ca. 60 mm were then cut, the base of which kept the unbroken - though now partially gelatinized - connective tissue layer. All the other surfaces were covered with paraffin to avoid desiccation, and 20 such slabs were placed, connective tissue layer down, on a 2-3 mm thick layer of NaCl pure for analysis, in Petri dishes which were kept in a chilled chamber at 2°-4°C.

Portions were taken from the dishes, 4 at the time, after 6; 12; 24; 48 and 72 hours. The slabs were briskly rinsed with distilled water and dried with filter paper. After separating the paraffin film, the samples were homogeneized by mincing twice through a 3 mm plate, and kept in resealable plastic bags at -25°C until analyzed, not more than 5 days after preparation.

Chloride content was determined by the method of the A.O.A.C. (1980).

RESULTS AND DISCUSSION

The theoretical model considered was a meat slab of infinite extension and thickness h, with one of its surfaces in contact with a brine.

The application of Fick's Law under such conditions has been thoroughly considered in a previous paper (Andújar and Tarrazo, 1981), following the lines of a detailed study by Körmendy and Gantner, (1958). After solving the differential equation, taking limits and considering only the first term of the resulting series - valid diffusion times not too short -, we can arrive at

$$\log \left(1 - \frac{c_t}{d_o} \right) = \log \frac{2}{\mu^2} - \frac{\mu^2 \, D \log e}{h^2} \, t$$

Where c_t stands for the average concentration of salt (m/v) in the meat slab at the time t, d_o is the concentration of a saturated brine (m/v) at the temperature of the experiment, μ is a constant and D is the coefficient of diffusion.

c_t values, expressed as salt mass per unit volume of meat were calculated from the analytical results (m/m) and the density of meat. The latter was estimated according to the equation reported by Körmendy and Gantner (1958), but substituting the density of cooked meat - 1,078 g cm^{-3} - for the density of raw meat in the original equation - 1,067 g cm^{-3}.

Analytical results are summarized in the Table, where the average salt content of the slabs is given, as well as it's confidence interval ($\alpha = 0,05$) at different diffusion times.

The Figure presents a plot of $\log (1 - c_t/d_o)$ vs. t. Vertical segments indicate the variation due to experimental error, according to the confidence limits of the measured salt content.

The regression equation was

$$y = - 0,000580 - 0,001393 \, x$$

with a very close fit, which indicates that Fick's Law applies under the conditions of this experiment, just as in the case of raw meat (Wood, 1966; Morley, 1977; Andújar and Tarrazo, 1981).

Regression parameters, however, are somewhat different from those obtained under almost identical conditions for raw meat (Andújar and Tarrazo, 1981). The Gelatinization of the epimysial connective tissue layer probably affects the surface mass transfer coefficient, and hence the intercept, whereas a larger proportion of "loose" water in the denatured, cooked meat, could explain a steeper slope, corresponding to a somewhat larger value of D: (4,00 ± 0,02) x 10^{-6} $cm^2 s^{-1}$, compared with (3,3 ± 0,2) x 10^{-6} $cm^2 s^{-1}$ for raw meat.

Both values are nevertheless rather close, taking into account the considerable variability that this value may exhibit even under fairly similar conditions.

According to these results, further homogenization of salt distribution in the finished product can be expected to occur during storage. However, as the concentration gradients driving diffusion are very mitigated by the time this phase is reached, diffusion should not be expected to be as effective here as it is during the curing phase, particularly in view of the very similar coefficients of diffusion

CONCLUSIONS

* Salt diffusion into cooked meat proceeds following Fick's Law, very much as it does in raw meat.

* A constant value of D, the coefficient of diffusion of salt in cooked meat was

obtained, equal to $(4,00 \pm 0,02) \times 10^{-6}$ $cm^2 s^{-1}$ at 2°- 4°C.

* A contribution, albeit moderate, to the uniformation of the distribution of salt, can be expected during storage of the finished products.

t (hours)	% NaCl (m/m)
6	0,51 ± 0,11
12	1,09 ± 0,29
24	2,20 ± 0,30
48	4,39 ± 0,09
72	5,73 ± 0,22

Table 1.- Average salt content in meat slabs at different diffusion times. Mean values and confidence limits for 4 replicates per treatment.

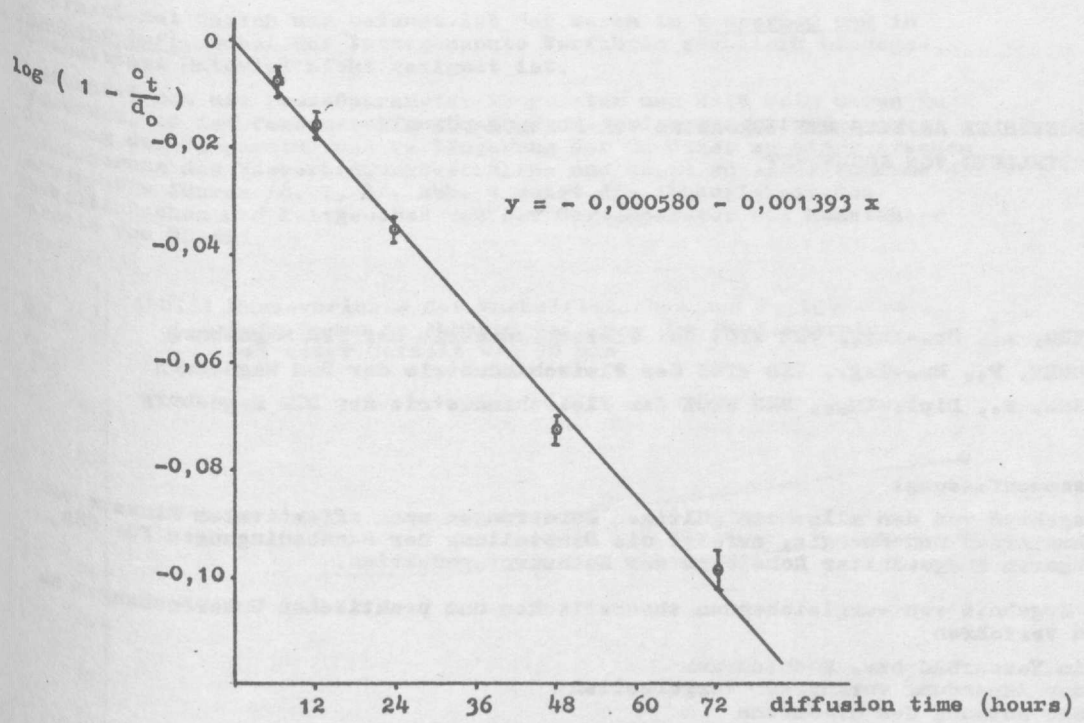

Figure 1.- Regression of log (1 - o_t/d_o) over t.

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