5:20 Lactobacillus plantarum and nitrite levels in pork as influenced by tumbling and temperature treatments .

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Introduction

Tumbling or massaging of meat is a relatively new process for improving the quality characteristics of cured meat (Mass, 1963; Rust and Olsen, 1973; Krause et al., 1978b; Cassidy et al. 1978). Theno et al. (1977) and Ockerman (1980) described both advantages and disadvantages of this new technology.

Cassidy et al. (1978) reported that tumbling leads to increased cell membrane disruption, disorganization of cell nuclei and decreasing clarity of striation. Tumbling combined with the reported disruption of the muscle sarcolemma has been found (Knipe et al., 1981) to force microorganisms into the internal regions of the tumbled meat, thus increasing the subsurface microbial numbers while apparently reducing the surface exudate bacterial counts. Reduced microbial numbers in the exudate were observed after 15 and 18 hours of intermittent tumbling by Knipe et al. (1981), but in this study no effort was made to determine if the microorganisms were migrating into the disrupted tissue thus resulting in reduced numbers in the exudate.

The addition of alkaline phosphates to increase yields of tissues that are tumbled and cured is also important for improving water holding capacity and improving cohesiveness of tumbled meats (Yasui et al., 1964; Krause et al., 1978a; Ockerman et al., 1978; Siegel et al., 1978; Elligner, 1972). Alkaline phosphates also increase the pH of the cured product and therefore retard the reduction of nitrite to nitrous acid. This reduction of nitrous acid should make the meat environment more favorable for bacterial growth (Lawrie, 1974). Since microbial growth also increases (Lechowich, 1971) with increased pH and a higher water activity (Aw) the addition of alkaline phosphates could result in an increase in microbial numbers.

The objectives of this project were to determine the effect of tumbling at 3°C and 23°C on:

1. The number of surface and subsurface Lactobacillus plantarum after inoculation during tumbling and nontumbling cycles.
2. The residual nitrite at various stages of tumbling.

Materials and Methods

Sixteen, 1.0-1.2 kg pieces of fresh boneless pork shoulder, closely trimmed of external fat and visible connective tissue were prepared using sterile techniques to keep the microbial load as low as possible for this experiment. Each piece was stitch pumped to 120% of green weight with curing solutions composed of the following ingredients by weight (w/w): 14.3% salt; 2.75% sugar; 0.29% sodium erythorbate; 0.0935% sodium nitrite; 2.75% sodium tripolyphosphate and 79.80% water.

These 16 samples allowed 4 replications in each treatment cell of tumbled or nontumbled (control) at each of two temperatures (3°C and 23°C). These temperatures were chosen to represent room temperature and meat holding refrigerated temperature. Each 1.0-1.2 kg piece of tissue was subdivided prior to analysis into 2 pieces which resulted in a total of 32 samples.

The pure culture of Lactobacillus plantarum used in this study was obtained from The Department of Microbiology at The Ohio State University. The pure culture media used for inocula preparation was ATP Broth (Difco) in which the pure culture L. plantarum was allowed to multiply for 48 hr at a temperature of 30°C. All samples were inoculated by placing 50 ml of the bacterial suspension on the surface of the meat pieces after they were stitch pumped with curing solution. The bacterial suspension contained approximately 5 X 10^8 viable cells per ml. Immediately after contamination one half of the muscle pieces were randomly assigned to the tumbling treatments and the other half to the nontumbling treatment (control). Both tumbled and nontumbled samples were placed in a cooler at 3°C or at room temperature at 23°C for the 18 hr treatment period. The tumbling process involved an intermittent cycle of 15 min on and 45 min off each hr for 18 hr.

Samples for investigation were taken at 6 stages; prior to brine injection (microbiological control) and at processing times of 0 (after brine injection and inoculatin) 12, 15, 18 hr and after cooking (in a glass vessel in boiling water bath for 12±3 min) to an internal temperature of 68°C. At each sampling period approximately a 0.5 cm slice was taken from the surface of the meat and another 0.5 cm slice from the subsurface area at the same location. A microbiological sample was taken at each sampling period from the exudate of the nontumbling treatment. The meat samples were homogenized with diluent (0.5% Bacto Peptone), dilutions made and the samples subsequently plated on ATP Agar and incubated four days at 25°C (Ockerman, 1982) for determination of Lactobacillus plantarum.

The portion of the surface and subsurface samples remaining after the microbiological analysis was obtained was mixed in equal quantities for analysis of nitrite using the procedure described by Ockerman (1982).

Analysis of variance (Harvey, 1960) was used to determine the effect of tumbling, temperature, time (linear, quadratic, cubic) and their interaction on the log. of the microbial number and the nitrite level. An additional analysis of variance was used to compare values before and after cooking.

Results and discussion

Fig. 1 illustrates the log of Lactobacillus plantarum of cured pork shoulder tissue at 3°C (upper) and 23°C (lower) treatment temperatures. The figure also shows the influence of tumbling and nontumbling as well as location such as surface, subsurface and nontumbling exudate on the microbial levels of cured pork during 18 hr of processing.

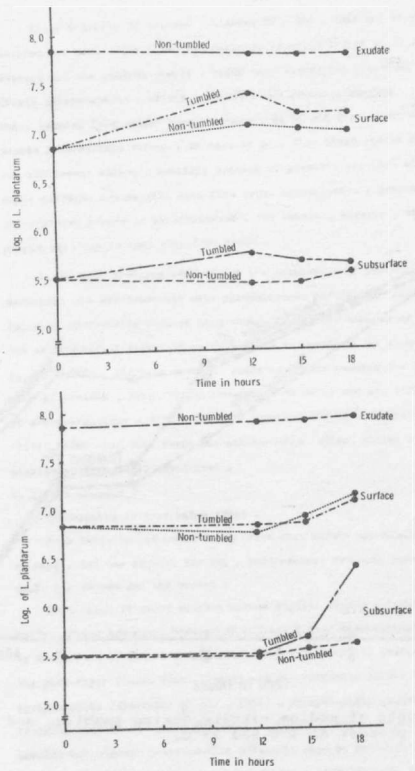

Fig. 1-Logs of surface, subsurface and nontumbling exudate for L. plantarum at 3°C (upper) and 23°C (lower).

The analysis of variance indicated that tumbling was significant ($P<0.05$) and that linear time and location were highly significant ($P<0.01$) for microbial plate count for L. plantarum. Temperature was not significant and all of the interactions proved also to be nonsignificant at the 5% level. The major differences for microbial numbers in Fig. 1 are attributed to location with numbers significantly decreasing from exudate to surface to internal samples in both 3°C and 23°C. Tumbling resulted in higher numbers of microorganisms in the internal tissue of product tumbled 18 hours at 23°C. This is as would be postulated with disruption of tissue as suggested by Cassidy et al. (1978) and with a more optimal growth temperature for L. plantarum. There is some nonsignificant suggestion that the 3°C tumbled surface tissue absorbed microorganisms from the exudate early in the tumbling cycle and that this level was reduced in the later stages of tumbling probably due to internal migration. This would agree with the observations of Knipe et al. (1981). The level of L. plantarum in the internal tumbled tissue at 3°C would also suggest greater microbial migration from the inoculum into the tissue at this temperature. The tumbled surface tissue had essentially the same number of L. plantarum microorganisms as the nontumbled surface tissue at 23°C suggesting that absorption of the exudate microorganisms had possibly occurred prior to the 12 hr sampling period and that migration toward the center of the sample had also occurred at a more rapid rate than at 3°C. The small increase observed on the surface tissues from 12 to 18 hr at 23°C probably was caused by the favorable growth temperature. Cooking reduced the number of L. plantarum to a nondetectable level in both the surface and subsurface tissue for all treatments.

Fig. 2 illustrates the level of nitrite in meat during tumbling and nontumbling processing at 3°C and 23°C. The analysis of variance indicated that tumbling time and tumbling temperature interactions were highly significant. This can be seen in Fig. 2. After 12 hr of treatment, tumbling at 23°C resulted in lower nitrite levels than the other 3 treatments. This agrees with the reports of Mills et al. (1980), Ockerman and Organisciak (1978a,b) and Vartorella (1975), who stated that tumbling improves cure distributions, speeds cure migrations and improves color development. The nontumbled tissue processed at 23°C had significantly higher residual nitrite than the other 3 treatments after 15 and 18 hrs of processing and after processing and cooking. This can partially be explained by the nontumbling treatment and also that increased temperature would promote the formation of nitrate from nitrite as described by Lee et al. (1978). This could explain the relatively lower nitrite levels during nontumbling at 3°C and the relatively higher levels of nitrite in nontumbled meat at a temperature of 23°C. The suggestion that tumbling at 23°C reduced nitrite level in uncooked meat does not agree with Krause et al. (1978a) that tumbling resulted in an increased residual nitrite. The cooking procedure resulted in a highly significant ($P<0.01$) reduction in residual nitrite.

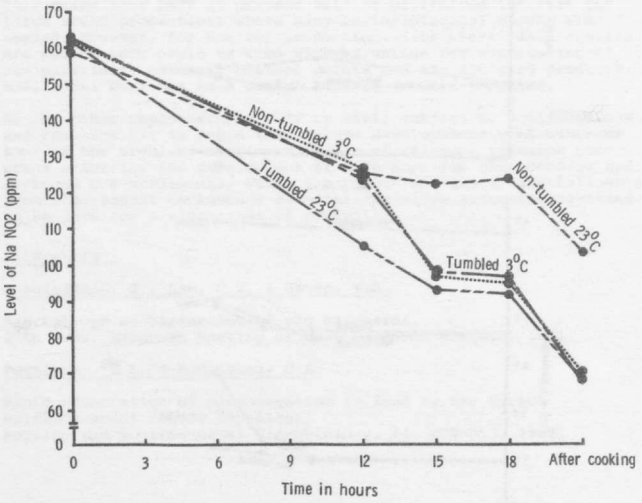

Fig. 2-Contents of sodium nitrite during tumbling and nontumbling process at 3°C and 23°C.

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