THERMAL AND RHEOLOGICAL PROPERTIES OF PORK EMULSION AS AFFECTED BY DIFFERENT CONTENTS OF SALT AND FAT REPLACERS

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Abstract – Thermal and rheological properties of pork emulsion with different salt (1%, 3% w/w) and fat content (10% fat, 5% fat + 5% microcrystalline cellulose gel, MCG) were investigated. Substitution of fat with MCG significantly lowered enthalpy of melting fat particles ($p<0.05$) and elevating final protein denaturing temperature ($p<0.05$) regardless of salt content. Increase in salt content resulted in reduction of onset and peak temperature, and enthalpy of protein denaturation ($p<0.05$). Additionally, salt content greatly influenced storage modulus and initial phase angle of pork emulsion ($p<0.05$).

Key Words – differential scanning calorimeter, meat emulsion, rheology

I. INTRODUCTION

Due to an increase in consumer health concern, the attempt of reducing sodium and fat in the emulsion-type sausages has been of interest. Numbers of research intensively focused on quality of emulsion-type meat products as subjected to adjusting salt content or replacing meat fat with other ingredients. However, information regarding interaction among those factors on thermal and rheological properties of pork emulsion is still limited. The objective of this study was to investigate the effects of replacing meat fat with microcrystalline cellulose gel (MCG) and reducing salt content on thermal and rheological properties of pork emulsion.

II. MATERIALS AND METHODS

Pork emulsion was prepared as previously described [1]. Each batch composed of ground pork shoulder (54.6%), ground back fat, sodium chloride (NaCl), sodium tripolyphosphate (0.3%), water (6.6%) and ice. Content of fat, NaCl and MCG were varied as follows, FL: 10% fat, 1% NaCl; FH: 10% fat, 3% NaCl; LL: 5% fat, 5% MCG, 1% NaCl; LH: 5% fat, 5% MCG, 3% NaCl. Temperature of the batter was maintained at below12°C during mixing. Thermal properties of the batter were determined using differential scanning calorimeter (DSC) model 822E (Mettler-Toledo GmbH, Switzerland) during heating from 2°C to 100°C with heating rate of 10°C/min [2]. Rheological pattern was examined according to the small-amplitude oscillatory procedure with constant frequency (0.1 Hz) and constant amplitude (0.015) using Gemini 200 HR Nano rheometer coupled with 20-mm parallel plate (Malera-Bohlin Instruments, US). Storage modulus and phase angel were automatically recorded under temperature sweep (25°C to 70°C, 1°C/min) [2]. The experiment was repeated twice (two replicates). All measurement was done in duplicates. The data was subjected to analysis of variance with 2x2 factorial complete randomized design. Mean difference was determined based on Duncan's multiple range test ($p<0.05$). The data are reported as mean ± standard deviation.

III. RESULTS AND DISCUSSION

The DSC results (Table 1) illustrate that the emulsion exhibited two thermal transitions. For the first transition, ranging between 25°C to 33°C, onset temperature and enthalpy were significantly affected by substitution of fat with MCG ($p<0.05$). This transition corresponds with melting of fat particles in the emulsion [3]. Hence, lowering fat by 50% resulted in two-fold decrease in the enthalpy. The second transition occurred during heating the emulsion between 50°C to 75.7°C. The transition related with denaturing of protein during heating [3]. Increasing NaCl content in the emulsion significantly reduced onset and peak temperatures as well as the enthalpy ($p<0.05$), indicating the greater degree of protein denaturation in the FH and LH than that of the FL and LL. The higher the NaCl content, the greater the degree of myofibrillar proteins was solubilized within the emulsion, thus requiring lower temperature and energy to further unfold during DSC determination. Focusing on the second transition, however, the higher final temperature of the LL and LH than those of the FH and FL was detected ($p<0.05$). The adding MCG might interrupt unfolding proteins, delaying completion of protein denaturation. No interaction between fat and salt content was found ($p\geq0.05$).

Table 1 Thermal properties of pork emulsion [1]

Parameter	Sample FL	FH	LL	LH	Statistical significant Fat	Salt	Interaction
Peak 1							
Onset temperature (°C)	$25.22^{a} \pm 1.05$	$25.77^{ab} \pm 0.73$	$26.58^{ab} \pm 0.94$	$26.70^{b} \pm 1.07$	*	ns	ns
Peak temperature (°C)	28.40 ± 2.10	29.43 ± 0.40	29.75 ± 0.58	29.97 ± 0.66	ns	ns	ns
Final temperature (°C)	32.13 ± 1.56	32.97 ± 0.44	33.25 ± 0.47	33.27 ± 0.44	ns	ns	ns
Enthalpy (J/g batter)	$1.92^{b} \pm 0.61$	$1.56^{b} \pm 0.30$	$0.78^{a} \pm 0.23$	$0.73^{a} \pm 0.19$	**	ns	ns
Peak 2							
Onset temperature (°C)	$51.89^{a} \pm 0.06$	$50.29^{b} \pm 0.16$	$52.06^{a} \pm 0.04$	$50.31^{b} \pm 0.14$	ns	**	ns
Peak temperature (°C)	$58.17^{a} \pm 0.00$	$57.30^{b} \pm 0.12$	$58.28^{a} \pm 0.07$	$57.28^{b} \pm 0.09$	ns	**	ns
Final temperature (°C)	$67.63^{a} \pm 0.06$	$67.07^{a} \pm 0.58$	$75.52^{b} \pm 0.65$	$75.70^{b} \pm 0.65$	**	ns	ns
Enthalpy (J/g batter)	$1.54^{bc} \pm 0.07$	$1.31^{a} \pm 0.20$	$1.56^{c} \pm 0.15$	$1.36^{ab} \pm 0.03$	ns	*	ns

[1] Different superscripts indicate statistical significant difference ($p<0.05$). * $p<0.05$, ** $p<0.0001$, ns = no significant difference

Based on rheological properties (Fig 1), no interaction between fat and NaCl was found ($p \geq 0.05$). Strong effect of NaCl on storage modulus (G') and initial phase angle was observed. The FH and LH samples exhibited lower initial G' but dramatic increased final G' ($p<0.05$), indicating an improved gel strength of pork emulsion after cooking.

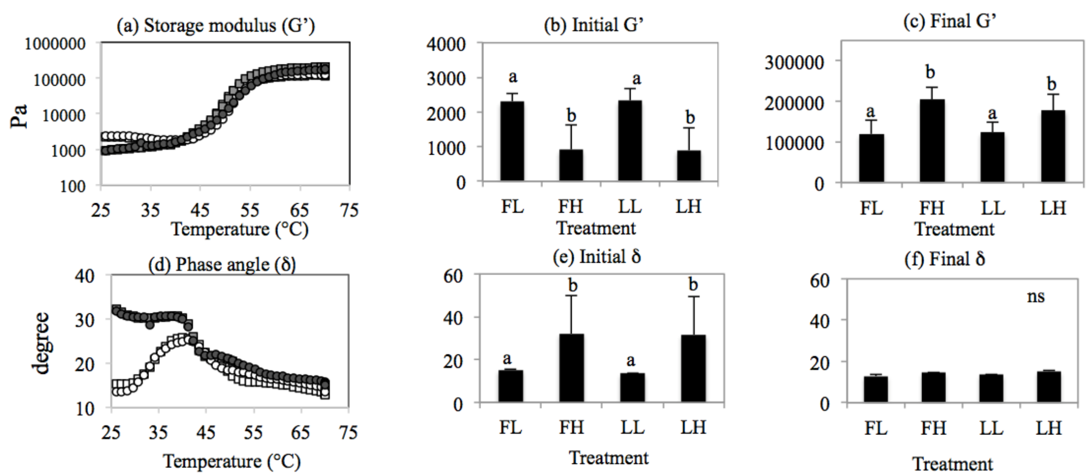

Fig 1 Storage modulus (a) and phase angle (d) of pork emulsion during heating, where FL (□), FH (■), LL (○) and LH (●) pork emulsion. Bars indicate mean ± standard deviation of initial G' (b, c) and phase angle (e, f). Different letter above bars indicate significant difference ($p<0.05$). ns = no significant difference ($p \geq 0.05$)

IV. CONCLUSION

Although no interactions between replacing fat with MCG and lowering NaCl content on thermal and rheological properties were observed, main effects of both fat and NaCl content were apparent. Substitution of fat with MCG impacted enthalpy of fat melting. Difference in NaCl content in pork emulsion greatly affected protein denaturing temperature shift. Increase in NaCl greatly improved gel strength of cooked pork emulsion.

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