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EFFECT OF STORAGE ON THE TEXTURE OF LEVERPATÉ AND EMULSION SAUSAGE

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Introduction

The BSE crisis in Europe in the last decade has resulted in numerous changes in the procedures used during the slaughter process, meat processing and in the composition of feed. Animal fat is no longer used as an ingredient in animal feed and has been replaced with lipids originating from vegetables. Vegetable lipids differ from animal lipids in the fatty acid composition. The former normally has a higher content of unsaturated fatty acids, which have a significant influence on the physical characteristics of the fat, e.g. melting point and hardness. The physical characteristics of fat often influence the texture of the final product. More unsaturated fat, the softer the resulting product will be. The fatty acid composition of feed is known to be reflected in the adipose tissue of monogastric animals like pigs. Thus, the fatty acid composition of feed might have a major impact on the texture of products containing large amounts of pork fat.

Besides the fatty acid composition the physical characteristics of fat are determined by the crystallization process. Normally triglycerides crystallize into three different forms: α, β’, β, with increasing order of packing of the crystal lattice, resulting in increasing stability and melting points. In a former study we found that fast cooling of lard resulted in a higher content of α-crystals compared to slow cooling (Svenstrup et al., 2004, 2005). The unstable crystal forms rearrange through an irreversible phase transition into more stable crystal forms with higher melting points. The timeframe of this rearrangement in meat products is not known. However, if the rearrangement of unstable crystals is a slow process running for days or weeks, the melting point of fat incorporated in meat products increases during storage which thereby changes the texture of the final meat product

Objectives

The objective of the study is primarily to investigate the effect of storage on the texture of liver pâté and emulsion sausage. Secondly to investigate the effect of two different fat sources derived from animals fed various fat types and the effect of cooling rate on the texture of an emulsion sausage during storage. The results presented are obtained from two independent, ongoing experiments.

Methodology

Experiment 1: Twelve freshly produced liver pâtés from the same batch were obtained from a commercial producer (Table 1, Fransk Postej, Stryhns A/S). The pâtés were stored at 5°C. At day 0, 1, 3, 5, 8, 10, 15, 18 and 25 after production, a randomly selected pâté was selected for determination of the complex modulus (G*) and the phase angle using small amplitude oscillatory shear. For the determinations a Bohlin C-VOR rheometer (Malvern Instruments, Malvern, UK) equipped with serrated parallel plates (diameter 25 mm) was used. A sample of the pâté was mounted between the plates and allowed to relax for 15 minutes before the measurement was started. During measurement, the rheological properties of the pâté were measured at a strain of 0.002 and a frequency of 1 Hz at temperatures from 5 to 40 ˚C. The temperature of the sample during measurement was accurately controlled and increased with an Asphalt Peltier element (Malvern Instuments, Malvern, UK) designed for the rheometer. Every time the temperature was increased, the sample was let to equilibrate for 2 minutes before the rheological properties were measured.

Experiment 2: Forty pigs, half females and half castrated males, were at an age of 35 days allotted to one of two treatments consisting of standard feed that contained either 3 % palm oil or 3 % rapeseed oil. Pigs were slaughtered at 100 kg live weight. After three days post-mortem, 500 gram of back fat were individually vacuum sealed and stored frozen at -20˚C for up till 3 months prior to processing. The fat samples were pooled into two groups either fed palm oil or rapeseed oil.

Emulsion sausages were prepared using a standard formulation (**Table 1**). Lean pork was ground through a 4,5 mm orifice plate, presalted with NaCl/nitrite and kept at 4°C for 18 h. The batter was prepared using a bowl chopper. Presalted meat was chopped while adding phosphate and ¼ of ice-water at low chopping speed. Dry milk and ice water were added. Fat, wheat flour and ice water were added at high speed gradually adding the remaining ice-water and spices. Chopping time was controlled so that the temperature of the batter did not exceed 11°C. The total chopping time was 13 min. The batter (190 g) was stuffed into aluminum cans using a manual filling machine. The filled cans were kept for 2 hours at 5°C to allow the curing reaction to complete. The sausages were cooked in a convection oven at 78°C to an internal temperature of 72°C.

After cooking the sausages were cooled using two cooling rates by immersing the cans into a water bath. The samples cooled rapidly were placed in ice-water (0°C) for 3 hours. Slow cooling was obtained using stepwise cooling. The cans were placed in a water bath at 40°C for 1 h, 20°C for 1 hour and finally in ice-water for 1 hour. After cooling the cans were stored at 4°C until analysis.

Four cans from each treatment (fat, cooling rate, storage time) were tested for Young’s modulus and penetration force, each sample being punched 5 times. A cylindrical stainless-steel plunger (diameter 9,8 mm) attached to a 100-N cell connected to the crosshead of the Instron machine, crosshead speed 50 mm/min was used.

Statistical analysis was carried out with the Statistical Analysis System version 8.02 (SAS Institute, Cary, NC, USA). The mixed procedure was applied when calculating least squares means (LSM) and standard errors (SE), and significant differences between LSM were evaluated using the option Pdiff. Degrees of freedom were estimated with the Satterthwaite method. The models for Young’s modulus included fixed effects of fat type, storage time and cooling rate and random effect of can nested within fat type, storage time and cooling rate. Two-way interactions were included in the models if significant.

Results & Discussion

Experiment 1. The complex modulus (G*) can be interpreted as a measure for the total stiffness of the samples (**Figure 1**). Freshly produced liver pâté had a G* of 25 kPa measured at 5°C, which increased to 43 kPa after 10 days storage. Thus, the total stiffness of the samples can be interpreted to increase approximately 70%, during the first 10 d of storage when G* is measured at 5°C. No further changes in stiffness occurred in the remaining storage period. When G* was determined at higher temperatures two effects were observed: the value at day 0 decreased with increasing measuring temperature and the effect of storage decreased No differences in G* were detected during storage at a measuring temperature of 35°C.

Liver pâté contains a large proportion of lard/fat (Table 1). In a former study we showed that the rate of fat melting in liver pâté increases when the temperature is increased to 32°C. At this temperature the rate of fat melting was at a maximum and at 48°C all fat was melted (Svenstrup et al., 2005). Melting of fat can therefore explain the effect of the measuring temperature on G* presented in figure 1. At 5°C a major part of the fat is in a solid state and this part decreased with increasing temperature making the pâté less stiff.

The effect of storage seemed to fade when G* was measured at higher temperature. Since the major part of lard melts within the temperature range of the measurements (Svenstrup et al., 2005), the increase in stiffness during storage might be related to the fat fraction of the product. A plausible explanation is, that during cooling of the freshly produced liver pâtés a major part of the fat crystallize into unstable crystal forms. During storage these are rearranged into more stable crystal forms. The more stable crystal forms of the fat probably create a more ridged network in the microstructure of the liver pâté. This gives the product a stiffer appearance in the rheological measurements.

Experiment 2. Young's modulus (E_u) can also be interpreted as a measure of total stiffness of the samples (**Figure 2**). There was an effect of feed ($P < 0.001$), cooling rate ($P < 0.0001$) and storage time ($P < 0.0001$). At day 1, sausages produced from pigs fed palm oil and cooled fast were approximately 15% stiffer than sausages cooled slowly (**Figure 2A**). At day 27, there was no difference in stiffness between the samples. Sausages produced from pigs fed rapeseed oil and cooled fast were approximately 8% stiffer than sausages cooled slowly (**Figure 2B**).

The effect of storage is similar to the results obtained in experiment 1, i.e. the sausages become stiffer during storage. A rearrangement of unstable fat crystals into more stable crystals might also explain the results obtained in experiment 2. However, the effect of cooling rate disagrees with this explanation. The order of packing of single tri-glycerides into the crystal lattice is time dependent. Thus, the faster the cooling rate, the less stable the crystals will be. The fast cooled sausages were expected, initially, to have a higher fraction of unstable fat crystals compared to the slowly cooled sausages. Therefore, it was expected that the fast cooled sausages would be less stiff and that the stiffness would increase more during storage compared to the slowly cooled sausages. However, the opposite effect was observed (**Figure 2**).

At this stage, we do not have an explanation for this contradiction. It might be related to the protein gel-network, starch gelation and/or the emulsion of fat. For more than 2 hours, the temperature of the slowly cooled sausages was above 20°C during the cooling procedure. Since a part of the fat is in liquid form above 20˚C, it might influence the emulsion stability. This could lead to coalescence of fat which will influence the texture.

Conclusions

The stiffness of both liver pâté and emulsion sausage increases during storage. For liver pâté changes in the fat fraction was clearly responsible for the increased stiffness of the product. Sausages produced from pigs fed palm oil are stiffer than sausages produced from pigs fed rapeseed oil. The cooling rate has an effect on the stiffness. Fast cooling resulted in stiffer sausages. The effect of storage might be related the crystallization of fat.

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References

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Tables and Figures

Table 1. Composition of liver pâté and emulsion sausage.

Liver pâté		Emulsion sausage	
Liver	33 %	Lean pork	52,7 %
Back fat	30 %	Back fat	19,7 %
Skimmed milk	25 %	Dry milk	2,4 %
Wheat flour	4 %	Wheat flour	1,98 %
Margarine	3 %	Dry onion	0,22 %
Onion	2 %	Phosphate mix	0,34 %
NaCl	1,5 %	Ice/water	21,9 %
Spices	1 %	NaCl	0,38 %
Sugar	0.5 %	White pepper	0,16 %

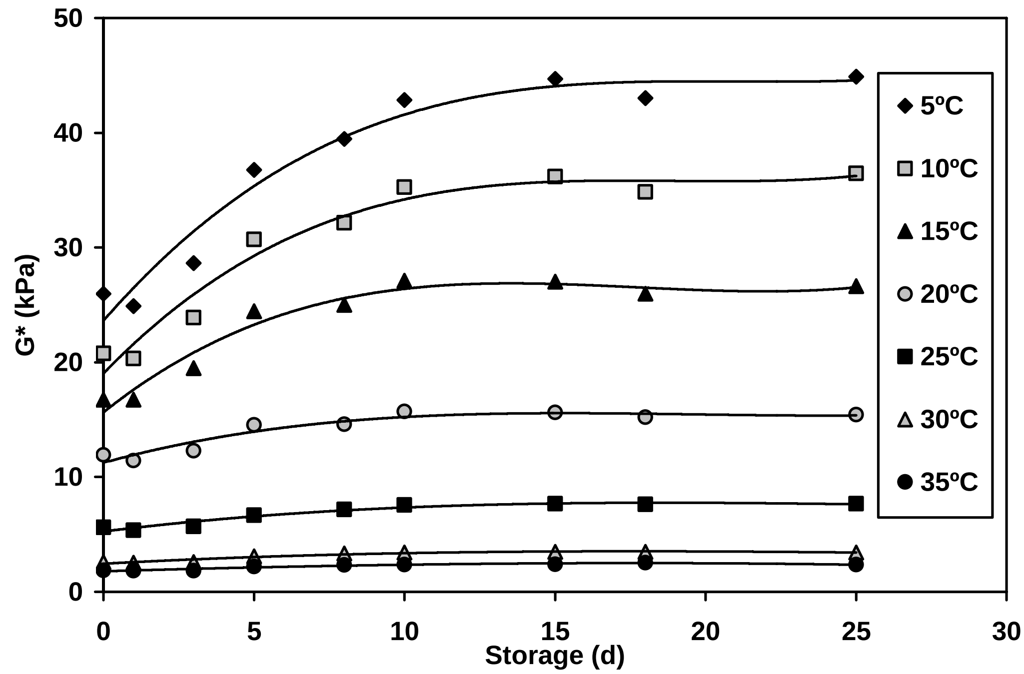

Figure 1. Complex modulus (G*) of liver pâté during storage at 5°C for up to 25 days. G* was determined at seven different temperatures. Lines are guidance to the eye.

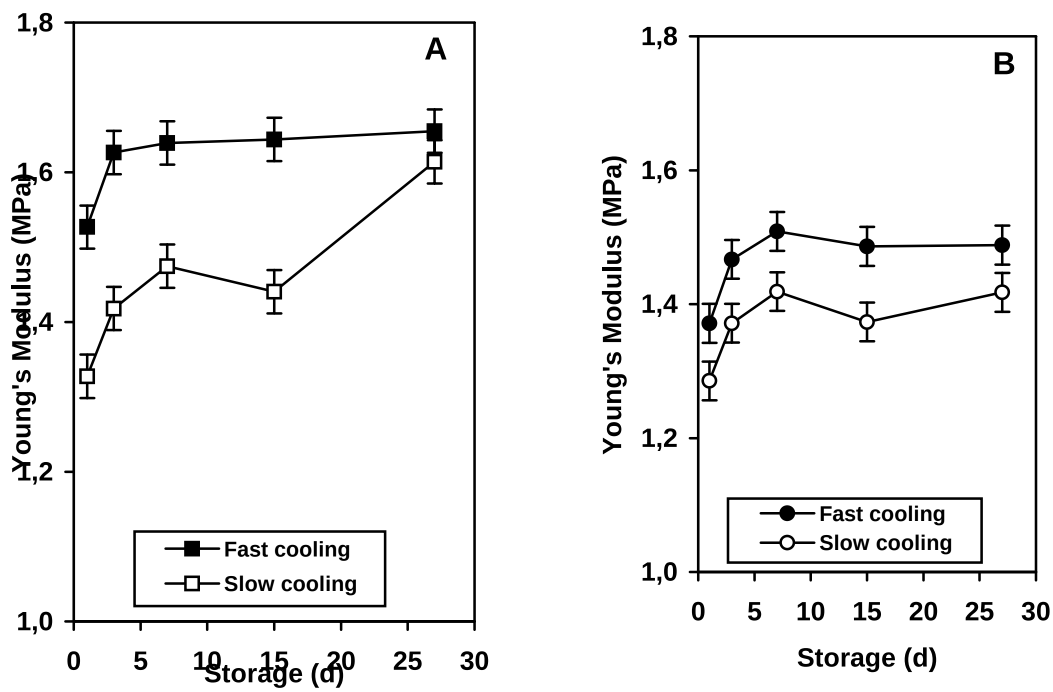

Figure 2. Young's Modulus (E_u) of emulsion sausages during storage for 27 days at 4°C. Fat is obtained from pigs fed either 3% palm oil (A) or 3% rapeseed oil (B). Sausages have been cooled either slowly (~0.5°C/min) or fast (~1°C/min).