DEVELOPING A NON-INVASIVE MODEL SYSTEM FOR THE QUANTIFICATION OF SODIUM MOVEMENTS DURING MEAT CURING

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Background

Curing is among the most important processing steps in meat technology. The most common curing method in Danish meat processing is multi-stitch pumping, basically consisting of brine injection and subsequent mechanical incorporation by tumbling. It can thus be expected that the distribution of salt is governed by both simple diffusion and by a "pumping effect" originating from the mechanical treatment. As an initial approach to understand the nature of the physics behind curing process, simple diffusion is being studied in model systems.

The relatively few previous studies evaluating diffusion in meat are rather inconclusive regarding the effect of raw material, perhaps due to the lack of reliable model systems (Andújar and Tarrazo (1981), Mittal G.S. (1999), Djelveh and Gros (1988) Fox, J.B. (1980). The most common, the diffusion cell, can thus be suspected to effect leaching of the rather thin meat discs typically mounted in the cells, and even pinpoint holes have marked effect on the diffusion coefficient. In fact, our data from working with the diffusion cell were rather inconsistent (Vestergaard 2001, not published). Contrarily, we have had good experiences with curing meat cylinders mounted in plexiglas tubes. However, if time-response effects are to be evaluated within in the same material, the determination of salt profiles must be evaluated non-invasively.

Objectives: The objective of the study was to investigate the application of 23Na Magnetic Resonance Imaging (^{23}Na-MRI) to meat cured in a model system and concurrently to quantify the differences in curability of meat of different pH.

Methods

Five pork loins with pH_{24} values of (A) 5.45, (B) 5.63, (C) 5.80, (D) 5.96 and (E) 6.61 (thus covering a broad range) were selected and cut into cylinders (Ø = 40 mm, L = 50 mm) with a sharp rotating coring tool. Samples were taken 5-10 cm from the hip end, transverse to the meat fibers. The meat cylinders were mounted in plexiglas cylinders designed to allow for exposure to brine at one end only. As an internal standard, the cylinders had build-in phantoms filled with 22 % (3.76 M) NaCl solution. At day two *post mortem* samples were cured in 22 % (w/w) brine at 5 °C. For 5 days, - with intervals of 24 h,- samples were removed from the brine and placed in a 2.4 T, Bruker Biospec 24/40 magnet with a 40 cm vertical bore.

^{23}Na images and one-dimensional ^{23}Na-profiles were obtained using a radio frequency coil which was tuned to 25.5 MHz and optimized for each sample, located inside a Ø = 120 mm gradient set (gradient switching time of 160μs), providing linear magnetic field gradients of max. 200 mT/m. ^{23}Na images were obtained at 25.5 MHz, with a slice thickness of 20 mm and a FOV of 80 mm across a 64 X 64 matrix. Total acquisition time was 8:32 min. for 32 averages. A spin echo pulse sequence with short echo time was chosen because of the rather short (~10 ms) transverse relaxation time of the quadropolar ^{23}Na. The echo time (TE) used in the sequence was 2.7 ms and repetition time (TR) 250 ms.

^{23}Na profiles of the same system (meat + salt reference) were measured in a separate experiment. The number of pixels in the salt profiles was 512. ^{23}Na profiles were first scaled to ensure that the reference salt solution had 22% concentration. In addition the meat region of the profile had been multiplied by a T2 correction factor. The latter correction factor took into account the difference between T2 relaxation times of the meat sample (7.7ms) and the reference salt solution (39ms).

Results and Discussion

Figure 1 shows an example of the ^{23}Na.sodium images obtained. It can be observed how the brine (left shadow) enters the meat over time. The bright field to the right in th upper figure is the 22% NaCl standard. Figure 2 illustrates that a profile of the sodium content within a sample can be obtained. These profiles provided the basis for further calculations. In figure 3 it can be seen how the salt penetrates the meat of varying pH (day 3). The profiles are rather similar and the effect of pH is not obvious. In order to test for any significant differences in pH the Students t-test was applied to pairs of salt concentrations at 1, 2 3, 4 and 5 cm distance of ingress, for all days. Confirming the tendencies of the example of figure 3, no significant differences could be attributed to the effect of pH. This finding is in accordance with Gros et al. (1984) and Lautenschläger (1996).

Conclusions

In more general terms, the present study showed that ^{23}Na Magnetic Resonance Imaging is an informative method when evaluating the diffusion of sodium into meat. Application of this method for studying the effect of meat pH on the penetration of salt into meat did not reveal any significant relationships.

Litterature

Andújar G. and Tarrazo J. (1981). The Rate of Penetration of Salt into Meat. Fleichwirtsch. 61 (9), p. 1366-1384.

Djelveh G. and Gros J.B. (1988). Measurement of Effective Diffusivities of Ionic and Non-Ionic Solutes through Beef and Pork Muscles using a Diffusion Cell. Meat Sci., (23), p. 11-23.

Fox, J.B. (1980). Diffusion of Chloride, Nitrite and Nitrate in Beef and Pork. J. Food. Sci. (45), p. 1740-1744.

Gros J.B., Dussap C.G., Gonzalez-Mendez, N.F. (1984). Solute Diffusivities in Meat- a review. In Engineering and Food. Vol.1- Engineering Sciences in the Food Industry. Ed. McKenna, B-M. Elsevier Applied Science Publishers.

Lautenschläger R. (1996) Das Pöklen von Rohen Fleicherzeugnissen. 1. Diffusionsverhalten der Salze. Fleichwirtsch. 76 (4). P. 401-405.

Mittal G.S. (1999). Mass Diffusivity in Food Products. Food. Rev. Int., 15 (1), p. 19-66.

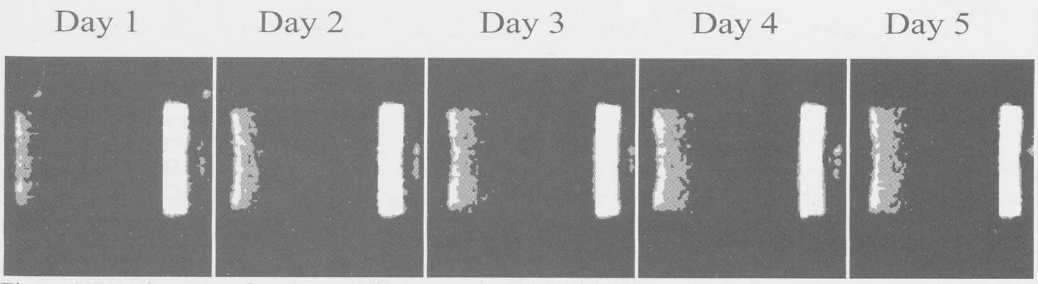

Figure 1. Development of sodium profile in sample B (pH 5.63) from day 1-5.

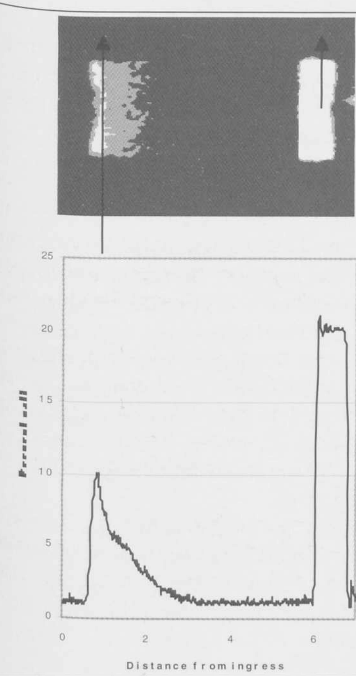

Figure 2. Relationship between sodium image and sodium profile in sample B (pH 5.63) on day 3.

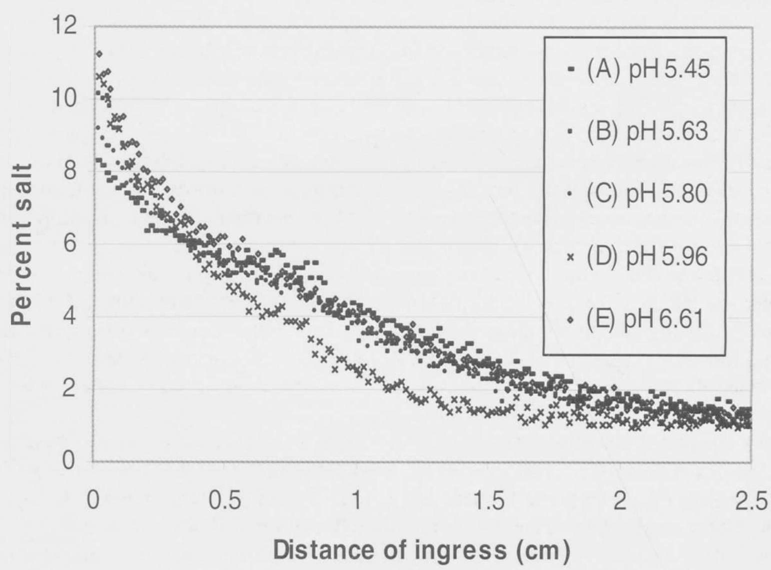

Figure 3. Sodium profiles of all samples on day 3.