Effects of freezing and thawing of pork on salt diffusion in wet and dry curing systems

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Introduction

The production of dry cured hams traditionally requires several weeks of curing, followed by weeks of drying. A total processing time of 100 days or more is not uncommon. This makes the process very expensive, and any step to shorten the time of production has potential economical benefits. One such step that has been proposed is to use frozen and thawed hams as raw materials.

The question of salt diffusion in frozen and thawed meat has been approached in several literature reports. According to a review by Morley (1977) conflicting evidences exist about the effects of freezing and thawing as compared to the use of fresh meat. Some authors (Rahelić et al., 1973; Wood, 1966), who examined curing in brine solutions, did not detect any significant changes in salt diffusion. Later, Gonzalez-Mendez et al. (1983), found an increased diffusion in frozen and thawed muscles of both pork and beef. Their results were obtained in experiments with a dry curing system.

The aim of the present study has been to elucidate whether freezing and thawing has improving effects on the salt uptake of pork. The experiments were performed with both wet and dry curing systems, to decide if the choice of testing method would be critical. To our knowledge, this kind of double curing test has so far not been reported.

Gonzalez-Mendez et al. (1983) indicated that the rate of thawing has an influence on the salt diffusion. Our experiments with frozen pork have therefore included the examination of both relatively fast and slow thawing rates.

Experimental

Pretreatment of raw materials

Porcine M. semimembranosus (pH 5.5±0.1) was exised from 6 commercially chilled hams of Norwegian Landrace . Each muscle was divided in 3 parts: one for fresh control, one for freezing/fast thawing, and one for freezing/slow thawing, that all were sealed in plastic bags. The meat was frozen and stored at -22°C for 3 days. Fast thawing conditions were 20°C for 10 hours. Slow thawing was performed at 3°C for 24 hours.

Curing conditions

The meat of the three treatments was divided in two parts and prepared both for wet and dry curing systems. Visible fat and connective tissues were removed, and the meat was cut and shaped in cylindrical pieces along the fiber direction. The meat pieces were fitted tightly in plexiglass tubes (10.0 cm in length, 2.5 cm in diameter), fastened with needles at top and bottom of the tubes and trimmed closely at both surfaces. The top meat surface was covered with plastic film.

The wet curing system consisted of a container with saturated (26%) salt solution. Food grade sodium chloride with nitrite (0.6%) added was used. Saturation of the brine was maintained by an excess of salt, which was kept in motion by a magnetic stirrer. Tubes with meat pieces were placed vertically in the container and immersed 1 cm below the brine surface.

The dry curing system consisted of a container with dry food grade sodium chloride with nitrite (0.6%) added. Meat tubes were placed 1 cm into the salt.

Curing, both in the wet and dry systems, was performed at 3.0±0.5°C for 7 days.

Salt analysis

The lower part from 0 to 1 cm of the meat pieces with salt contact was removed. The distance of the meat between 1 and 6 cm above the meat/salt interface was sliced in 5 discs of 1 cm each and analysed. Sodium chloride was extracted from samples of 2.5 g with 50 ml distilled water at 80°C during homogenisation. After filtration, the salt content was determined by chloride titration on a Chloride Analyzer 926 (Corning Ltd., Halstead, UK).

Results

Salt concentrations at different levels of the meat in the wet curing system are shown in Fig. 1. There are only minor differences in salt content at all levels between the fresh control, the frozen/fast thawed, and the frozen/slowly thawed meat.

Correspondingly, Fig. 2 shows the results from the dry curing system. Frozen meat, which either has been thawed fast or slowly, has a clearly higher salt content than the fresh control meat at the lower part of the meat pieces. As the distance from the salt source increases, the differences are gradually reduced.

By regarding the 5 analysed samples from 1 to 6 cm of the meat pieces as a whole, the average salt per cent of the samples is calculated. Table 1 shows the mean values with statistical significances ($p<0.05$, two-tailed t-test) in addition to a comparable ratio of each treatment by the two curing systems. The mean salt uptake after a 7-days period is evidently higher in

Fig. 1
Salt content (%, mean and S.E.) of pork at different levels above meat/salt interface in the wet curing system. Curing in saturated (26%) brine solution at 3.0±0.5°C for 7 days. n=6.
□ Fresh, control
▨ Freezing at -22°C for 3 days, fast thawing at 20°C for 10 hours
▩ Freezing at -22°C for 3 days, slow thawing at 3°C for 24 hours

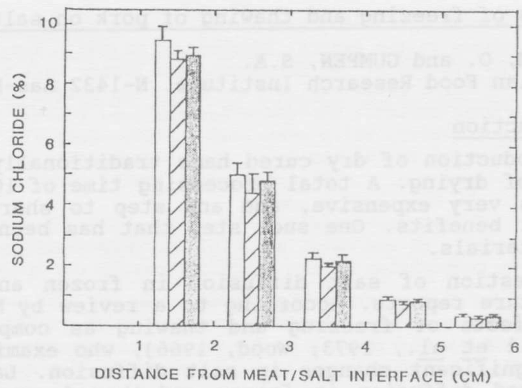
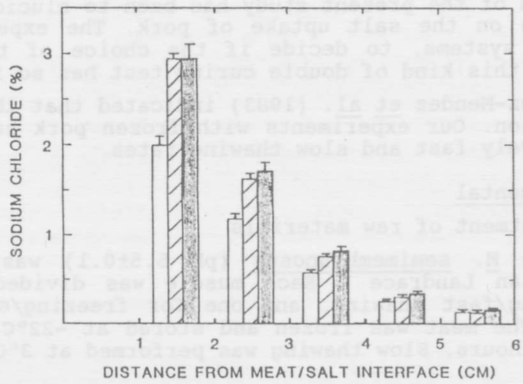


Fig. 2
Salt content (%, mean and S.E.) of pork at different levels above meat/salt interface in the dry curing system. Curing at 3.0±0.5°C for 7 days. n=6.
Symbols as described in legends to Fig. 1.



the wet than in the dry curing system. In the wet curing system there are no significant differences between the three treatments of the meat. Curing in the dry system gives a significantly higher salt content (approximately 40%) in frozen and thawed meat than in fresh control meat. Slow and fast thawing rates show no significant differences in the dry system.

Table 1 Mean salt content (%) of pork of total samples between 1 and 6 cm above meat/salt interface in wet and dry curing systems. Freezing, thawing and curing conditions as described in legends to Fig. n=6.
Treatments with different superscripts are significantly different ($p<0.05$, two-tailed t-test).

	NaCl (%) (Mean value ± S.E.)	Ratio (Controls = 100)
Wet curing system		
Fresh, control	3.57 ± 0.24^{a}	100
Freezing/fast thawing	3.25 ± 0.14^{a}	91
Freezing/slow thawing	3.39 ± 0.16^{a}	95
Dry curing system		
Fresh, control	0.83 ± 0.03^{b}	100
Freezing/fast thawing	1.15 ± 0.02^{c}	139
Freezing/slow thawing	1.19 ± 0.07^{c}	144

Discussion

Use of frozen and thawed meat does not increase the salt uptake in a wet curing system (Fig. 1 and Table 1). These findings are in accordance with Wood (1966), who found no significant changes in salt diffusion between frozen and unfrozen pork cured in saturated brine solutions. Rahelic et al. (1973) came to the same conclusion after similar wet curing experiments, where pork cuts were dipped in 12% brine solutions for various lengths of time.

The results from our dry curing system, however, clearly reveal that freezing and thawing will be beneficial to the salt uptake (Fig. 2 and Table 1). In dry curing experiments with pork Gonzalez-Mendez et al. (1983) also found a positive effect limited to 28%, as compared to more than 40% in our experiments.

The different results of the dry and wet curing systems are best explained by regarding the dry curing as a two-stage process. In the first stage salt is dissolved and a saturated brine formed. The second stage is the diffusion of dissolved ions from the saturated brine, equivalent to the diffusion in the wet curing system.

Obviously, the brine formation is a slow process that retards the salt uptake in dry curing systems. When the meat has been frozen and thawed prior to the curing, the brine formation is accellerated due to the reduced water holding capacity and the excess of juice released. Since brine formation is not involved in wet curing systems, the rate of salt uptake is not influenced by these mechanisms. These results may explain some discrepancies in the literature concerning the effects of freezing and thawing on salt diffusion.

An increased salt uptake in slowly thawed compared to fast thawed meat, as stated by Gonzalez-Mendez et al. (1983), has not been confirmed by our experiments. Probably, our thawing conditions did not differ enough to separate significantly the fast and slow thawing with regard to the amount of thaw juice formed.

References

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Table 1 Mean salt content (%) of pork of total samples between 1 and 6 cm above meat/s[alt] interface in wet and dry curing systems. Freezing, thawing and curing conditions [as] described in legends to Fig. 1. n=6.

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