EFFECT OF TEMPERATURE AND FAT TYPE ON THE VISCOELASTIC PROPERTIES OF MEAT BATTERS PREPARED WITH WHITE AND RED CHICKEN MEAT

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Abstract – This study investigated the effect of temperature (50 – 80 °C), fat composition (high vs. low degree of saturation) and meat type (red vs. white muscle fibers) on the viscoelastic properties of meat batters. Therefore, the viscoelastic properties of 4 different meat batters were investigated during different time-temperature profiles. In most cases, higher temperatures lead to stronger gels. The fat type with the highest degree of saturation always resulted in the strongest gels. Meat batters prepared with red meat resulted in the strongest gels after heating, but the effect was less pronounced after cooling or at the end of the process. In summary, temperature and fat type greatly affected the viscoelastic properties of the final product, whereas the effect of meat type was less pronounced.

Key Words – Isothermal heating, Muscle fiber types, Fatty acid composition, Rheological Properties

I. INTRODUCTION

Gel-type emulsified meat products such as cooked sausages consist of a finely comminuted lean meat fraction mixed with a fat fraction, ice and additives. The functional behavior of the raw materials together with the processing conditions largely define their structure and macroscopic properties. Temperature and muscle fiber type have been shown to have a significant impact on the gelation properties of myofibrillar proteins [1] and therefore the quality of meat products. The chemical composition of pork fats can vary widely. Fats with a different chemical composition result in a different crystallization behavior during cooling, which is important with regard to structure formation [2]. Moreover, some macroscopic properties of gel-type emulsified meat products such as hardness and mouthfeel are mainly determined by the properties of the crystallized fat. Therefore, the aim of this study was to elucidate the effect of temperature, fat composition and meat type on the viscoelastic properties of meat batters. Knowledge of the structure-forming potential is a support on how to steer the quality of meat products through intelligent choice of raw materials and processing conditions.

II. MATERIALS AND METHODS

Meat batters with two types of meat (white versus red chicken meat) and two types of lard derived from pork backfat (33.5% degree of saturation versus 42.0% degree of saturation) were prepared. Meat was comminuted together with salt (3.5%), ice and lard for 3 minutes at 3500 rmp in a Grindomix GM200 cutter. The amount of raw materials was calculated so that the total system contained 55.2% water, 8.6% protein and 35.5% fat. The viscoelastic properties of the 4 different model systems were tested (AR2000ex, TA instruments) according to the following time-temperature profiles: (1) isothermal heating step for 60 minutes at 4 different temperatures (50-60-70-80 °C); (2) cooling step to 7 °C at a controlled cooling rate (2 °C/min); (3) isothermal step for 60 minutes at 7 °C. G' (elastic modulus) and δ (phase angle) were recorded. The influence of temperature, fat type and meat type on G' after isothermal heating (G'high), G' after cooling (G'cool) and G' at the end of the process (G'process) were evaluated via three-way ANOVA using IBM SPSS Statistics 22. Analysis were performed on the logarithmic values of G'. Mean and standard errors (n=3) are presented.

III. RESULTS AND DISCUSSION

Generally, G' increased during the isothermal heating step at 50, 60, 70 and 80 °C, probably due to the denaturation and aggregation of myofibrillar proteins and the formation of a more permanent elastic gel network. During the first part of the cooling phase, G' further increased, probably because of the interactions between the denatured proteins [3]. During the second part of the cooling phase, at temperatures lower than 30 °C, another sharp increase in G' was observed, presumably attributed to the crystallization of the lipids [2]. During the isothermal step at 7 °C G' slightly decreased, probably due to the stabilization of the formed gel network. δ values during the total process were low, indicating that all meat batter systems predominantly exhibited elastic properties. The influence of temperature (of the isothermal heating step), fat type (degree of saturation) and meat type (white or red muscle fibers) on G' after isothermal heating (G'high), G' after cooling (G'cool) and G' at the end of the process (G'process) are presented in Table 1.

Table 1: Effect of temperature, fat type and meat type on G'high, G'cool and G'process (mean ± standard errors, n=3)

		G'high (10^3 Pa)		G'cool (10^3 Pa)		G'process (10^3 Pa)	
T (°C)	Saturation (%)	White meat	Red Meat	White meat	Red Meat	White meat	Red Meat
50	33.5	11.9 ± 2.9	27.8± 4.7	26.9 ± 3.6	39.9 ± 3.0	21.2 ± 4.0	26.5 ± 3.5
	42.0	33.2 ± 5.2	46.8 ± 8.2	45.8 ± 9.1	68.6 ± 9.9	33.3 ± 4.1	48.6 ± 9.2
60	33.5	27.3 ± 3.2	37.0 ± 8.4	81.7 ± 9.1	88 ± 14	82.0 ± 4.5	83.3 ± 7.9
	42.0	22.2 ± 4.6	99 ± 28	109.8 ± 1.2	180 ± 22	116 ± 4.7	129 ± 24
70	33.5	20.7 ± 0.93	45.2 ± 5.2	130 ± 11	147 ± 28	147 ± 20	137 ± 23
	42.0	22.8 ± 2.6	70.0 ± 3.4	208.7 ± 4.7	205 ± 24	215 ± 18	192 ± 40
80	33.5	22.7 ± 1.2	34.6 ± 8.9	199 ± 58	178 ± 39	182 ± 45	147 ± 25
	42.0	25.0 ± 2.6	72.9 ± 7.4	334 ± 54	348 ± 26	364 ± 89	320 ± 11

G'(high) analysis revealed a three-way interaction ($p<0.05$) with an overall effect of temperature ($p<0.05$), fat type ($p<0.05$) and meat type ($p<0.05$) and two-way interactions for temperature × fat type ($p=0.006$) and fat type × meat type ($p<0.05$), but not for temperature × meat type ($p=0.064$). G'high increased when temperature increased from 50 to 60 °C, however, G'high then seemed to stabilize or even decreased when temperature increased to 70 or 80 °C. In most cases, G'high was higher for the fat type with the highest degree of saturation, however, as lard is completely liquid while heating at these high temperatures (>50 °C), this effect cannot be explained easily. G'high was higher for red meat compared to white meat, especially at 70 or 80 °C. Differences in viscoelastic properties of meat batters prepared with white or red meat were hypothesized to be the result of the different myofibrillar isoforms present [1,3]. G'(cool) analysis revealed no three-way interaction ($p=0.195$) but an overall effect of temperature ($p<0.05$), fat type ($p<0.05$) and meat type ($p<0.05$) and a two-way interaction for temperature × meat type ($p=0.006$). There was no two-way interaction observed for fat type × meat type ($p=0.224$) and temperature × fat type ($p=0.452$). G'cool increased with an increase in temperature, probably due to a more complete denaturation and aggregation of the myofibrillar proteins, and G'cool was always higher for the fat type with the highest degree of saturation, probably due to the higher solid fat content during cooling [2]. At low temperatures (50 and 60°C) G'cool was lower for white than red meat whereas G'cool was approximately the same magnitude at higher temperatures (70 and 80 °C) for both types of meat. G'(process) analysis revealed no three-way interaction ($p=0.902$) but an overall effect of temperature ($p<0.05$) and fat type ($p<0.05$) but not for meat type ($p=0.668$), and a two-way interaction for T × meat type ($p=0.004$) and T × fat type ($p=0.018$) but not for fat type × meat type ($p=0.435$). G'process increased with an increase in temperature and was always higher for the fat type with the highest degree of saturation. G'process for white and red meat were more or less the same.

IV. CONCLUSION

An increase in temperature had a limited effect on the gel strength after the heating step but lead to stronger gels after the cooling step and at the end of the process. For every parameter studied, meat batters prepared with the fat type with the highest degree of saturation resulted in the strongest gels. The effect of meat type on the viscoelastic properties was especially seen after the heating step, but its effect diminished after the cooling step and at the end of the process. Therefore, it could be concluded that especially temperature and fat type affected the viscoelastic properties of meat batters, whereas the effect of meat type on the final product was less pronounced.

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