MODIFICATION OF TEXTURAL PROPERTIES OF REDUCED-SALT EMULSION-TYPE SAUSAGE BY GLUCOSE OXIDASE

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I. INTRODUCTION

The quality of comminuted, emulsion-type sausage is evaluated by a number of parameters, of which textural properties are the most highly regarded. In particular, the ability of salt-soluble myofibrillar protein (MFP) to form a three-dimensional gel matrix capable of entrapment of water and fat particles is a determinant factor for the success of such meat products. To produce a cohesive gel during sausage preparation, salt (NaCl up to 3%) is generally added to extract MFP [1]. In a previous study, we had observed that protein structural modification with Glucose Oxidase (GluOx) could enhance the gelling potential of MFP [2]. Further, we found that the increased exposure of Lys and Gln groups due to GluOx treatment facilitated protein cross-linking by transglutaminase (TGase) via ε-(γ-Glu)-Lys isopeptide bonds and promoted the gelation of MFP [3]. The objective of the present study was to explore the feasibility of applying GluOx/TGase in emulsion-type sausages to improve the textural attributes of cooked products.

II. MATERIALS AND METHODS

Porcine lean shoulder meat (48 h post-mortem) and back fat were ground through a 4.5 mm orifice plate. Emulsion-type sausages were formulated with lean meat (60%), sodium chloride (1.5 or 3%), dextrose (0.5%), sodium nitrite (78 ppm), sodium erythorbate (275 ppm), and pork fat (15% final fat content). These ingredients were mixed with ice/water in a food processor with the above order. Meat batters were treated with GluOx (0, 20, 100, or 500 ppm) and set at 4 °C for 12 h, and then reacted with TGase (0 or 0.1%) at 4 °C for 2 h. The meat batters were stuffed into 19 mm diameter cellulose casings and slowly cooked in a water bath from 20 to 75 °C at a heating rate of approximately 0.7 °C/min.

The weight of each sausage link (~12 cm length) was measured before and after cooking to determine the cooking yield per the following equation: cooking yield (%) = [(raw sausage weight – cooked sausage weight)/raw sausage weight] × 100. Textural analysis was performed on 19 mm thick sausage sections using an Instron machine. Firmness was defined as the peak force (N) during a 3.8 mm compression test with a speed of 20 mm/s. To determine the breaking strength, another set of sausage samples (19 mm height) were compressed until the structure was disrupted. The initial force (N) required to break the sample was recorded to express the breaking strength.

Data from the two independent trials (2 batches of sausage, n=2), each with duplicate sample analyses, were collected. The results were submitted to the analysis of variance using the general linear model's procedure of Statistix software 9.0 (Analytical Software Tallahassee, FL, USA). Significant ($P < 0.05$) differences between means were identified by the least significance difference all-pairwise multiple comparisons.

III. RESULTS AND DISCUSSION

The textural profile and cooking yield of cooked sausages are summarized in Table 1. Under the reduced-salt condition (1.5% NaCl), the firmness increased by a net of 25-34% for GluOx oxidation, 49% for TGase cross-linking, and 36-60% for combined GluOx/TGase treatment ($P < 0.05$), when compared with non-oxidized control. For sausage with 3% NaCl, the firmness was slightly decreased by treatment with 20 or 100 ppm GluOx. When treated with combined GluOx/TGase, the firmness increased by 18-23% ($P < 0.05$). The GluOx/TGase treatment was notably more effective under the low-salt condition.

A nearly 2-fold increase of rupture force (breaking strength) was recorded for the GluOx/TGase treatment at both salt levels ($P < 0.05$), indicating an improved structural integrity. The binding strength of the 1.5% NaCl sausage reached 50.4 N with GluOx/TGase, comparable to the strength for non-oxidized control with 3% NaCl (53.0 N), in accordance with similar increases in firmness. As reported previously [3], GluOx/TGase catalytically promoted protein cross-linking and aggregation via disulfide and isopeptide bonds, giving rise to greater gelling potential of the MFP-lipid emulsion composites. The occurrence of stronger protein-protein interactions within the microenvironment of the sausage matrix was accentuated by GluOx/TGase, with a consequent rheological and textural quality enhancement in low-salt sausages. The cooking yield slightly decreased after GluOx/TGase treatment but the effect was nonsignificant ($P > 0.05$). No obvious off-flavor was noted for 50 ppm GluOx treatment presumably due to the antioxidant balance effect of nitrite.

Table 1 Changes in the textural parameters and cooking yield of emulsion-type sausages containing 1.5 or 3% NaCl and treated with GluOx (12 h) followed by cross-linking with TGase (2 h) at 4 °C.

NaCl	*GluOx (ppm)*	TGase (%)	Firmness (N)	Rupture force (N)	Cooking yield (%)	TGase (%)	Firmness (N)	Rupture force (N)	Cooking yield (%)
1.5%	***0***	**0**	6.8 ± 0.8^{d} (–)	20.6 ± 2.6^{d}	88.1 ± 3.0^{ab}	**0.1**	10.1 ± 1.6^{ab} (49%)	41.8 ± 4.1^{b}	88.1 ± 3.0^{ab}
	50		8.6 ± 0.6^{c} (25%)	21.2 ± 1.7^{cd}	90.6 ± 0.3^{a}		9.4 ± 1.2^{bc} (38%)	40.5 ± 5.1^{b}	90.9 ± 0.3^{a}
	100		8.7 ± 1.3^{c} (27%)	21.2 ± 1.4^{cd}	84.7 ± 2.8^{abc}		10.6 ± 0.9^{ab} (56%)	50.4 ± 3.9^{a}	84.7 ± 2.8^{abc}
	200		9.1 ± 0.3^{bc} (34%)	24.7 ± 2.4^{c}	84.3 ± 3.8^{abc}		11.3 ± 0.6^{a} (66%)	42.3 ± 2.1^{b}	84.3 ± 3.8^{abc}
3%	***0***	**0**	7.9 ± 0.6^{CD} (–)	53.0 ± 2.7^{C}	85.6 ± 3.0^{A}	**0.1**	7.8 ± 0.6^{DE} (–1.8%)	91.3 ± 11.0^{B}	88.1 ± 1.8^{A}
	50		7.0 ± 0.5^{E} (–11%)	49.7 ± 6.3^{CD}	86.7 ± 5.1^{A}		9.3 ± 0.9^{AB} (18%)	107.7 ± 8.1^{A}	88.0 ± 1.1^{A}
	100		7.3 ± 0.6^{DE} (–7.6%)	50.5 ± 5.2^{CD}	83.1 ± 10.3^{A}		9.3 ± 0.7^{AB} (18%)	103.8 ± 7.2^{A}	87.0 ± 1.0^{A}
	200		8.6 ± 0.4^{BC} (13%)	42.7 ± 3.0^{D}	86.8 ± 7.9^{A}		9.8 ± 0.8^{A} (23%)	91.6 ± 6.5^{B}	83.7 ± 1.6^{A}

[a-c, A-E] Means within the same quality trait at the same NaCl level without a common letter differ significantly ($P < 0.05$).
*Data in parentheses denote the change relative to the non-oxidized control.

IV. CONCLUSION

The combined GluOx/TGase treatment improved the textural properties of emulsion-type sausages, which was confirmed by increased firmness and breaking strength. Such effects were especially obvious for low-salt (1.5% NaCl) sausage which obtained a firmness level comparable to that of the control high-salt (3% NaCl) sausage. Hence, the combined GluOx/TGase treatment may be applied to the processing of reduced-salt sausage to compensate for the lower amount of salt-extractable, gelation-impactful MFP.

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