6:7 Influence of electrical stimulation on distribution and rate of migration of sodium nitrite, sodium chloride and glucose in pork tissue.

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Introduction

Electrical stimulation has been reported to improve tenderness in beef, lamb and goats (Chrystall and Hagyard, 1975, 1976; Grusby et al., 1978; Gilbert and Davey, 1976; Gilbert et al., 1976; Davey et al., 1976; Smith et al., 1977; Savell et al., 1977 and Sorinmade et al., 1978) as well as influencing other meat quality (flavor, lean color, heat ring, marbling, retail case life) parameters (Savell et al., 1979).

Pork tissue has not been intensively investigated in terms of the influence of electrical stimulation on meat quality but in the pork research work of Smith et al. (1980) and Crenwelge et al. (1980), it was reported that electrical stimulation does not appear to improve quality, quality indicating or palatability traits of pork muscle.

The effects of electrical stimulation have not previously been evaluated to any major extent in terms of the migration and distribution of curing ingredients in either beef or pork tissue. Only one paper was located concerning the influence of electrical stimulation on migration and distribution of curing ingredients in bacon after electrical stimulation and during the tumbling process (Ockerman and Dowiercial, 1980) and the authors stated that neither tumbling nor electrical stimulation had a significant effect on the levels of sodium nitrite or sodium chloride under the conditions of this research. They did, however, report improved distribution of curing ingredients, especially nitrite, by electrical stimulation and this can be a very valuable factor in the current attempts to shorten the curing time or to reduce the nitrite level in curing solution and cured meat.

The objectives of this study were to determine if electrical stimulation influences the distribution and rate of migration of curing ingredients in pork tissue during the curing process.

Materials and Methods

Three pigs were conventionally slaughtered and the left side of each carcass was electrically stimulated within 45 min post-slaughter. The carcasses were stimulated using a High Voltage JASEC Electrical Meat Stimulator. Each treated side received 50 electrical impulses of 400V alternating current of 1.5 sec each in duration followed by 1.5 sec of no current. The other side (right) was used as a control (non-stimulated). The triceps brachii muscles were removed 24 hrs post mortem from both sides of the chilled carcasses. Cylindrical samples of 1.5 cm in diameter and 5 cm in length (parallel to muscle fibers) were prepared from the muscles using an electrical cork borer on the firmly chilled tissue. These cylindrical samples were tightly placed into plastic tubes (1.5 cm internal diameter X 9 cm in length) in an effort to prevent migration of curing solution between the sample and sides of the tube. Two and one-half ml of curing solution composed of 20% NaCl, 6% glucose and 0.16% sodium nitrite was added to the tubes above the samples. Both stimulated and nonstimulated samples in the tubes were held at 3°C-5°C and sampled at 24, 48 and 72 hrs. At each sampling time, the excess cure above the sample was discarded and the cylindrical sample was removed from the tube and divided into 4 cylindrical segments of 1.25 cm in depth from the top (adjacent to curing solution) to the bottom of the sample. These segmented samples were each individually analyzed for nitrite level using the procedure described by Ockerman (1981) with two necessary changes: (1) samples were blended in a Stomacher Lab-Blender with 80 ml of hot 70°C distilled water for 2 min and, after that, were quantitatively transferred into 500 ml volumetric flask, (2) no mercuric chloride was added to the flask after 2 hrs extraction in a water bath to avoid the addition of any extra chloride ions. Ockerman and Dowiercial (1980) have reported that elimination of mercuric chloride did not affect the analysis for nitrite in cured tissue. In this way it was possible to use the same extract to determine content of nitrite, sodium chloride and glucose. Salt was analyzed by the Dicromat(R) procedure (Anonymous, 1977) which involved using the salt analyzer. Glucose was determined by the procedure described by Koniecko (1979) for meat products. Ten triceps brachii cylindrical samples were prepared for each treatment (stimulated and nonstimulated) and each time period (24, 48, 72 hrs) and each segment (0-1.25, 1.26-2.50, 2.51-3.75, 3.76-5.0 cm) was analyzed for NaCl, $NaNO_2$ and glucose. This resulted in a total of 40 determinations for nitrite, salt and glucose for each treatment and for each period of time.

Analysis of variance (Harvey, 1968) was used to determine the significance of stimulation, depth of sample, time and their interactions. Means were separated by Duncan Multiple Range Test (Ockerman, 1983).

Results and Discussion

The results of migration and distribution of curing ingredients (nitrite, salt, glucose) in stimulated and nonstimulated pork tissue are shown in Fig. 1-6.

All two-way interactions (stimulation X time, stimulation X depth, time X depth) were significant (P<0.01) for nitrite concentrations and Fig. 1 illustrates the stimulation X depth relationships. This suggests that nitrite concentration was increased at each depth by stimulation and the analysis of variance indicated that stimulation had a significant (P<0.01) influence on this nitrite level. Figure 2 shows the three-way interaction (stimulation X time X depth) for nitrite concentration and again illustrates the effect of stimulation, depth and linear time on the penetration rate. The differences in the levels of nitrite in each cylindrical sample depth between stimulated and nonstimulated samples were approximately the same (20-30 ppm) during the total time period of curing, except the segment of sample adjacent (0-1.25 cm in depth) to the curing solution after the 24 hrs curing period where the levels did not differ significantly between stimulated and nonstimulated samples.

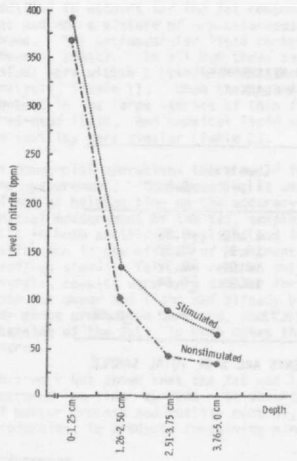

Fig. 1-Effect of electrical stimulation on the concentration of nitrite at several depths in pork tissue.

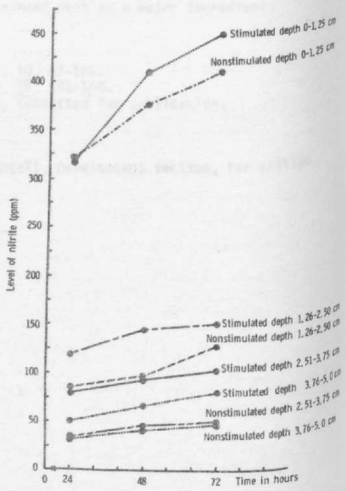

Fig. 2-Effect of electrical stimulation, time and sample depth on the concentration of nitrite in pork tissue.

As shown in Fig. 3 and 4 electrical stimulation caused a significant increase (P<0.01) in the NaCl concentration at all sample depths. Figure 3 illustrates the significance (P<0.01) stimulation X depth interaction and the general shape of the pattern is similar to Fig. 1 for nitrite. Figure 4 shows the three-way interaction (stimulation X time X depth) for salt and it is similar to Fig. 2 for nitrite except there is a slightly greater difference in the salt concentration for stimulated and nonstimulated tissue at the 0-1.25 cm depth at 24 hrs and the salt differences are not as great and are not significant in the 3.75-5.0 cm depth at any time period. The analysis of variance indicated that electrical stimulation as well as linear time and depth of tissue had a highly significant (P<0.01) influence on the salt concentrations.

Electrical stimulation also caused an increase in glucose penetration and concentrations for all depths of cylindrical segmented samples in comparison to nonstimulated tissues (Fig. 5, 6), and again the shape of the glucose concentration curve (Fig. 5) is similar to the shape of the nitrite curve in Fig. 1. Figure 6 illustrates the concentration of glucose for the stimulation X time X depth interaction. The pattern once again is similar to the nitrite (Fig. 2) and salt (Fig. 4) patterns previously observed.

This overall increase in migration and concentration of cure ingredients was probably influenced by the disruption of muscle tissue caused by electrical stimulation as would be expected and agrees in general with the report of Ockerman and Dowiercial (1980). In a normal curing operation the movement of brine components would be caused by osmotic pressure. When electrical stimulation is applied the distribution and migration of the cure ingredients may also be promoted by the disruption of the muscle sarcolemma, which may take place during stimulation (Savell et al., 1978; Sonaiya et al., 1982; Cross, 1978). This would promote the migration of curing ingredients both between muscle bundles and fibers and into those fibers with fragmented sarcolemma, resulting in a quicker and more uniform distribution of curing ingredients.

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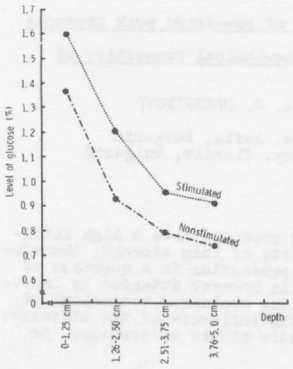

Fig. 5-Effect of electrical stimulation on the concentration of glucose at several depths in pork tissue.

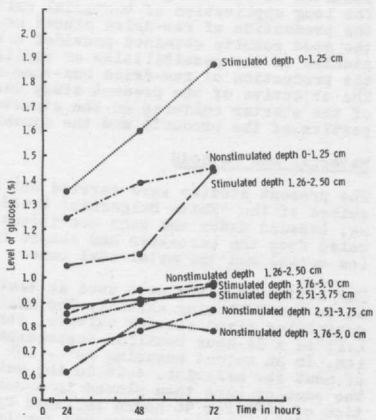

Fig. 6-Effect of electrical stimulation, time and sample depth on the concentration of glucose in pork tissue.

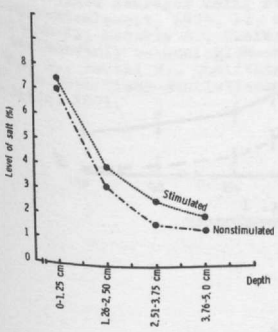

Fig. 3-Effect of electrical stimulation on the concentration of salt at several depths in pork tissue.

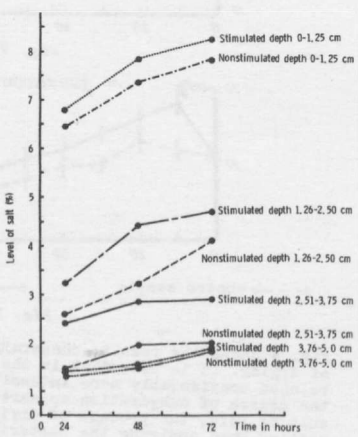

Fig. 4-Effect of electrical stimulation, time and sample depth on the concentration of salt in pork tissue.