Effect of mild curing treatments on the microbial quality and mechanical properties of stored hog and sheep sausage casings

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Summary
Sausage containers, derived from animal intestines, are usually preserved by salting and/or drying. Adequately salted final products are microbiologically fully acceptable. However casings, even those packed in dry salt, sometimes degrade in quality. Experiments were performed to improve salting procedures by using food-grade additives to the salt to obtain both desirable microbiological and mechanical properties. Casings, and sausages obtained from production trials, were tested for these properties. Before storage, selected additives were applied during 3 weeks, and after that the rinsed and re-salted casings were stored for 6 months at different temperatures (10, 20 and 40°C). During storage only growth of halophylic bacteria was observed, this exlusively in the blanks and in the casings initially treated with orthophosphate. This effect was not observed when citric or lactic acid, combined with their Na-salts, were used initially.
Keywords: animal casings, sausage containers, food-grade acids

Introduction
In the meat industry natural animal casings are used as sausage containers. The submucosa layer, which is the actual casing, derived from the small intestine is obtained by cleaning and stripping off mucous and muscular layers. Casings are usually preserved by salting and curing, and/or drying (Fischer & Schweflinghaus, 1988a&b). Mechanical properties of the casings play an important role for both the consumer (toughness) and the sausage manufacturer (strength and elasticity in filling processes).

From an inventory study and literature (Gabis & Silliker, 1974) it was observed that hog and sheep casings from the small intestine come from the animal in a moderately contaminated way. During cleaning microbial counts sometimes increased, except for the salt tolerant organisms. Overall, adequately salted final products were microbiologically fully acceptable. However, even casings packed in dry salt sometimes degrade in quality (Ockerman & Hansen, 1988; Rust, 1988).

Experiments were performed to improve and/or optimize salting and curing procedures by using food-grade additives to the salt. The work focussed on hog and sheep casings from the small intestine by searching for mild treatments that give both desirable microbiological and mechanical properties. With casings from the most promising treatments sausage production trials were made. Sausages obtained were also investigated with respect to their mechanical properties. In this context desirable properties of the casings are reduced microbial counts which can improve the keepability, and no changes in strength of the casings; important for the stuffing purposes.

Further, experiments were done to improve storage and transport procedures with respect to microbial and mechanical properties of the resulting casings. For that, the most promising treatments were applied for 3 weeks, and after that the rinsed and re-salted casings were stored for 6 months at different temperatures (10, 20 and 40°C) to simulate various storage and transport conditions.

Materials and methods
Salt concentrations
For the experiments fresh and sorted hog and sheep small casings of the following calibres (= diametres) for hog casings: 32 - 35 mm, and for sheep casings: 20 - 22 mm were used. For dry salting and curing excess salt was used. That is for hog casings 700 g NaCl per 100 m casings and for sheep casings 300 g NaCl per 100 m casings. After salting, de-watering on a grid was allowed. For slush salting and curing the same amounts of salt were used as for dry salting and curing without de-watering; and with minimal water addition (< 250 ml water per kg salt) to obtain 'slush' salt.

Salt and additives
For the experiments various food grade organic acids and bases and their Na-salts were used as additives to the salt to obtain a final pH-range of 4.5 to 9.5. By using these combinations, additional anti-microbial effects were anticipated (Houtsma *et al.*, 1993). For practical reasons the same concentration was chosen to be used for the acid or base and its Na-salt. Both dry, slush and wet salting and curing were applied. The combinations of chemicals used were well-mixed with the salt. The additives used in explorative trials were, citric acid / Na_3-citrate (code: C) and lactic acid / Na-lactate (code: L), glucono-delta-lacton / Na-gluconate, tartaric acid / Na-tartrate, Na_2CO_3 / $NaHCO_3$, Na_3PO_4 / Na_2HPO_4 (code: P), NaOH and acetic acid / Na-acetate (this latter and L not in dry salting and curing). Coded combinations were used in the final storage experiments. Treated casings were stored for 11 days in closed containers at 20°C for all salting and curing experiments. Blanks (= only salt and no additives used) were included in all experiments.

Storage conditions
Salting and curing was applied for 21 days at 20°C in closed containers. Then the casings were rinsed again and re-salted (dry or slush salting the same as was applied in the salting and curing treatment. However, now with salt only). Next, the casings were stored for 6 months in closed containers at different temperatures (10, 20 and 40°C) to simulate various storage and transport conditions. Intermediate microbiological measurements were done after 3 months storage.

Mechanical and microbiological measurements on casings and sausages
For compression measurements on sausages and casings a texture analyser was used. The probe applied was a blade (1.3 mm thick) that moved downwards through an exactly fitting opening in a fixed table. Casings and sausages were positioned on the table under the blade perpendicular to the opening. Downward displacement speed of the blade was 100 mm/min. The test results are a possible indication for toughness.

A new extension of the probe used for testing the tensile strength of casings was developed. For hog casings it consisted of a bar (30 mm diameter) which was divided in two pieces in the axial direction. For sheep casings the divided bar had a smaller diameter (18 mm). For a measurement, a piece of casing (length of 4 cm) was shoven on the bar. Directly after that, the tensile force and elongation needed for fracturing the casing was determined by displacing the superior half of the bar at 100 mm/min in upward direction. The outcome of this measurement can be seen as an indication for the elasticity of the casing and as a response to the forces that are applied during filling. Additional mechanical measurements on casings were performed to obtain tensile strength in the longitudinal direction and burst pressure.

Microbiological counts consisted of: total aerobic bacteria, *Enterobacteriaceae* and extremely salt tolerant (halophylic) bacteria. All microbiological determinations were done according to standard procedures and with standard media.

Sausage preparation

The meat batter was prepared according to standard recipes. For hog casings Guelder ring sausages were made, and for sheep casings Frankfurters. Sausages were vacuum packed after smoking and pasteurized at 80°C (hog casings: 45 min; and sheep casings: 20 min) to result in so-called 'cooked and smoked' sausages. Sausages were parralel also cooked (same intensity) without smoking. Sausages were vacuum packed and stored at 2°C until measurements were done.

After the storage period sausage production trails were done with the sheep casings stored at both experimental temperature extremes (10 and 40°C), and stored casings were pro-visionally judged by a meat technologist for colour, slipperyness and failures during filling.

Results and discussion

Selected additives to the salt

The acidic combinations of additives finally selected to be used for salting and curing before storage and transport were: citric acid / Na_3-citrate (code: C) and lactic acid / Na-lactate (code: L). The dry C-mixture was used for both slush and dry salting; lactic acid / Na-lactate solutions can not be used for dry salting. As an alkaline treatment phosphates (Na_3PO_4 / Na_2HPO_4; code: P) were selected. All additive combinations to the salt gave reduced microbial counts of total aerobic counts and *Enterobacteriaceae* (by several log-units) for hog and sheep casings compared with using only salt. Further, no effect of using additives to the salt on mechanical properties (tensile strength and burst pressure) of the resulting casings was observed, again when compared with using only salt.

Compression measurements were also done with sausages that were made in the treated casings shortly after the initial treatment (after day 11). Significant effects of the various treatments on the mechanical properties were rarely observed for sausages (cooked and cooked and smoked) in hog casings. Only, for the dry salting and curing treatments, opposite to that for the cooked sausages, a decrease in the force needed to break the cooked and smoked sausages was seen when compared to the blank. For the sheep casings fracture force measurements were also done on the cooked and cooked and smoked sausages and no such pronounced effects were found.

Storage experiments

After 6 months storage at 10, 20 and 40°C for the slush and dry salting the initial treatments with lactic acid / Na-lactate (L) and citric acid / Na_3-citrate (C) showed a good microbiological keepability at the temperatures tested. For the blanks of slush salting and curing a bad smell was observed at all temperatures, and a pink/red colour of the salt was observed at 10, 20 and 40°C. Spoilage with halophylic bacteria was also observed for the cases where treatment with phosphates (P) was applied during both slush and dry salting and curing. When compared to the situation after 3 months storage at different temperatures halophylic bacteria were found to have grown further at the end. This was seen for the casings stored at 20 and 40°C after the dry salting and curing treatment with phosphates (P), and at 10 and 20°C in the blank. Further, such an increase was seen for the casings stored at 10°C after the dry salting and curing teatment with citric acid / Na_3-citrate (C). This was also seen for the blank at 10°C for slush salting and curing and after the treatment with phosphates (P) and subsequent storage at 20 and 40°C.

Sausage production trials with sheep casings

After the storage period sausage production trails were done with the sheep casings stored at 10 and 40°C, and they were provisionally judged by a meat technologist for colour, slipperyness and failures during filling. From these judgements an overall qualification (good or bad) was derived. In general, blank or white casings are preferred above yellow and grey products. Also slipperyness should be good, and few failures should occur.

Storage at 40°C gave a bad overall judgement with respect to colour, slipperyness and failures of the casings in all cases. This was less the case for the casings that were treated with citric acid / Na_3-citrate (C) and phosphates (P) in slush and dry salting and curing when subsequently stored at 10°C. Also the blank (B) was good when slush and dry salting and curing was applied followed by six months storage at 10°C.

Conclusions

From the storage experiments after both dry and slush salting and curing of hog and sheep casings, the treatments L and C were selected that gave the best results with respect to the hygienic aspects that were assessed here. After prolonged storage at various temperatures the treatment with phosphates was found to be less effective with respect to reducing growth of halophylic bacteria. Treatments C and P gave good results for the manually filling characteristics of the casings. Up to now, the latter was not found for treatment L.

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