INJECTION OF CURING SALT SOLUTION DURING THE PRODUCTION OF MEAT EMULSIONS IN AN EXTENDED GRINDER-FILLER SYSTEM

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Abstract – A high shear disperser was attached to a grinder-filler system. Between them an injector nozzle was integrated to inject a curing salt solution during the production of fine dispersed meat emulsions. The amount of curing salt (CS) injected with the solution varied between 0-100wt% in terms of total CS in the meat emulsion formulation. Surprisingly, shorter exposure time of the CS in the meat emulsion did not negatively affect myofibrillar protein solubilization. For all treatments relative dissolved protein content was at around 3.6 g/100g meat emulsion. Moreover, curing was not noticeably impacted by the subsequent addition of the coloring nitrite. Both, photographic images and chromameter measurements exhibited nearly no differences in optical appearance. L* varied between 66.9±0.3 and 67.8±0.3, a* between 10.9±0.1 and 11.2±0.1, and b* between 7.7±0.1 and 8.0±0.1. Furthermore, a trained sensory panel did not assess any differences in color.

Results showed that continuous injection of CS solution is feasible without altering product quality negatively.

Key Words – Energy consumption, High shear disperser, Protein solubilization

I. INTRODUCTION

Due to energy and staff savings, and improved hygiene, industry desires continuous working systems for the manufacture of comminuted meat products. The development of high shear dispersers that can be attached after the grinder-filler may also permit the continuous manufacture of fine dispersed meat products [1]. Irmscher *et al.* continuously prepared fine dispersed meat emulsions with a high shear disperser, consisting of a saw-tooth rotor-stator system, connected to a conventional grinder-filler system.

By the integration of an injector nozzle prior to the emulsifier liquid components such as water or curing salt solutions can be added continuously into the production process [2].

Curing salt (CS), consisting of 0.45wt% nitrite in sodium chloride, is added to emulsified sausages for organoleptic antimicrobial but also for technologically reasons [3, 4]. Nitrite reacts with the muscle pigment, myoglobin and forms after cooking the cured-meat pigment, nitrosohemochrome. This leads to the curing of the meat emulsion creating the typical red color.

Myofibrillar proteins selectively bind chloride ions of NaCl leading to an increased negative charge within the protein matrix and resulting in repulsive forces between the protein molecules. As a result, myofibrils start to swell [5]. Hence, a raise of ionic strength in the meat batter stabilizes myofibrillar proteins in solution. After heating myofibrillar proteins form a three dimensional gel network entrapping water and fat globules. Consequently, water binding capacity of meat emulsions enhances.

We hypothesize that the application time between CS and the meat pre-mixture may affect the solubilization of myofibrillar proteins and may influence curing during the production of meat emulsions in an extended grinder-filler system. A curing salt solution with varying CS content (0-100wt% related to meat emulsion formulation) were injected via a nozzle after grinder unit and prior to the high shear disperser. Total CS concentration in the meat emulsions was set to 18 g/kg as the rest of CS was already added to the pre-mixture. Thus, increasing proportion of CS had shorter exposure time in the meat emulsion.

II. MATERIALS AND METHODS

Meat emulsion preparation. In a T-paddle mixer a pre-mixture of 50wt% lean pork meat (5 mm ground), 27wt% pork belly (5 mm ground), and 8wt% crushed ice with 5.0 g/kg spice mixture, 1.5 g/kg diphosphate, and 0.5 g/kg ascorbic acid was generated. The amount of CS in the pre-mixture was varied between 0-18.0 g/kg. The remaining salt to a constant total content of 18.0 g/kg in the meat emulsion was injected as 15wt% liquid solution with a nozzle.

Table 1 Concentration of curing salt (CS) in injected solution and pre-mixture.

Relative amount of CS injected with solution (%)	CS (g/kg meat emulsion) in injected solut.	pre-mixture
0	0.0	18.0
25	4.5	13.5
50	9.0	9.0
75	13.5	4.5
100	18.0	0.0
without injected solut.	---	18.0

Meat emulsions were prepared in an extended grinder-filler system (Figure 1) consisting of a vacuum filler with an attached grinder unit and a high shear disperser. An injection nozzle was integrated between grinder and high shear disperser.

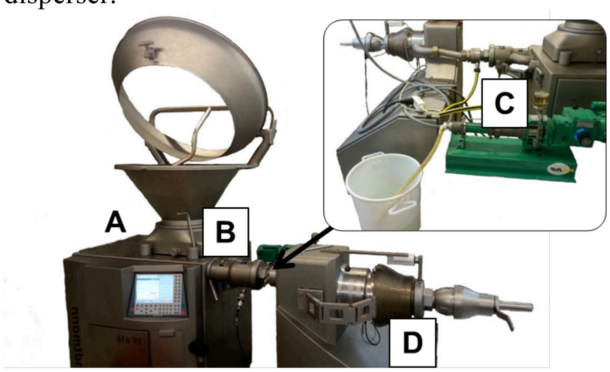

Figure 1. Extended grinder-filler system consisting of vacuum filler (A), grinder (B), injection nozzle (C), and high shear disperser (D).

V_{filler} was set to 34 L/min and V_{pump} was 6 L/min resulting in a V_{total} of 40 L/min. N_{knifes} in the grinder was set to 236 rpm and N_{rotor} in the high shear disperser was set to 3000 rpm. Meat emulsions were directly filled into impermeable casings, heat treated until a core temperature of 72°C, and stored at 1°C until analysis.

Analysis. Photographic images were taken under defined conditions with a Pentax K5. Water, protein, fat, and sodium chloride content of sausages were analyzed according to the AOAC methods [6]. Water binding capacity of the raw meat batters was determined gravimetrically after a heat treatment (45 min at 98°C). Dissolved protein content was quantified by a color reaction according to Bradford after extraction in an isoionic sodium chloride solution. Firmness of sausage slices was measured in an Instron 1011 texture analyzer. Color of sausage cross sections was captured in the CIE L*a*b* color space with a Konica Minolta chromameter CR-200. Sausage slices were evaluated by a trained panel (n=25) regarding redness and texture. Results were analyzed with statistical software SAS 9.3 from SAS institute (Cary, USA).

III. RESULTS AND DISCUSSION

Directly after processing, temperatures of the meat emulsions prepared with an injected CS solution ranged from 12.9-15.8°C while a sample prepared with conventional formulation and process in an extended grinder-filler system exhibited just a temperature of 6.5°C. However, this was expected as the pre-mixture featured a temperature of -2.7°C prior to processing due to the formulation contained solely crushed ice instead of a CS solution.

Chemical analysis proved that injection of CS solution was sufficient. Water content was around approx. 64wt%. Fat and protein content were between 21.0-22.7wt% and 11.8-12.4wt%, respectively. Sodium chloride content varied between 1.62 and 1.84wt%.

Photographic images of the sausage cross sections illustrated in Figure 2 show that all meat emulsions were stable during heat treatment. That is that at none of the sausages visible water or fat separation occurred. The equal emulsion stability during a heat treatment could also be discerned from the water binding capacities which were determined as liquid loss after heating the meat emulsions. Relative liquid losses ranged from

13.4±1.2 g/100g meat emulsion when no CS was added with the injected solution to 10.6±1.4 g/100g while 25wt% of the total CS was added with the injected solution. In case of total CS injection as solution the meat emulsions lost 11.3±0.4 g/100g liquid.

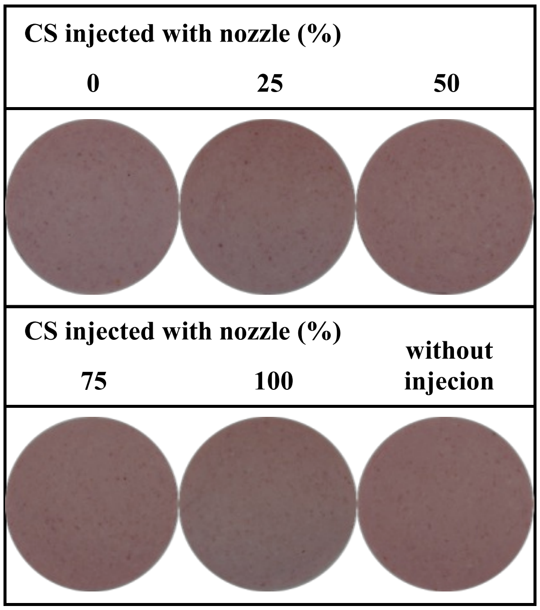

Figure 2. Sausage cross sections produced with varying CS amount in injection solution and pre-mixture, respectively.

No significant differences between the samples, where a CS solution was injected, and a control without injection in terms of structural properties could be observed. Both, visible fat particles and visible muscle particles had similar particle diameters. Confocal laser scanning microscopy images confirmed equally formed protein matrices at all samples. Also, the color appearance revealed no differences. The results of the sensory evaluation are shown in Figure 3.

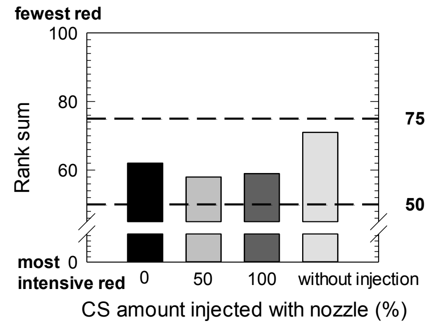

Figure 3. Rank sum versus CS amount injected with nozzle ant sensory evaluation of redness of sausage slices (n=25, α=0.05).

The sensory panel evaluated the redness of sausage slices in a rank order test. Testers could not find any significant differences in red color (p>0.05). This impression was confirmed by L*a*b* color values as well as by sensory evaluation of the redness.

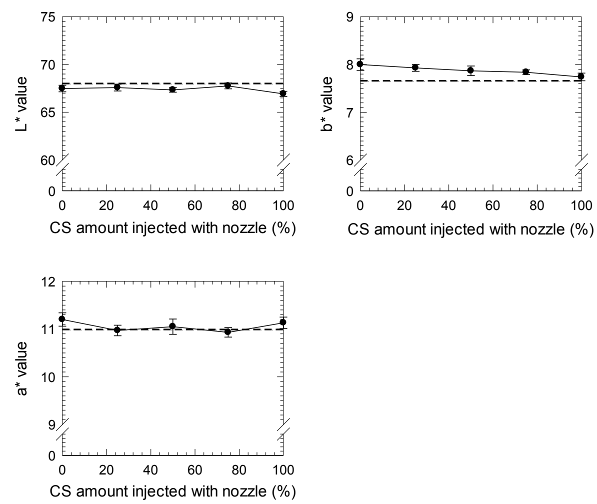

Figure 4. L*a*b* values of sausage slices prepared with varying amount of CS (0-100wt%) in injection solution and control sample without injection (dashed line).

The amount of CS added with the injected solution did not affect L*, a*, and b*, Figure 4. In addition, there were no differences for sausage slices that had been prepared without injecting any solution. L* was located at 66.9±0.3 to 67.8±0.3, a* at 10.9±0.1 to 11.2±0.1, and b* at 7.7±0.1 to 8.0±0.1 for sausage slices when a solution was injected. The sample that had been prepared solely with crushed ice featured L*=68.0±0.3, a*=11.0±0.1, and b*=7.7±0.2.

The firmness of sausage slices strained in a Kramer shear cell is shown in Figure 5.

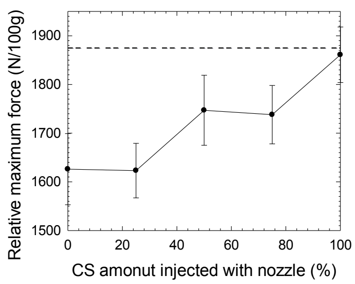

Figure 5. Relative maximum force versus amount of CS in the injected solution and control prepared without injection (dashed line).

Surprisingly, the relative maximum force increased with rising amount of CS incorporated with the injected solution from 1630±70 at 0wt% CS to 1860±60 N/100g product at 100wt% CS. This means that longer exposure times of sodium chloride in the meat emulsion resulted in a less firm protein network. This finding stands in total contrast regarding the nearly equal relative contents of dissolved proteins, which were around 3.3±0.1 to 3.6±0.1 g/100g meat emulsion at all samples. The firmness of the sample, where the total CS was incorporated with the solution, was nearly equal to the samples prepared with the conventional formulation containing only crushed ice. The sensory panel confirmed the instrumentally measured firmness. They rated the sample, where a water solution without CS was injected as the least hardest ($p<0.05$). Between the other samples, no significant differences could be determined.

When replacing a part of the crushed ice by an injected solution, the temperature of the pre-mixture increased from -2.5 to ~0°C. Consequently, relative acting torque of the high shear disperser decreased and energy consumption could be reduced by up to 22%. The reduced acting torque was due to the lower exerting forces, when cutting unfrozen raw material. This is in good agreement with the observations of Brown et al. [7]. They reported substantial differences between forces exerting when frozen (-5°C) or unfrozen (+5°C) beef cubes were cut.

IV. CONCLUSION

Curing salt amount injected via nozzle impacted neither myofibrillar protein solubilization nor curing. Thus, color and water binding capacity were relatively equal. Firmness was slightly influenced by curing salt amount in the injected solution. However, when total amount of curing salt was incorporated with the solution sausage firmness did not differ compared to the firmness of samples prepared with the conventional grinder-filler process. Nevertheless the study exposed, injecting the curing salt in solution is feasible during preparation of fine dispersed meat emulsions in an extended grinder-filler system with integrated injector nozzle.

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