6:1 Effect of time of salt addition on water binding properties of hot-boned beef from non-stimulated and electrically stimulated carcasses

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Introduction

Water binding and fat emulsifying properties are important quality characteristics of meat for sausage production. The binding properties of sausage emulsions are influenced by pH, the comminution of the meat and the concentration and time of addition of salt (Honikel, 1983).

Processing in the pre-rigor state or methods of preserving the pre-rigor binding properties of hot meat have been shown both in experiments and practice to be of advantage in sausage production. Thus, the time course of rigor mortis in relation to comminution, salting and processing becomes of decisive importance (West, 1983; Kastner, 1983).

Electrical stimulation which is often incorporated in hot processing systems to ensure the tenderness of steaks and roasts, accelerates the post-mortem processes and might reduce the binding properties of pre-rigor meat (West, 1983) or the available time post-mortem in which the meat must be preblended with salt or frozen to preserve the pre-rigor properties.

The purpose of the present study was to compare the binding properties of hot-boned beef preblended with salt at various times post-mortem with special reference to the practical time available between slaughter, preblending and processing to capitalize on the pre-rigor binding properties of non-electrically stimulated (NES) and electrically stimulated (ES) beef.

Materials and Methods

Hot-boned meat was obtained from five NES and three ES (low voltage system: 80 V, 14 Hz, 30 sec., 10 min p.m.) mature cow carcasses (Norwegian Red cattle; grades I and II, awe. dressed weight 232.2 kg). The right thoracic limb was excised from the carcass within 40 minutes post-mortem, the meat was cut from the bones, mixed thoroughly and run through a grinder without plates.

At 2, 4, 8, 12 and 28 h p.m. in the case of NES and at 2 and 28 hr for ES, the meat was blended with 2.5% salt (equal parts of NaCl and NaCl with 60 ppm $NaNO_2$) added as 15% ice-water solution. The meat was stored in portions of 6 kg at 4°C, chilling starting approximately 3.5 hr p.m. Prior to chilling the meat was kept and transported at environmental temperature. Fortyeight hours after slaughter all raw material categories (NES salted at 2, 4, 8, 12, 28 hr and unsalted control; ES salted at 2, 28 hr and unsalted control) were ground in a meat grinder with a 5 mm plate.

pH of the raw material was determined before each addition of salt and after salting before each production. A 10 g sample (approx. 1 g from 10 randomly selected chunks; triplicate) was homogenized in 50 ml distilled water in a MSE laboratory homogenizer and pH was measured with a Orion Research model 201 digital pH-meter fitted with Ingold LOT 406-M4 combined glass electrode. A similar procedure was used for determining pH in the final sausage emulsions and in the sausages.

Each of the raw material categories were used to produce smoked emulsion type sausages at 48 hr (prod a), 72 hr (prod. b) and 144 hr after slaughter (prod. c). In addition to beef meat, the recipe included lard, water, salt and spices (pepper, ginger, ascorbic acid) to make up sausages with the following calculated chemical composition (including 10% processing shrinkage):

protein: 11.7%, fat: 24.0%, water: 62.3% (82% in "fat free phase"), salt (and spices): 1.96%.

This composition has been found to discriminate well between similar raw material categories with regard to binding properties (Mielnik, unpublished data).

After chopping (8-10 min, the avarage emulsion temperatures at the end of chopping being 18.3, 15.9 and 16.8°C for productions a, b and c, respectively), the emulsion was stuffed into swine casings (diameter: 32 mm; length of sausages: 10-12 cm) using a vacuum stuffer. The sausages in each production series were showered gently with tap water 30 minutes before being placed in the smoke cabinet in order to remove salt from the surface and to eliminate possible differences in surface drying prior to the cooking/smoking procedure which consisted of: drying at 50°C for 15 min (prod. a) or 30 min (prod. b and c), smoking at 50-55°C for 45 min and cooking at 76°C to an internal temperature of 71-72°C. The sausages were then left to cool at room temperature for 1 hr before chilling over night at 4°C.

Total processing loss (%) was calculated from the weight of raw sausages recorded immediately after stuffing and that of smoked/cooked sausages after overnight chilling: $\frac{(\text{raw weight} - \text{cooked weight}) \times 100}{\text{raw weight}}$

The binding properties of the ground beef raw material were also assessed by a frying test method: Patties (55-60 g, diameter: 6.5 cm, thickness: 1.5 cm) were formed in a hand operated patty-forming machine (Hamburger 2000; Système brevete, S.G. D.G.) and fried at 165°C for 4 plus 3 min on a 80 cm diameter frying pan with all meat categories represented in each of 5 repetitions. After frying the patties were left to cool for 1 hr at room temperature and then chilled at 4°C over night. Total frying loss (%) was calculated from the weights of the raw and fried patties (after chilling) as described for sausages.

Microbiological examination was performed on preblended (2 and 28 hr p.m.) and unsalted control samples of NES and ES raw material immediately prior to productions a (48 hr pm) and c (144 hr pm).
Total aerobic counts were determined on plate count agar (PCA; Diffco) after incubation at 4°C for 12 days. Coliform bacteria were determined on red violet bile agar (RVBA; Diffco) after 1 day incubation at 37°C.
(2% NaCl was added to both media used for preblended samples).

Results and Discussion

As shown in Fig. 1, unsalted NES and ES meat reached pH of 5.9-6.0 approximately 6 hr and between 3 and 3.5 hr post-mortem, respectively.

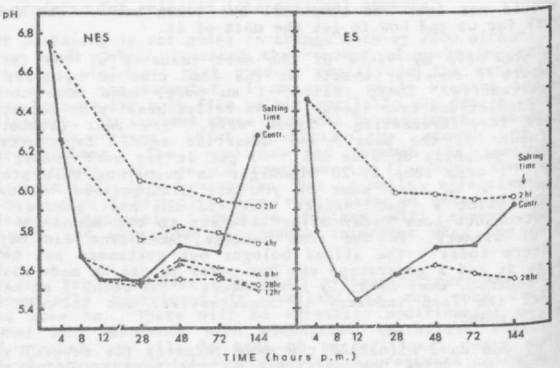

Fig. 1 Changes in pH of NES and ES raw material prior to and after preblending with salt

The thoracic limb is composed of a number of muscles with different metabolic profiles and varying responses to electrical stimulation (Devine et al. 1984; Bendall, 1978), and it is difficult to compare the present findings with the patterns reported for individual muscles in the literature. However, the pattern for ES meat is in the mid-range of four fore-quarter muscles (Mm. brachiocephalicus, pectoralis superficialis, supra spinatus and triceps) of ES cattle at an abattoir using the same ES procedure (Norwegian Meat Research Laboratory, unpublished results, 1983).

Preblending with salt at 2 hr (NES and ES) and 4 hr post-mortem (NES) retarded the pH-drop and resulted in higher ultimate pH-values for these raw material categories compared to those salted at later stages. Both unsalted control samples revealed increases in pH during chill storage extending beyond 48 hr. This can be attributed to microbial spoilage which was evident both organoleptically and from bacterial examination at 144 hr post-mortem (Table 2).

The water holding capacity of the NES meat, expressed as processing loss of sausages (Fig. 2) or frying loss of minced beef patties (Fig. 3), decreased almost linearly when the time of salting was extended from 2 to 8 hr post-mortem, after which no definite change was observed. Both sausages and patties produced from ES meat revealed shrinkage levels comparable to those obtained for NES samples blended at 2 and 28 hr, respectively. Control samples (salt added in conjunction with production) showed markedly higher cooking and frying losses than preblended samples with comparable ultimate pH-values.

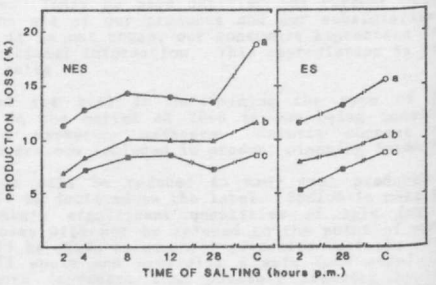

Fig. 2 Total production loss (%) of sausages produced at 48 hr (a), 72 hr (b) and 144 hr p.m. (c), vs. time of salting (hours p.m.) of meat from non-stimulated (NES) and electrically stimulated (ES) carcasses.

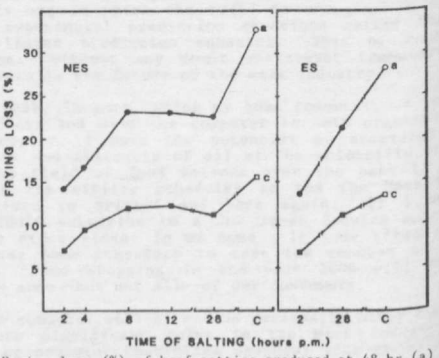

Fig. 3 Frying loss (%) of beef patties produced at 48 hr (a) and 144 hr p.m. (c) vs. time of salting (hours p.m.) of meat from non-stimulated (NES) and electrically stimulated (ES) carcasses.

The relationship between the pH of the meat immediately prior to production and the production loss of the sausages and frying loss of beef patties are illustrated in Fig. 4.

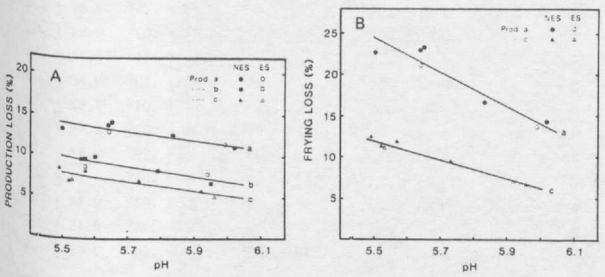

Fig. 4 Percentage processing loss of sausages (A) and frying loss of beef patties (B) as functions of pH of the raw meat immediately prior to production at 48 hr (a), 72 hr (b) and 144 hr post-mortem (c).

Similar relationships were also established between pH of the raw meat prior to salting as well as pH of the sausage emulsions and the parameters expressing water holding properties. The simple correlation coefficients resulting from linear regression analyses of cooking and frying loss vs. the various pH values are summarized in Table 1.

Table 1 Simple linear correlation coefficients (r) between pH values and the corresponding water holding properties of the meat expressed as cooking loss of sausages and frying loss of beef patties (%).

	Cooking loss			Frying loss	
	48 hr	72 hr	144 hr	48 hr	144 hr
pH of meat prior to salting	-0.900**	-0.922**	-0.782*	-0.957***	-0.943**
pH of meat prior to production	-0.943**	-0.867*	-0.870*	-0.947**	-0.980***
pH of meat emulsion	-0.931**	-0.938**	-0.678	-	-

Levels of significance (df = n-2 = 5): 5%, 1% and 0.1% for *, ** and *** respectively.

These results are in general agreement with more extensive studies on the complex influences of post-mortem changes on the binding properties of beef (Honikel et al., 1981; Hamm, 1981).

The apparent overall improvement of the water binding capacity with extended storing of the meat raw material from 48 hr (prod. a) to 72 hr (prod. b) and 144 hr after slaughter (prod. c) is not readily explained. However, the fact that the raw materials were ground immediately prior to the first production (a) might have left this meat with too short a period for optimal distribution of the salt. According to Hamm (1960) the water holding capacity might increase with aging due possibly to an opening of the protein structure. A certain degree of evaporation might also occur during storage of the raw materials. This was not recorded, however, and it could not be confirmed by the chemical analysis of the raw materials (not presented).

The apparently greater reduction in production losses for the unsalted control samples during storage compared to the preblended samples, can be ascribed to increasing pH caused by microbiological activity.

The results from the microbiological examination of the raw material prior to productions a (48 hr p.m.) and c (144 hr p.m.) are summarized in Table 2.

Table 2 Total aerobic counts (Plate count agar, 4°C, 12 days) and coliforms (Violet red bile agar, 37°C, 1 day) of preblended (2 and 28 hr p.m.) and control samples (unsalted) of NES and ES raw material obtained at 48 hr and 144 hr post-mortem.

		Total aerobic counts (x $\log_{10}$/g)		Coliform bacteria (x$\log_{10}$/g)	
		48 hr	144 hr	48 hr	144 hr
NES	2 hr	4.48	6.45	1.74	1.70
	28 hr	4.85	5.30	3.10	2.45
	Contr.	5.91	8.0-9.0	4.55	6.00
ES	2 hr	3.94	6.78	1.98	1.57
	28 hr	4.50	5.18	2.87	2.17
	Contr.	6.00	8.0-9.0	4.15	7.04

A delay in preblending from 2 to 28 hr post-mortem tends to allow for a slight increase in both total aerobic counts and coliforms in samples obtained 48 hr post-mortem, while unsalted controls revealed markedly higher counts and a more flourishing flora on both media. A further 4 day storage at 4°C resulted in slightly greater increase in total aerobic counts (2-3 $\log_{10}$-units) in samples preblended at 2 hr post-mortem compared to the 28 hr-samples (1-1.5 $\log_{10}$-units), due possibly to a longer period of adaptation to the higher salt concentration and/or the higher pH-value in the early salted meat. At this stage both unsalted control samples revealed total aerobic counts and coliforms indicative of pronounced microbial spoilage. These results are in agreement with reports in the literature (Lin et al. 1977; Ockerman & Crespo, 1981) stating that the bacteria responsible for the spoilage of fresh meat at cold temperatures are quite sensitive to and thus inhibited by addition of salt and/or nitrite.

The number of samples in the present study were not sufficient to allow for statistical analysis. However, there were no indications of microbiological differences between samples from NES and ES carcasses. Such differences have been reported in the literature. They have been rather inconsistent, however, and in an extensive review on the microbiology of hot-bonded beef Oblinger (1983) concluded that the practice of hot-boning itself, with or without ES, does not alter the microbiological quality of the resultant products.

Summary and Conlusions

The present study confirms that the good water binding properties of pre-rigor meat can be preserved by hot boning and preblending with salt in the pre-rigor state. In meat from non-stimulated carcasses the pre-rigor binding properties can partly be retained by preblending up to approximately 6 hr post-mortem, whereas in electrically stimulated meat the time course of the pH-fall indicate that the time available for boning and pre-blending is about 3 hr.

It also appears that preblending with salt in the early post-rigor period might have some advantages over non-preblended meat both with regard to water binding properties and microbiological stability.

Despite the fact that no spesific hygienic precautions were taken, preblended meat as opposed to non-salted controls, was found to retain acceptable hygienic quality up to 6 days after slaughter.

This opens for the application of hot-processing as an alternative or supplementary processing system to make advantage of the pre-rigor processing properties of beef in addition to the advantages related to primal cuts and the conservation of energy.

In practice hot-boned, pre-rigor salted, and chilled or frozen meat could be introduced as a raw material with high "bind-values".

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