INFLUENCE OF LOW VOLTAGE ELECTRICAL STIMULATION AND POST-MORTEM SALTING TIME OF TEXTURAL TRAITS OF BEEF BOLOGNA

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SUMMARY

This study compared the textural and sensory traits of bologna produced from either electrically stimulated (ES) or non-stimulated (NS) round muscles which were minced and salted (2.5% NaCl) at 1, 4, 8 and 24 hour post-mortem. Non-stimulated samples salted at 1, 4 and 8 hour exhibited higher ($P < 0.05$) pH values than ES muscles. The same trends are evident in the pH of cooked bologna. The moisture, fat and ash content of the cooked bologna was not affected ($P > 0.05$) by either electrical stimulation or delayed salting. The crude protein percentage of the bologna increased ($P < 0.05$) as salting was postponed. Objective measurements of bologna hardness increased and peaked when salting was delayed 4 and 8 hr in NS samples, but decreased ($P < 0.05$) in all ES samples. Sensory texture scores paralleled the objective measurements. Thermal stability tests indicated that es muscles had reduced water holding capacity when compared to NS muscles as salting time was delayed.

INTRODUCTION

The water-holding capacity (WHC) of muscle minces has been shown to be the primary element involved in the production of stable meat batters rather than the solubility of the salt-soluble muscle proteins (Hamm, 1973, 1981). Addition of salt (NaCl) has two effects, firstly it increases the hydration and swelling of meat proteins resulting in increased WHC by an anion "screening" effect which immobilises water and fixes fat in the meat batter when cooked (Hamm, 1960; Schut, 1976). Fat fixed in this matrix is physically trapped with little being lost during cooking (Hamm, 1975). Secondly, pre-rigor meat, when salted with over 1.8% NaCl (Hamm, 1975), processes greater WHC and better fat "emulsifying" properties than meat in the rigor or post-rigor state. These superior properties are lost when salting is delayed due to the onset of rigor mortis (Hamm, 1975, 1982).

Electrical stimulation (ES) has been found to hasten the onset of rigor mortis by speeding ATP turnover and accelerating glycolysis (Hamm, 1982; Fabiansson and Reutersward, 1985). The use of meat trimmings in sausage production from electrically stimulated beef carcasses poses several interesting problems to the meat processor. The processor would like to identify the point at which the superior WHC and emulsifying abilities of salted pre-rigor meat are lost due to ES and determine how ES might change the texture of the final sausage product.

The objectives of this study, therefore, were to investigate the effects of salting and grinding muscles from electrically stimulated and non-stimulated carcasses at different periods after slaughter on the pH, sensory and textural characteristics of beef bologna.

EXPERIMENTAL METHODS

Preparation of pre-blended beef - Meat was obtained from the round muscles (*M.semimembranosus, M.semitendinosus, M.adductor, M.biceps femoris*, and *M. gracilis*) from three non-stimulated (NS) and three electrically stimulated (ES) (45 volts AC, 1.2 amps, 90 sec) crossbred steers (ca. 400 kg live weight). One-fourth of these muscles (sliced laterally) were composited together at 1, 4, 8 and 24 hr post-mortem, minced (2.5 cm plate), salted (2.5% NaCl), re-minced (3 mm plate), hand mixed (5 min), placed in plastic bags and frozen at -25°C. Samples were held frozen until used approximately eight weeks later.

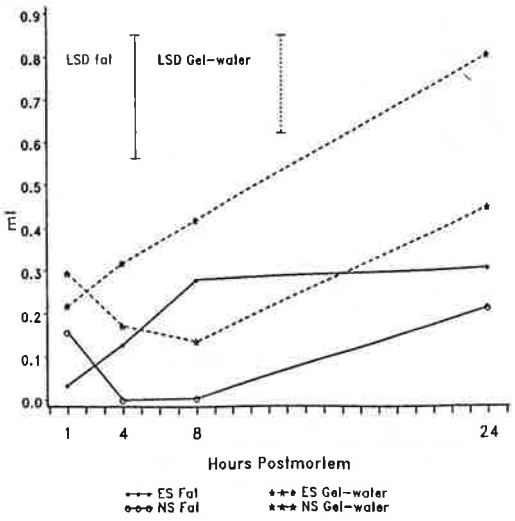

Fig 1. Thermal stability values of bologna influenced by salting time (1,4,8 and 24 hours) and electrical stimulation treatment.

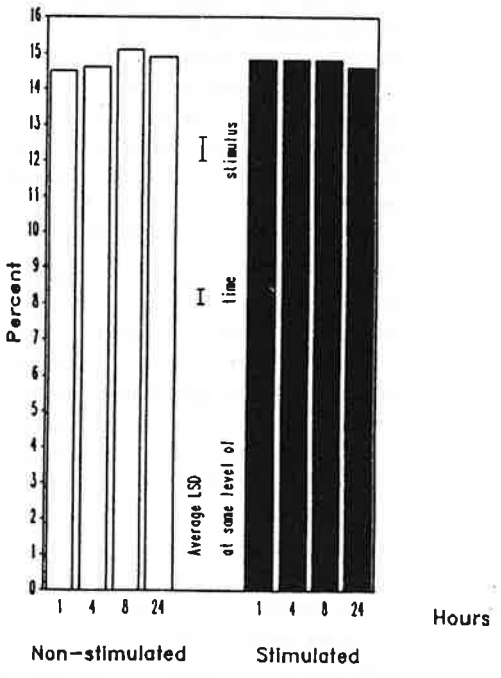

Fig 2. Crude Protein content of bologna from electrically stimulated and non-stimulated round muscle salted at 1,4,8 and 24 hours postmortem.

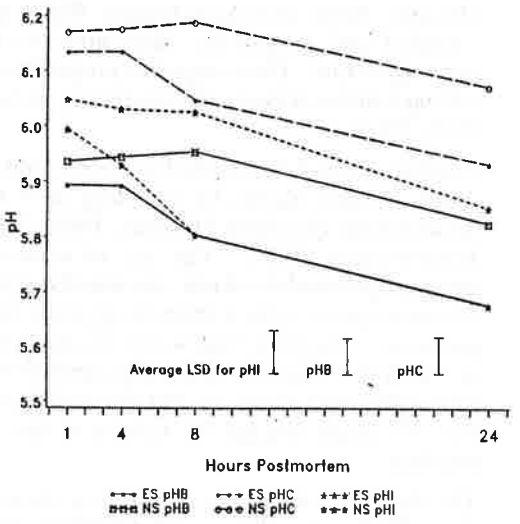

Fig 3. Mean pH values of salted beef mince, raw batter and cooked bologna influenced by salting time (1,4,8 and 24 hours) and electrical stimulation.

Preparation of Bologna -Bologna was prepared by thawing the salted pre-blended beef for 48 hrs, formulating the pre-blended beef (37.6%), beef fat (46%), water/ice (15%), salt (1.15%), dextrose (1%), white pepper (0.25%), nutmeg (0.07%), sodium nitrite (0.01%) and sodium erythorbate (0.04%) (Sofos 1983) and chopping with one-half the ice/water for two minutes. Beef fat (44.9% ether extractable lipid), all spices and cure ingredients, and the remaining water were added to the EMS Muller bowl chopper and chopped until the batter temperature reached 10.5°C.

Thermal Stability - Thermal stability of the raw batters were assessed according to the method of Townsend et al. (1968).

Bologna Processing - The meat batter was stuffed into fibrous casings forming bologna sticks 7.3 cm in diameter by 74 cm in length. The bologna was cooked in a smokehouse (Whitlock Speedy Smoke-n-cooker, Progressive Machinery, Auckland) using the following schedule; 30 min at 40°C; 30 min at 40°C with smoke application, 25% RH; 40 min at 60°C, 60% RH; and approximately two hrs at 80°C, 60% RH to an internal temperature of 68°C. Subsequently, the bologna was immersed in cold water (16°C) for 10 min, and placed in a chiller (2 ± 2°C) overnight.

Textural Measurements - Objective textural properties of beef bologna were determined two days after processing using the General Foods Texture Profile Analysis (Bourne, 1968). Two cm thick slices (in triplicate) of bologna were weighed and compressed to 50% of their thickness twice (cross-head speed 5 cm/min) between two steel plates mounted on an Instron Universal Testing Machine with values for hardness (kg/g sample weight) being recorded.

Proximate Analysis and pH Determinations - Moisture content of bologna was determined by freeze drying approximately 50 g duplicate samples for 48 hr to a constant weight. Moisture-free samples were extracted with petroleum ether for 7 hrs in a Soxhlet fat extractor. The fat-free, moisture-free residue was ashed overnight in a muffle furnace at 500°C. Crude protein was determined by difference. The pH of the salted mince (pH_I), raw batter (pH_B) and cooked bologna pH (pH_C) was determined by the method of Bendall, (1973).

Sensory Evaluation - A consumer sensory panel consisting of 41 untrained individuals evaluated the bologna samples for colour intensity and texture using a six point scale: 6 = extremely dark, firm and 1 = extremely light, soft).

Statistical Analysis - Data for all measured variables were analysed using Residual Maximum Likelihood with day of processing and animal as random effects and electrical stimulation (ES or NS), salting time and the interaction of electrical stimulation x salting time as fixed effects.

RESULTS AND DISCUSSION

Thermal stability - The amount of fat cooked from the meat batters of NS meat did not differ ($P > 0.05$) with salting time, but increased in ES samples when salted at 24 hrs (Figure 1). Non-stimulated samples in which salting was postponed from 4 to 8 hrs released less gel water ($P < 0.05$) than those salted at 1 or 24 post-mortem. Released gel-water increased in ES samples as salting was delayed to 24 hrs. Total cookout paralleled the gel water data (data not reported). These data indicate that the high WHC and concomitant binding ability of pre-rigor salted meat steadily decreased as salting was postponed and the musculature slowly entered rigor in non-stimulated carcasses. Electrical stimulation, however, speeded rigor onset and resulted in increased drip losses possibly caused by altered actomyosin structures (Oreshkin et al., 1986).

Composition - No differences ($P > 0.05$) were found due to treatment or salting time for moisture, fat or ash content (mean values of 58.7%, 22.5% and 3.0%,

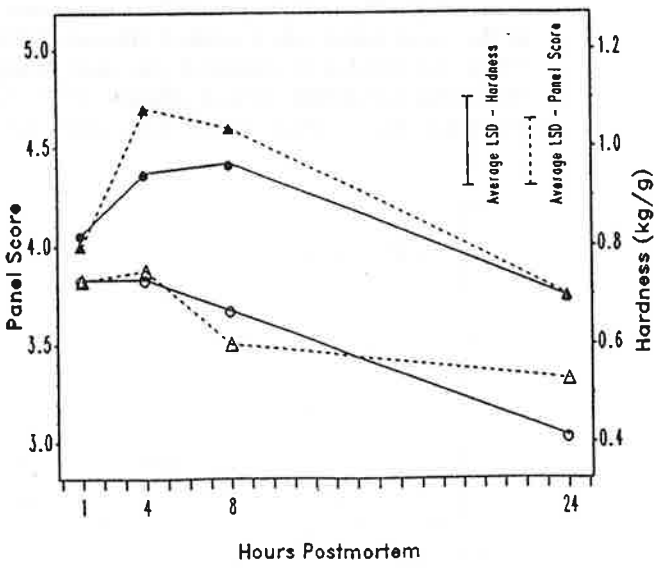

Fig 4. Instron hardness and panel texture for bologna from electrically stimulated and non-stimulated round muscles salted at 1,4,8 and 24 hours postmortem.
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respectively) in the bologna but slight differences ($P < 0.05$) were found in crude protein (Fig 2). Crude protein content tended to increase as salting was delayed in NS samples, but no clear trend was evident in ES samples. Sofos (1985), when comparing meat batters produced using various salt levels (0.8 to 2.4%) and potassium sorbate (0 or 0.26%), observed that batters of lower thermal stability contained lower fat and higher moisture values than more stable batters. Low fat and high moisture levels indicate reduced binding ability of meat batters for fat produced with the lower levels of NaCl (Sofos & Mandrill, 1986). In the present study, electrical stimulation and delayed salting made little significant change in bologna composition.

pH - The pH of salted mince (pH_I) and raw batter (pH_B) generally decreased as pre-blending was delayed from 1 to 24 hrs post-mortem (Fig 3). As expected pH values from ES samples were always lower at each salting time than pH values for NS samples. Salting has been found to inhibit glycolysis in pre-rigor muscles and to stop the accumulation of lactic acid resulting in higher pH values. Salting essentially "locked" the pH at the level found at the time of salting in both ES and NS muscles (Choi et al., 1984). Non-stimulated muscle samples salted at 1, 4 and 8 hrs were in the pre-rigor state (Honikel et al., (1983). Electrical stimulated muscles on the other hand, which were salted at 1 hr (pH_I) were entering rigor at the time of salting. Electrical stimulation lowered ($P < 0.05$) the pH and speeded the onset of rigor in beef muscles (Fig 3). Van et al. (1980) observed that the pH of the meat at the time of pre-blending seemed to be more important to the functional properties of meat proteins than the pH at the time of processing.

Textural Traits - Hardness values for bologna produced from NS pre-blended meat increased ($P < 0.05$) from 0.8 kg up to 1.08 and 1.04 kg/g when meat was salted 4 and 8 hrs post-mortem, respectively (Fig 4) but dropped to 0.70 kg/g at 24 hrs ($P < 0.05$), lower than the initial values. Hardness values of ES bologna were lower than those for NS samples decreasing from values of 0.73 and 0.75 kg/g for meat salted 1 and 4 hr post-mortem to 0.53 kg/g when salted 24 hr post-mortem.

Sensory Evaluation - Panel texture scores decreased ($P < 0.05$) if salting was postponed from 1 to 24 hr post-mortem in ES meat with the lowest values observed at 24 hrs (Fig 4). Sensory panel scores for texture in bologna produced from NS meat were highest when salted at 4 to 8 hrs post-mortem and lowest in bologna produced from meat salted at 24 hrs.

This increase in Instron hardness and panel texture scores in NS samples salted after 4 to 8 hr post-mortem appears not to be related to pH differences because at 4 to 8 hrs since the difference in pH were not great enough to influence extremes in WHC, but is apparently due to the onset of rigor mortis. Hamm (1975) reported an increase in yield value and viscosity in unsalted muscle homogenates prepared from 1 to 24 hrs. After 24 hrs, however, yield and viscosity decreased. In other words, viscosity measurements increased during rigor onset even though WHC decreased. It is probably that the myofibrillar fragments in the batter matrix, caused by chopping, behaved as tightly contracted particulates (NS samples) which resulted in the higher Instron hardness, and sensory texture scores at 4 and 8 hr post-mortem (Acton, personal communication).

Electrical stimulation, however, negated any effects derived from salting pre-rigor beef. It also resulted in texture values which were lower at each salting time than those of the NS treatment in sensory values of texture, and in Instron hardness. Oreshkin et al. (1986), using fluorescent analysis techniques, observed that electrical stimulation significantly altered the structure of actomyosin which resulting in weakened protein structures and increased drip losses.

CONCLUSIONS

The texture of bologna was significantly affected by electrical stimulation in this study indicating that care must be taken in the selection and use of meat from electrically stimulated carcasses. Further research should be conducted to assign bind constraints to ES meat to better characterise their contribution to the texture of the final products.

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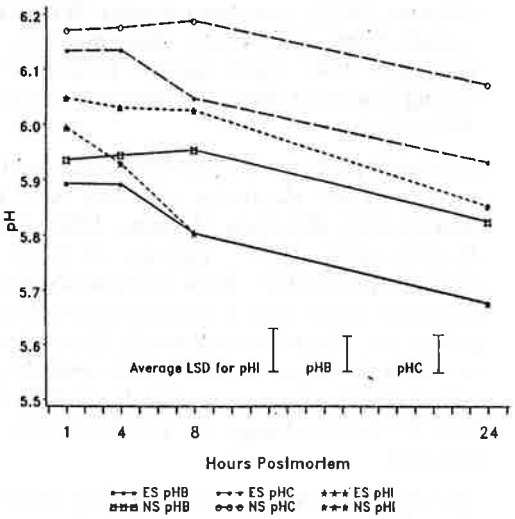

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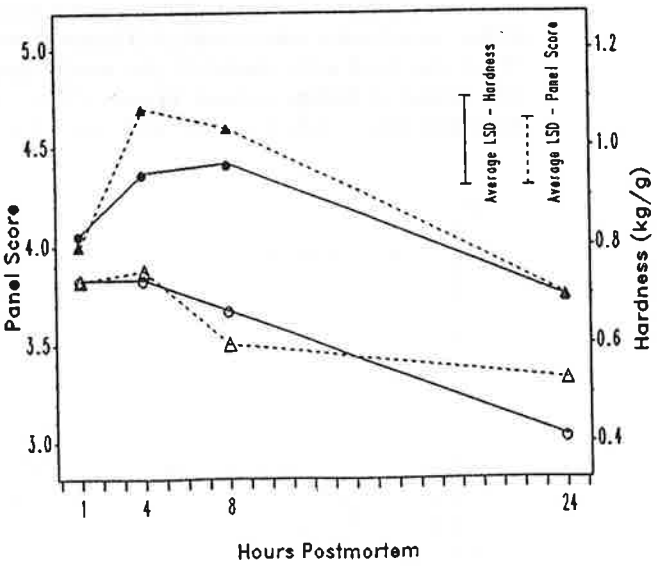

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