THE INFLUENCE OF SOME AGENTS ON DIFFUSION OF NITRITES IN PORK MEAT CURED BY INJECTION

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Background

Nitrite curing by meat injection is commonly used in industrial technologies, but in professional literature there is no information on any successful investigation of the process of diffusion of nitrites and their changes after injection into meat. Our previous study showed, that propagation rate of the front of nitrite and nitrate diffusion in injected muscle was proportional to the square root of time what means that process went according to the Fick's diffusion law [Tyszkiewicz, Kłossowka, Tyszkiewicz, 1995]. Concentration of nitrites and nitrates in diffusion area during the process of equalising of concentration was roughly of a normal distribution. The lowest ratio of nitrites to the sum of nitrites and nitrates was observed in the front of diffusion. Agents possibly affecting the efficiency of diffusion were not studied

Objectives

The aim of present work was to study the influence of pH values of meat, sodium nitrite concentration in brine and amount of injected brine on diffusion efficiency and change of nitrites to nitrates in the diffusion area.

Materials and methods

The tests were carried out on the porcine *Longissimus dorsi* muscle. From each muscle, two end sections about 4 cm long were cut off as control samples and 5 cylindrical sections, each 8 cm long, as test samples. Sample diameter was about 7 cm. The samples were placed in beakers, 10 - 12 cm high and of a diameter approximately equal to that of a muscle cross-section. For injections a medical syringe with a 4 cm long needle was used. In the central point of the cross-section, having the whole needle length inserted into meat, 1 ml of brine was injected. A surgeon stitch had been put on the muscle around the needle before it was retracted in order to protect the brine against its outflow through the hole made by the needle. The time of diffusion was 9 hours at ambient temperature 4 - 6° C. After this time each portion of the muscle was thermally denatured in a microwave oven Toshiba type ER-5420W during 8 min. at the maximum radiation intensity. The samples were cut crosswise at their mid-height and then slices 1 cm thick were cut upwards and downwards from that line. The red spots of cured meat on the slices were contoured on transparent foil. Then analytical samples were prepared by cutting out the red spots from each slice. Three experiments were performed: (1) The influence of pH tested on muscles of pH within the range of 5,3 to 6,5, injected with 1 ml of brine containing 1350 µg of $NaNO_2$/ml. (2) The influence of $NaNO_2$ concentration examined on muscles of pH within the range of 5,6 to 5,9 injected with 1 ml of brine containing 675, 1350 or 2700 µg of $NaNO_2$ / ml. (3) The influence of amount of brine studied on muscles of pH within the range of 5,6 to 5,9 injected with 0,5, 1, or 2 ml of brine containing 1350 µg of $NaNO_2$ in 0,5, 1 or 2 ml respectively. In all experiments the concentration of sodium chloride was 18 g in 100 ml of brine. The contour of red spot on each slide was measured using area integrator and then volume of diffusion space was calculated. In analytical samples the contents of nitrates and nitrites was determined using a flow-injection method [Kłossowska., Tyszkiewicz, Borys, 1993]. The colour reaction with Griess reagent was used and nitrates were reduced to nitrites in a cadmium column. All experiments were performed in 5 or 6 replicates. Results were tested statistically using Statgraphics Plus for Windows.

Results and discussion

The calculated values of diffusion volumes were evaluated in order to determine the influence of the examined agents on diffusion efficiency. In the examined muscles of nine different concentrations of hydrogen ions in the pH range varying from 5.3 to 6.49, the values of diffusion volumes varied from 50 to 62 cm^3 and they were independent of the pH value. Following the increase of the concentration of sodium nitrite in brine (675, 1350 and 2700 µg/ml) the value of diffusion volumes grew amounting to 46, 56 and 85 cm^3 respectively. The said differences were statistically significant. Following the increase of the injected volume (0.5, 1.0 and 2.0) at the constant amount of injected sodium nitrite of 1350 µg, the value of diffusion volumes amounted to 50, 56 and 61 cm^3 respectively. As it was proved by statistical analysis, the said differences were significant. The diffusion efficiency depended more on the concentration of sodium nitrite than on the injection volumes applied. No significant influence of the concentration of hydrogen ions in the examined muscles on diffusion efficiency was confirmed.

The distribution of the sum of nitrites and nitrates in the diffusion area had a normal character with the maximum in the centre of the diffusion area for all the examined agents. As it is shown in the Fig. 1 the maximum value grew following the increasing concentration of $NaNO_2$ in brine. Moreover, the increase of the sum of nitrites and nitrates in the diffusion area was observed which, however, was out of proportion with the increase of the amount of sodium nitrite injected into the muscle and equal to about 40%, 55% and 75% of the amount of injected nitrite for successive concentrations. The injection volume had not significant influence on the lowering or raising of the maximum of the distribution curves. The results showed the dependence of the maximum value of the sum of nitrites and nitrates on acidity of muscles. That dependence was reflected by a curve with the inflexion around the pH 5.9. The small number of examined cases of pH values over 5.9 unabled to determine if it was the maximum of the curve or the inflexion only.

The research confirmed the results of our previous works in which it had been stated that the ratio of nitrites to the sum of nitrites and nitrates had been the lowest in the front of diffusion and had grown to its maximum in the centre of diffusion area. It means that in the centre the relative content of nitrates was imperceptible and grew rapidly towards the front of the diffusion. Such a distribution was affected by the concentration of brine and by the injection volume. pH values within the range from 5.30 to 5.91 did not differentiate the

distribution. Another picture of the distribution of the ratio of nitrites to the sum of nitrites and nitrates was shown while a muscle of pH 6.49 had been examined. It is presented in Fig. 2. In case of meat of pH 6.49 there were observed the stabilized, very high values of the ratio $NO_2'/(NO_2' + NO_3')$ decreasing slightly in the front of the diffusion only. Such a distribution of relative contents of nitrites and nitrates in the diffusion area at the unchanged efficiency of curing of meat may suggest that at the high pH values of about 6.5 the origination of nitric oxide is not accompanied by oxidation of nitrite to nitrate so that there exists another oxygen acceptor in the muscle or that the reduction of nitrite is limited. It is generally known that in dark muscles of a high pH the oxidation process dominate over glicolytic ones and, moreover, such muscles require less nitrite at curing. It may be the right explanation of the phenomenon observed.

Conclusions

1. The diffusion efficiency measured as the value of the diffusion area depended more on the nitrite concentration in brine than on the injection volume.
2. No influence of the concentration of hydrogen ions in the muscle on the diffusion efficiency was confirmed.
3. The distribution of the total content of nitrites and nitrates in the diffusion area had an approximately normal character with its maximum in the centre of the diffusion area. The maximum value was affected by the concentration of sodium nitrite in brine and by pH value of meat. It showed an approximately linear increase following the increase of the concentration of sodium nitrite in brine and curved line increase following the pH value increase in the range from 5.3 to 5.9. No further increase of this maximum was observed for pH values over 5.9.
4. The distribution of the ratio NO'/(NO' + NO') in the diffusion area had an approximately parabolic character and did not depend on the concentration of sodium nitrite in brine, injection volume nor pH value in the range from 5.3 to 5.9. Only for meat of pH value of 6.5 the value of the said ratio was on an unchanged, high level in the whole diffusion area what confirms the limited dismutation.

Literature

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Fig. 1 Influence of nitrite concentration in brine on the sum of nitrites and nitrates in diffusion area

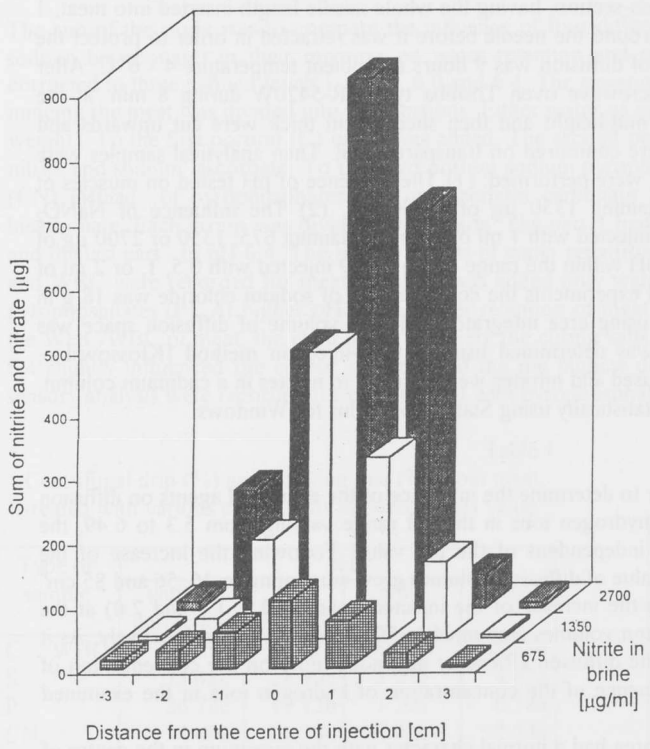

Fig.2 Influence of pH on the ratio of nitrites to the sum of nitrites and nitrates in diffusion area