The Tenderizing Effect of NaCl on Cold Shortened Pork

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SUMMARY: Paired M. longissimus dorsi from carcasses, representing pH_1 values from 5.4 to 6.4, were either cold boned (controls) or hot boned / fast chilled in ice water to obtain various levels of cold induced shortening. Subsamples were placed in .15, .60 or 1.20 M sodium chloride (NaCl) solution for 24 hr before heat treatment at 80°C for 20 min. Cooking loss and cross-sectional cooking shrinkage were reduced as NaCl was increased from .15 to .60 M while further increase in NaCl to 1.20 M had minor additional effect. Tenderness as measured by the Warner-Bratzler shear device was also predominantly affected by increased NaCl level to .60 M. The potential of NaCl to reduce cold induced toughening in porcine M. longissimus dorsi showed that acceptable tenderness was obtained from NaCl treatment when cold induced shortening did not increase above thirty percent.

INTRODUCTION: Although pork is generally not considered tough accelerated processing procedures has resulted in less than optimum tenderness (Barton-Gade et al., 1987; Møller & Vestergaard, 1987). Tenderness of meat is known to be improved by the application of sodium chloride (NaCl) prior to cooking. Weiner et al. 1966 showed that hams processed prior to rigor mortis had significantly lower drip loss, cooking loss and shear force values. Palladino and Ball (1979) injected various inorganic salts into the muscle to equalize charge and found that salts, with the exception of calcium salts, had a tenderizing effect on spent hen muscle. Brine chill solutions varying from 2.5 to 7.5 % NaCl has been shown to increase tenderness in broilers (Dukes & Janky, 1984). Furumoto and Stadelman (1980) found that regardless of rigor state, the addition of 1.5% NaCl significantly improved tenderness of pork, chicken, turkey and beef rolls.

The tenderizing effect of NaCl has been attributed to the enhanced charge on muscle proteins caused by chloride binding and additionally because salts reduce structure restraints by the dissociation of actomyosin (Offer et al., 1983). Another important role of salts in meat products is to increase the temperature the meat can be heated to before they aggregate because of salts affecting the thermal denaturation of the major meat proteins (Trout & Schmidt, 1986). In the range of marinades available to food manufactures, salts have also been used as an ingredient for providing functionality. The objective of this study was to determine the potential of NaCl to minimize tenderness variations due to cold induced shortening in pork.

MATERIALS and METHODS: Sixty-five pigs of Danish Landrace or Yorkshire breeds were slaughtered conventionally at approximately 90 kg live weight. The pigs, reared at the same progeny testing station were stunned with carbon dioxide. The left sides of the carcasses were used as controls and chilled by transferring the sides immediately after dressing through a conveyorized chilling tunnel operating at -18°C, 3.0 m/s, for 65 min. These sides were then placed in a chill room at 2-4°C, 0.2 m/s, until 24 hr post stunning. From right sides of carcasses the 12th to 15th rib section of M. longissimus dorsi (LD) was excised immediately after dressing and trimmed of subcutaneous fat. The pH values were measured using a Knick digital model 653 and direct insertion probe electrode. The LD sections were cut into subsamples, 20 x 20 x 60 mm, with the last dimension being along the muscle fibres. After cutting, and within 1.5 hr post stunning, these samples were placed in polyethylene bags and cooled in ice water until 24 hr post stunning. Length changes produced after ice water chilling were measured with the aid of pins inserted at set distances in the pre rigor samples just before chilling. The length changes were used for calculating the percentage of cold induced shortening. Additionally, the sarcomere length was measured by a helium-neon laser with a wave length of 632.8 nm as earlier described (Møller & Vestergaard, 1987). All samples were then vacuum packed and stored at -20^{o}C for 8-12 weeks until further measurements.

Subsamples from forty-four carcasses were used to examine the effect of NaCl on cooking loss, cooking shrinkage and Warner-Bratzler (WB) peak shear values. Subsamples were cut into rectangular blocks, 10 x 10 x 50 mm, with the last dimension being along the muscle fibres. Blocks from each muscle were randomly assigned for 24 hr soaking in .15, .60 and 1.20 M NaCl solution. The blocks were then individually placed in test tubes containing .15 M NaCl and heated in a waterbath at 80^{o}C for 25 min. After cooking, the blocks were cooled in cold running tap water and carefully dried with paper tissues. Measurement of weight, length and volume of the meat blocks before and after heat treatment enabled cooking loss, changes in length and cross-sectional area to be determined. An Instron Universal testing machine model 4301 was used to measure the WB peak shear forces, N/cm^{2}.

RESULTS and DISCUSSION: The extent of cold induced muscle shortening for the hot boned / fast chilled samples were as expected significantly related to the pH_1 values at time of boning, i.e. approximately 1 hr post stunning ($r = -.88$, $P < .001$). A linear relationship was found in the range of pH_1, values from 5.4 to 6.4 causing increased muscle shortening from 2 to 35 %. Corresponding mean values of pH and sarcomere length are shown in table 1 when the results are grouped according to various levels of cold induced shortening. The effect of NaCl on cooking loss and dimensional changes produced on heating as influenced by level of shortening are illustrated in fig. 1. As shown, cooking loss was greatly reduced by increased ionic strength of NaCl which obviously is caused by a decreased cross-sectional shrinkage while the shrinkage along the fibres was less affected. The main effect of NaCl appeared at .60 M and a further increase to 1.20 M during soaking had minor additional influences on water retention and shrinkage after heat treatment. These results are in general agreement to earlier published data (Offer et al., 1983). From fig. 1. it also appears that the overall trend in values were independent of shortening which is in agreement to Honikel & Reagan (1986).

WB shear force data as affected by NaCl are illustrated in fig. 2. The results presented are mean values derived from the four groups of various degree of shortening inclusively their corresponding controls. As indicated, the main effect of NaCl on WB values appeared at .6 M NaCl. The response on WB values from NaCl treatment was seen to be related to the levels of cold shortening as shown by a larger difference between controls and hot boned samples at increased level of cold shortening. Based upon our previous taste panels, WB values at about 60 N/cm^{2} are on the borderline of acceptable tenderness. Therefore it is concluded from the present results, that toughness induced by cold shortening can be reduced to acceptable tenderness by the tenderizing effect of NaCl as far as shortening is below thirty percent.

CONCLUSION: The effect of soaking samples of hot boned / fast chilled pork loins in NaCl solutions at .15, .60 and 1.20 M was studied. The major effect of NaCl on obtaining reduced cooking loss and cooking shrinkage was found at .6 M NaCl and independent of level of shortening. The potential of NaCl to reduce cold induced toughening, however, was related to the degree of shortening. Acceptable tenderness could be obtained when cold induced shortening did not increase above thirty percent.

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Table 1.- Mean values (± s.d.) of pH at boning and sarcomere length as referring to intervals of percent cold induced shortening in hot boned / fast chilled Porcine M. Longissimus dorsi.

No. of muscles	% shortening	pH at boning	sarcomere length, µm
16	0 - 10 %	5,40 (± 0,13)	1,80 (± 0,11)
12	11 - 20 %	5,65 (± 0,11)	1,69 (± 0,09)
10	21 - 30 %	5,93 (± 0,21)	1,68 (± 0,08)
6	> 30 %	6,19 (± 0,16)	1,64 (± 0,09)

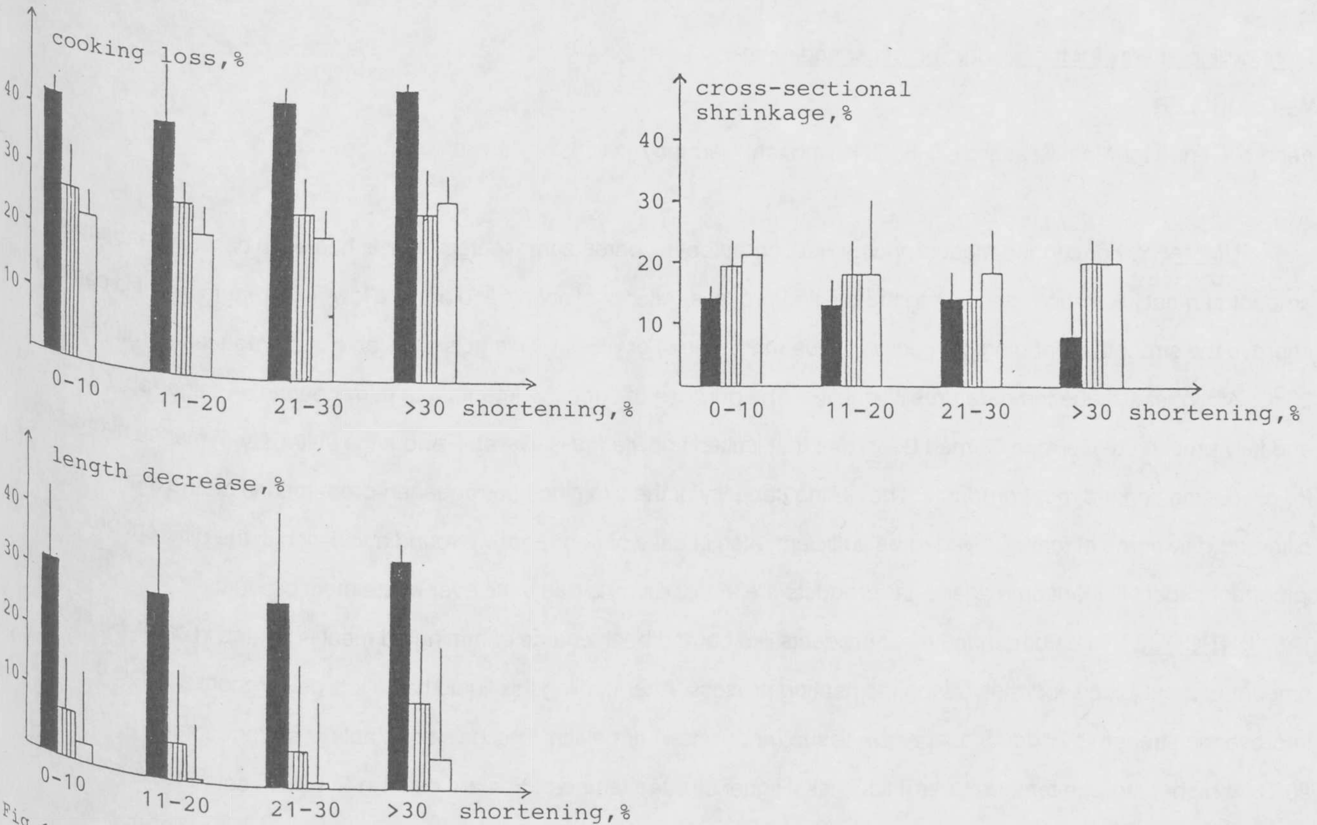

Fig.1 - Cooking loss and dimensional changes in samples from hot-boned porcine M.longissimus dorsi heated at 80°C for 20 min. as influenced by level of cold induced shortening. ▬, ▥ and ☐ = .15, .60 and 1.20 M NaCl (vertical bars are standard deviations).

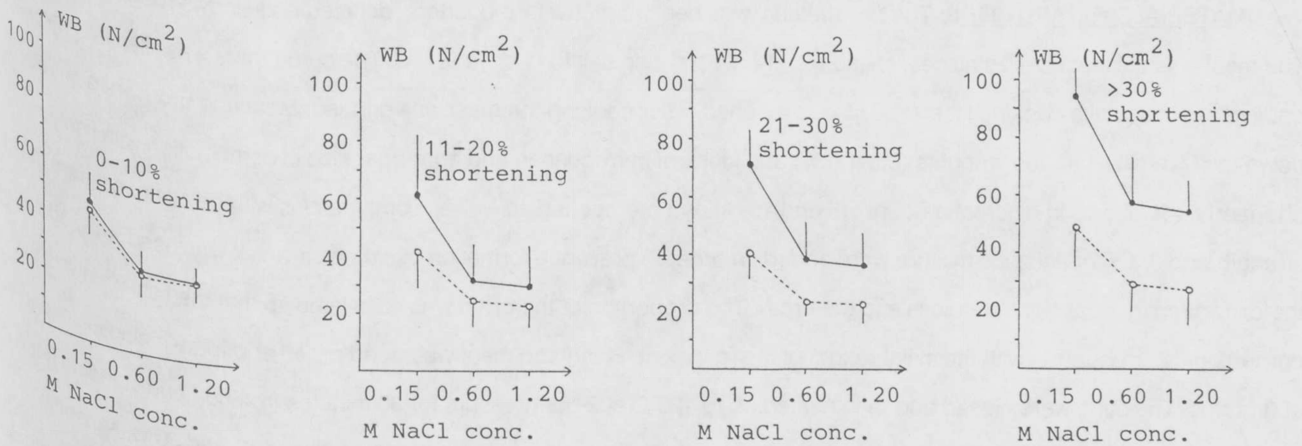

Fig.2 - The effect of NaCl concentration on Warner-Bratzler (WB) shear force values of cold (controls) - and hot boned samples from porcine M.longissimus dorsi as influenced by level of cold induced shortening.
●—● = hot boned samples, o---o = cold boned controls
(vertical bars represent standard deviations).