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The effect of raw materials and thermal processing on structure and stability of cooked sausages (#104)

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Introduction

Cooked sausages are prepared by finely comminuting meat, fat tissue, ice and ingredients into a meat batter. During batter preparation, the fat, which is macroscopically solid, is stabilized through the formation of an interfacial protein film, which should prevent fat coalescence during the subsequent pasteurization. During this heating step, the proteins form a three dimensional protein gel, physically entrapping water and fat. Upon cooling, the fat crystallizes and the gel network is further stabilized. The goal of this study was to investigate the effect of raw materials (meat consisting of either white or red muscle fiber types, fat with a varying degree of saturation) and processing temperature on structural properties as well as water and fat stabilization in cooked sausages.

Methods

Fresh chicken breast (consisting mainly of white muscle fiber types) and leg (consisting mainly of red muscle fiber types) meat as well as pork back fat with either a low degree of saturation (37.5% of saturated fatty acids, denoted as the 'U' (unsaturated) fat) or a high degree of saturation (42.9% of saturated fatty acids, denoted as the 'S' (saturated) fat) were purchased. Batters containing 30% (w/w) of chicken meat, 35% (w/w) of pork back fat and 35% (w/w) of ice were prepared, 1.8% (w/w) of nitrite curing salt and regular spices were added. Meat batters were prepared, their emulsion stability (water and fat loss caused by forced destabilization of the meat batter, represented by the total expressible fluid or TEF) was measured (Hughes, Cofrades, & Troy (1996). *Meat Science*, 45, 273-281). Batters were filled into cans and pasteurized at either 60 or 70 °C. The heating time was adjusted to obtain a $F_{70°C}$-value of 40 min. After one week of cold storage, pH was measured, cooking losses (CL) were determined and texture (hardness) was measured through a penetration test. Furthermore, the microstructure of the cooked sausages was visualized using cryo scanning electron microscopy (cryo-SEM). The effects of meat type (chicken breast vs. leg meat), animal fat type (U vs. S fat) and temperature (60 vs. 70 °C) on pH, TEF, water/fat part of TEF, CL and hardness were evaluated by three-way ANOVA. Tukey's post hoc test was performed in the case of significant interactions ($P<0.05$).

Results

P-values for all main effects and interactions between fat type, meat type and temperature for values of pH, TEF, water/fat part of TEF, CL and hardness of sausages are indicated in Table 1. Results of these respective analyses are presented in Table 2. In Figure 1, cryo-SEM images of sausages are shown. Small differences in fatty acid composition between both pork back fats proved to have a substantial effect on the structural properties and stability of the cooked sausages, in contrast to meat type (and thus, muscle fiber type) or temperature which had a more moderate effect. Sausages prepared with the S fat showed a significantly lower emulsion stability (higher TEF) and the greater part of TEF was fat, while the opposite was observed for the U fat (Table 1 and 2). In correspondence with these findings, substantial fat coalescence was observed at the microstructural level for sausages prepared with the S fat (Fig. 1). These observations may relate to the fact that the S fat had a higher solid fat content (results not shown), possibly resulting in a lower ability of meat proteins to properly coat the fat particles during meat batter preparation, in turn causing fat coalescence during pasteurization. CL was slightly lower for sausages prepared with the S fat, but the fat type clearly affected the hardness of cooked sausages, irrespective of the type of meat or temperature, with higher hardness values obtained for sausages prepared with the S fat.

Conclusion

The degree of saturation of fat used in the preparation of cooked sausages strongly affected structure and stability of the product. A high degree of saturation resulted in a higher hardness, but reduced stability. These results are relevant for all cooked sausage manufacturers, as the fatty acid composition of different animal fat sources, even originating from the same anatomical location, differs widely, which may substantially affect cooked sausage structure and stability.

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Notes

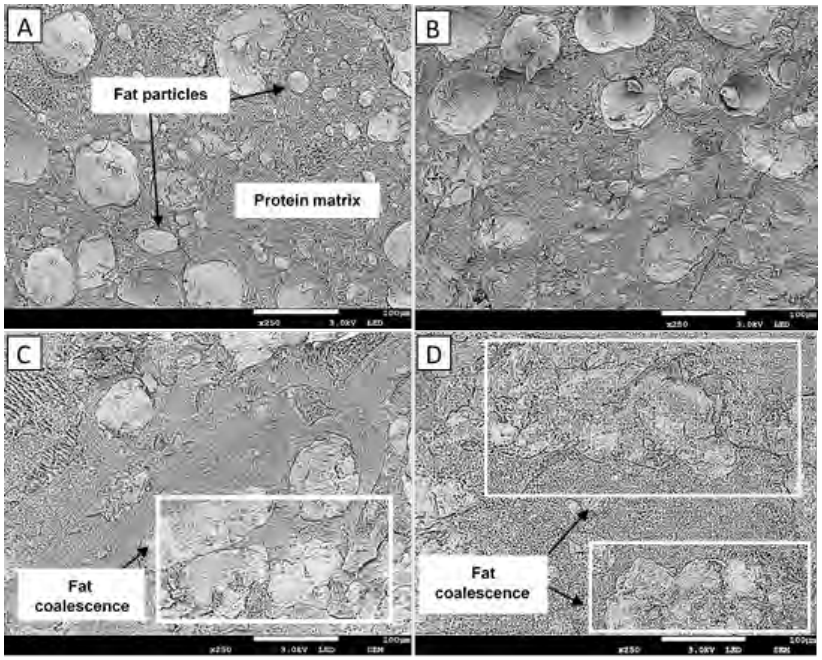

Figure 1 Sausage microstructure. (A) U fat 60 °C; (B) U fat 70 °C; (C) S fat 60 °C; (D) S fat 70 °C. Magnification bar: 100 µm.

Notes

	60 °C				70 °C			
	U		S		U		S	
	Breast	Leg	Breast	Leg	Breast	Leg	Breast	Leg
pH (-)	6.11 ± 0.01	6.32 ± 0.01	6.04 ± 0.03	6.21 ± 0.02	6.10 ± 0.01	6.31 ± 0.01	6.02 ± 0.02	6.20 ± 0.03
TEF (%)	0.18 ± 0.06	0.3 ± 0.1	9.3 ± 0.3	9.7 ± 0.3	4.1 ± 0.6	5.1 ± 0.5	9.6 ± 0.3	12.2 ± 0.1
Pooled values for T x Fat	0.26 ± 0.07^{C}		9.5 ± 0.2^{A}		4.6 ± 0.4^{B}		10.9 ± 0.9^{A}	
Water part of TEF (%)	95.3 ± 0.2	91.6 ± 4.9	9.0 ± 2.0	6.9 ± 2.0	93.50 ± 0.06	93.53 ± 0.03	11.1 ± 2.5	12.2 ± 2.7
Fat part of TEF (%)	4.6 ± 0.3	8.4 ± 4.9	91.0 ± 2.0	93.1 ± 2.0	6.50 ± 0.06	6.47 ± 0.03	88.9 ± 2.5	87.8 ± 2.7
CL (%)	1.1 ± 0.3	2.3 ± 0.4	0.6 ± 0.1	1.0 ± 0.1	2.3 ± 0.6	2.8 ± 0.5	0.8 ± 0.2	1.5 ± 0.4
Hardness (N)	15.9 ± 0.3	12.2 ± 0.3	20.9 ± 1.0	17.0 ± 0.7	14.9 ± 0.7	11.4 ± 0.4	22.2 ± 1.1	17.3 ± 0.2

Table 2 Means and standard errors of pH, TEF, water/fat part of TEF, CL and hardness of sausages (n=3). With regard to TEF, the interaction term T x meat was significant, but is not shown as post-hoc analysis revealed no significant differences. Different letters reflect differences (P<0.05) for T x fat (underlined).

	pH	TEF	Water part of TEF	Fat part of TEF	CL	Hardness
Main effects						
T	0.373	<0.001	0.264	0.271	0.023	0.915
Fat type	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Meat type	<0.001	0.001	0.481	0.472	0.009	<0.001
Interactions						
T × Fat type × Meat type	0.904	0.197	0.938	0.927	0.290	0.535
T × Meat type	0.804	0.011	0.285	0.279	0.637	0.669
T × Fat type	0.802	<0.001	0.278	0.273	0.271	0.079
Meat type × Fat type	0.804	0.069	0.675	0.665	0.637	0.409

Table 1 P-values for all main effects and interactions between temperature, fat and meat type for pH, TEF, water and fat part of TEF, CL and hardness of sausages. Significant (P<0.05) main effects and interactions are underlined.

Notes