The effect of the level of hot boned pork fat on water-binding capacity and fat retention in cooked sausage

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Introduction

The mode of fat binding in cooked sausage is not fully clear. Since Hansen (1960) presented his famous emulsion hypothesis the amount and the emulsifying capacity of salt-soluble proteins have in many cases been the main measure of the functional properties of meat. Most of the studies have used methods by which the emulsifying capacity has been determined using very high water/meat ratios and vegetable oil. The results may or may not correlate with those obtained with the cooked-sausage process, where the water/meat ratio is usually well below 1, and where only a minor part of the meat fat is in liquid form. However, many researchers (eg. Hansen 1960, Theno and Schmidt 1978, and Swasdee et al. 1982) have produced micrographs showing that an emulsion can be formed.

According to Hamm (1972, 1981), the structure of cooked sausage is based on a gel, inside which the fat particles are enclosed; only a minor part of the fat is in the form of an emulsion. The gel is made up partly of swollen myofibrils and partly of solubilized protein that has coagulated during heating. van den Oord and Visser (1973) have shown that most of the fat cells remain intact during chopping. The studies conducted by our group during the past five years have also indicated that the decisive factor in cooked sausage is the protein matrix. Water binding and fat binding are based on the firmness of the gel. If the repulsive forces between the protein filaments or between solubilized molecules are strong enough to keep them apart during heating, a firm gel containing both moisture and fat will be formed. If the repulsive forces are too low as a result of low salt content, low pH value, etc., the proteins will coagulate too much, and the gel will break. The sausage mass is hot during cooking. If the gel then breaks, the hot water and hot melted fat released will separate. Our experiments show that fat is released only when a considerable amount of water is released during cooking (provided that abnormally high fat or abnormally low lean meat contents are not used).

Most studies of the effects of fat have been carried out using cold fat. Townsend et al. (1971), Haq et al. (1973), Schut and Brouwer (1974) and Puolanne and Ruusunen (1979, 1980a) have shown that some fat must be present in finely chopped cooked sausage to produce optimum water binding. Fat is usually best stabilized when the temperature during chopping is low (Hermansson and Åkesson 1975, Lee et al. 1981). Lee et al. showed that when the temperature during chopping is high, the fat starts to coalesce to from larger units that constitute "channels" in the gel. This easily causes fat to separate during cooking. Schut and Brouwer (1974), however, found that with melted fat optimum stability was obtained at a chopping temperature of 28^{o}-33^{o}C. This may mean that melted fat must be emulsified, something which occurs more easily at elevated temperatures.

The aim of this work was to study the use of pre-rigor boned pork fat, while still hot, in cooked sausage.

Materials and methods

Subcutaneous fat was dissected from the ventral side of ham of 70-73 kg pork carcasses 30 min post mortem. The fat was transported to the laboratory in a styrox box and then kept at 30^{o}C until used in cooked sausages (1-2 h post mortem).

The sausage batters were prepared as follows: pre-homogenised lean meat was chopped in a kitchen chopper (Moulinex Moulinette, manufactured by Moulinex, France) for c. 15 sec with salt, followed by the addition of pork, phosphate and the gradual addition of water (ice). The final temperature of the emulsion was 20^{o}C. When ready the sausage batter was stuffed into a 45 mm collagen casing (manufactured by Naturin-Werke, Weinheim, FRG), cooked for 30 min at 74^{o}C in a steam chamber and cooled in an ice-water bath.

Calculations for released fat are based on the grams of fat physically separated from the cooked, chilled sausage relative to the original recipe weight. Water binding capacity is determined by difference between the weight of stuffed sausages (weight of casing excluded) and the weight of the cooked and peeled sausage after removing released water and jelly. Released fat is included in the weight of the cooked peeled sausage.

The compositions of the sausages were as follows:

		With phosphate		Without phosphate	
Lean beef (8 % fat)		40 g		70 g	
Water		120 g		100 g	
Salt		2 %		2 %	
Pyrophosphate (calc. as P_2O_5)		0.3 %		-	
Added pork fat (fat content 90%)	0 g	0% fat	0g/100 lean beef	0% fat	0g/100g lean beef
	20 g	10% "	50g/" " "	9% "	29g/ " " "
	40 g	18% "	100g/" " "	17% "	57g/ " " "
	60 g	24% "	150g/" " "	24% "	86g/ " " "

Six series of sausages with phosphate, and seven series of sausages without phosphate were made. The results were tested by analysis of variance, and means were separated at the level of significance of p<0.05 %

Results and discussion

Without added phosphate the amount of bound water increased linearly as the amount of added fat was increased (Table 1, Figure 1). When the amount of added fat was 86 g fat/100 g lean beef (24 %) the amount of bound water was significantly (p<0.05) larger than at other levels. At 27 (10 %) and 57 (17 %) g fat/100 g lean beef, the results did not differ from each other, but the latter differed from the sausage made without added fat.

The amount of released fat did not increase significantly when the amount of added fat increased to 27 g fat/100 g lean beef (10 %) (Table 2, Figure 2). When the level of added fat was 57 (17 %) or 86 (24 %) g fat/100 g lean beef a slight increase of fat separation was observed, but only at the highest level was the difference significantly higher.

The sausages containing added phosphate but without added fat had a significantly lower water binding capacity than those to which fat was added (Table 1, Figure 1). The amount of released fat enhanced slightly with increasing levels of added fat. With the addition of 150 (24 %) g fat/100g of lean beef the amount of fat released was significantly higher than in the other sausages (Table 2, Figure 2). In this case the amount of fat released was about 3 % of added fat and about 0.9 % of the total weight of the sausage batter (raw weight).

Table 1. Water binding capacity (WBC) (g water/100 g lean beef) of cooked sausage with various addition of hot pork fat.

Without added phosphate[1)] Added fat g fat/100 g lean beef		WBC g water/100 g lean beef	With added phosphate[2)] Added fat g fat/100 g lean beef	WBC g water/100 g lean beef
0	x	28.7[a]	0	128.0[a]
	s	8.1		16.7
27		40.3[ab]	50	182.4[b]
		4.5		22.3
57		50.4[b]	100	196.9[b]
		6.9		21.3
86		64.7[c]	150	180.0[b]
		11.7		7.8

1) N = 7 2) N = 6

abc) Means within the same column bearing a common superscript letter are not different (p>0.05).

Table 2. The amount of released fat (g fat/100 g lean beef) in cooked sausage with various additions of hot pork fat.

Without added phosphate[1)] Added fat g fat/100 g lean beef		WBC g water/100 g lean beef	With added phosphate[2)] Added fat g fat/100 g lean bef	WBC g water/100 g lean beef
0	x	0.0[a]	0	0.0[a]
	s	0.0		0.0
27		0.2[a]	50	0.1[a]
		0.1		0.1
57		1.1[ab]	100	0.8[a]
		1.6		0.5
86		2.5[b]	150	4.9[b]
		1.7		1.9

1) N = 7 2) N = 6

abc) Means within the same column bearing a common superscript letter are not different (p>0.05).

It can be concluded that the addition of fat increases the water-binding capacity of lean chopped beef. When no phosphate was added the optimum fat level was not reached between 0 and 24 % added fat. In sausages containing added phosphate the optimum fat level (not significant) was reached with 17 % added fat. The results confirm our earlier results with cold fat (Puolanne and Ruusunen 1979). The increase in water binding cannot be due entirely to the increase in salt content of the water phase of the sausages (salt content of whole sausage remained constant), because the optimum found with added phosphate was reached below optimum salt content (Puolanne and Ruusunen 1980b). One reason for the increase in water binding could be that the lipids of fat slightly loosen the protein matrix and change the structure of the layers of water that lie between the proteins (Schut and Brouwer 1974). However, it must be borne in mind that this was an experimental study, and that the amounts of water added are higher than in practice.

This study showes that in experimental conditions the properties of "hot" fat are essentially the same as those of cold fat (see Puolanne and Ruusunen 1979). However, the amount of fat released was higher with "hot" fat, although unfortunately the comparisons were not made at the same time. The results indicate a higher risk of fat separation as the amount of added "hot" fat is increased. According to Schut et al. (1978), the melted fat must be emulsified before or during chopping. It can therefore be assumed that an emulsifying agent (eg. caseinate, soya proteins) can be used to reduce the risk of fat separation from hot boned pork when the fat is still warm.

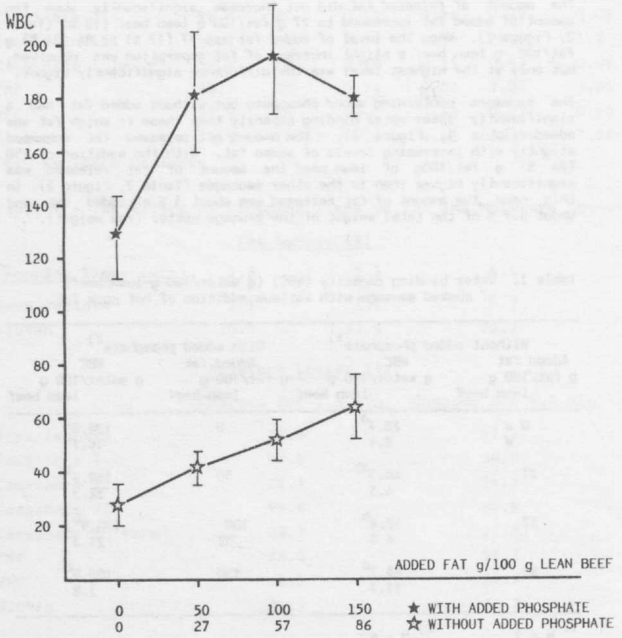

Figure 1. Water binding capacity (WBC) (g added water/100 g lean beef) of cooked sausages with various fat additions

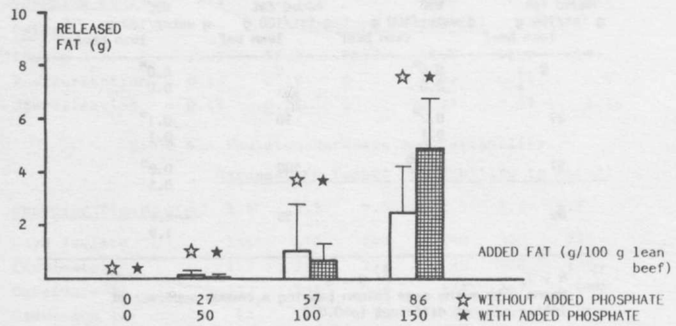

Figure 2. The amount of released fat (g/100 g lean beef) of sausages with various fat additions.

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