Diffusion of sodium chrloride in meta pork: Influence on its microstructure

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Meat curing can be conducted by immersion of meat tissues in NaCl brines. Different authors have determined effective diffusion coefficients in meat tissues.[1–3] The objectives of the work were: (a) to determine the diffusion coefficient of NaCl in pork tissue using brine solutions at 4°C and 20°C; (b) to establish the effect of NaCl on tissue microstructure.

A unidirectional diffusion system was adopted; long cylinders of *Longissimus dorsi* pork tissue were immersed in well stirred NaCl solutions (30, 70, 100, 140, 200 g/L). At different times two cylinders were taken out from the brine, keeping the central zone of each cylinder.[4] Experiments were performed at 4 and 20°C and the water content of the tissue was measured. Equilibrium concentrations were obtained by immersion of samples in the brines during 48 h.

Mass balances were proposed to analyze changes in the water, proteins, and NaCl contents in the tissue. These determinations were done on small pork cylinders that wer weighted before and after being immersed in the NaCl so lutions. To measure the amount of NaCl ion selective elec trode was used. Dry-matter content of treated and untreate tissue samples were also determined. Meat samples wer observed by scanning electron microscopy (JEOL, JSM 100, Tokyo, Japan).[4]

The total uptake (mass of solute that enters the tissue) a a given time t, M(t) was calculated as:

$$M(t) = M(\infty)\left(1 - \sum_{n=1}^{\infty} 4\,\frac{\exp(-Dm\,\alpha_n^2\,t)}{R^2\,\alpha_n^2}\right) \qquad (1$$

Table I Effective diffusion coefficients of NaCl (Dm) in pork tissue

	Dm (m^2/s) × 10^{10}	
NaCl concentration(g/L)	4°C	20°C
30	0.6	1.6
70	1.1	1.8
100	1.7	1.9
140	1.9	2.1
200	5.0	6.3

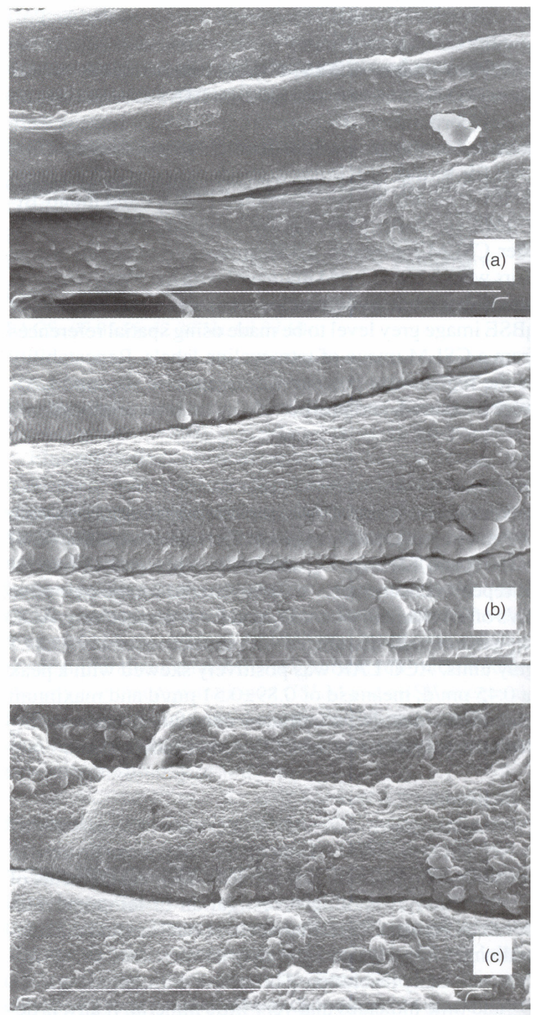

Fig.1 Scanning electron micrographs of pork tissue treated wit NaCl (a) 10g/L, (b) 70g/L, (c) 140g/L. Scale=100 μm between marks

where $R\alpha_n$ are the n-roots of equation $Jo(R\alpha_n)=0$ being Jo the zero order Bessel's function; $M(\infty)$ is the maximum amount of solute that enters at infinite time in equilibrium with the external solution. M(t) and $M(\infty)$ were expressed as gsolute/gwater in the tissue. A computer program was used to determine the diffusion coefficients (Dm) of NaCl. Values of Dm were proposed and predicted values of M(t) were obtained using Eq. 1 to obtain the best fit.

The mean water content in the tissue ranged between 72 and 74 %. When water penetrates into the matrix, part of the proteins are solubilized; thus meat tissue cannot be considered as formed by an insoluble matrix and an aqueous phase through which the solute diffuses. To determine the diffusion coefficients, M(t) and $M(\infty)$ (Eq. 1) were corrected by the water content of the sample at each time. A satisfactory agreement between experimental and predicted values was observed. The obtained values of the diffusion coefficients of NaCl in pork tissue at 4 and 20°C are shown in Table I for the assayed brine concentrations. As can be observed the diffusion coefficients increased with NaCl concentration and temperature. NaCl uptake values expressed per mass of water in the tissue led to correct values of Dm. In contrast, when solute uptake values were expressed per mass of tissue without introducing the correction factors that consider the actual water content in the sample, erroneous overestimated Dm were obtained, higher than the diffusion coefficient of NaCl in water.

The microestructural changes, as shown by the SEM micrographs (Fig.1a,b), could explain the rise in the diffusion coefficients of NaCl at higher brine concentrations. At low concentrations of NaCl swelling of the fibers, and higher values of water content were observed. The phenomenon was reversed at higher NaCl concentrations; fiber volume decreased, the tissue lost its own water and proteins precipitated causing disruption in the matrix which facilitates salt penetration.

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