D.7

Studies on the Mode of Action of Emulsifiers in Cooked Sausages

KARL O. HONIKEL and R. HAMM

Federal Centre for Meat Research, Kulmbach, Federal Republic of Germany

Introduction

In a wide variety of foods like soft drinks, candies, milk and bakery products emulsifiers are used successfully in order to facilitate homogenisation and to stabilize the final products. In meat products especially in finely comminuted cooked sausages (frankfurter type) and liver sausages the use of emulsifiers is recommended in order to reduce fat rendering out during cooking. The idea is that the emulsifiers form an interphase layer between fat and protein-water phase. This layer is supposed to facilitate the fat dispersion during comminution and to stabilize the dispersion on heating. The results obtained by applying emulsifiers in these meat products are contradictory. In order to solve this problem we studied the mechanism of action of emulsifiers in meat batters, especially in cooked sausages.

Material and Methods

The cooked sausages prepared for this study contained 10-11% of protein, 25-28% fat, various salt concentrations and 0.35 to 0.8% emulsifiers of different types. As emulsifiers we used food industry lecithins containing more than 95% phopholipids, monoglycerides (glyceromonostearate, palmitate) of more than 90% purity, monoglycerides esterified with various amounts of citric and lactic acid, and ethylesters of acetic, lauric, palmitic, stearic, arachidonic and behenic acid of more than 95% purity.

Sausages were prepared by using beef (shoulder) 3-5 days old, which was trimmed of visible fat and connective tissue before grinding through a 4.5 mm plate. 450 g of this ground material were put in a bowl chopper. 10 sec after starting the comminution the amount of salt was added immediately followed by 315 g of crushed ice. 20 sec later 3.5 to 8 g of emulsifier was added as a fine powder or as a liquid in some cases. The comminution progressed during that time. By inserting a thermocouple (Pt 82) the temperature of the batter was measured continuously. The temperature was below 5°C within this period of comminution. 180 sec after start 250 g of ground back fat of pork was added and comminution went on for another 180 sec. The final temperature of the batter was 11-13°C. About 200 g of the batter was filled in tins (99 mm diameter, 36 mm high), sealed and heated for 35 minutes in a water bath of 80°C. After cooking the tins were cooled in running tap water for 45 minutes and chilled for 20 hours at 6°C. Then the tins were warmed up to about 45°C, opened and the now fluid jelly and fat was poured into a measuring cylinder. The amount of jelly and separated fat was calculated as percent of total batterweight.
Fat-free batters were prepared as described above but without fat addition. Comminution lasted 360 sec. The

temperature was kept below +6°C; if necessary the careful addition of small amounts of liquid nitrogen kept it at this temperature.

Results

Action of Lecithin

Heidtmann and Fleischmann (1963), Meyer (1964), Pyrcz et al. (1981) and Honikel et al. (1982) reported that the addition of lecithins in cooked sausages with an overall concentration of 2-2.5% salt increased jelly separation and rendering out of fat. Also the increase in the lecithin concentration lead to an increase in jelly separation in cooked sausages (Honikel 1982). A very strong separation of jelly and fat was observed, when the emulsifier was premixed with water and fat before the addition into the bowl chopper (Honikel 1982). Therefore, the generally accepted mode of action of emulsifier valid for a two phase water/oil system, in which the emulsifier forms an interphase layer, does not apply in meat batters containing meat, salt, water and fat. Starting from these results we found, that the addition of lecithin in increasing concentrations to salted meat homogenates without fat also increased the cooking loss (fig. 1).

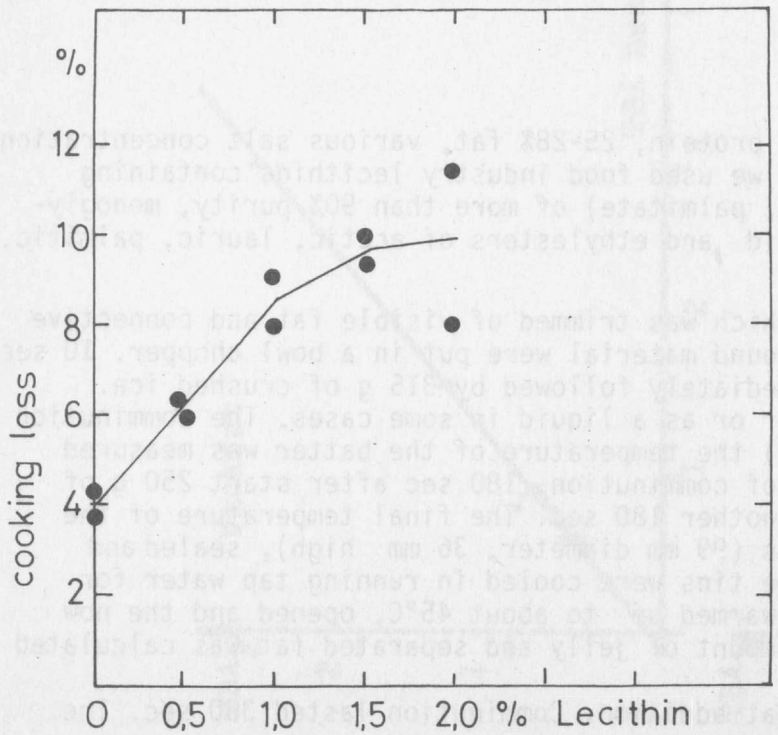

Fig. 1:

Influence of lecithin concentration on cooking loss in fat-free meat homogenate.

The homogenates consisted of 64% beef and 32% water and 4% salt.

As there is no possibility for lecithin to form an interphase between water and fat in these fatt-free homogenates we came to the conclusion that lecithins must interact with meat proteins.

Myofibrillar meat proteins are the predominant meat proteins responsible for water and fat binding. Their action depends on the salt concentration in the batter. Therefore we studied the dependence of lecithin action on the salt concentration. The results are shown in fig. 2.

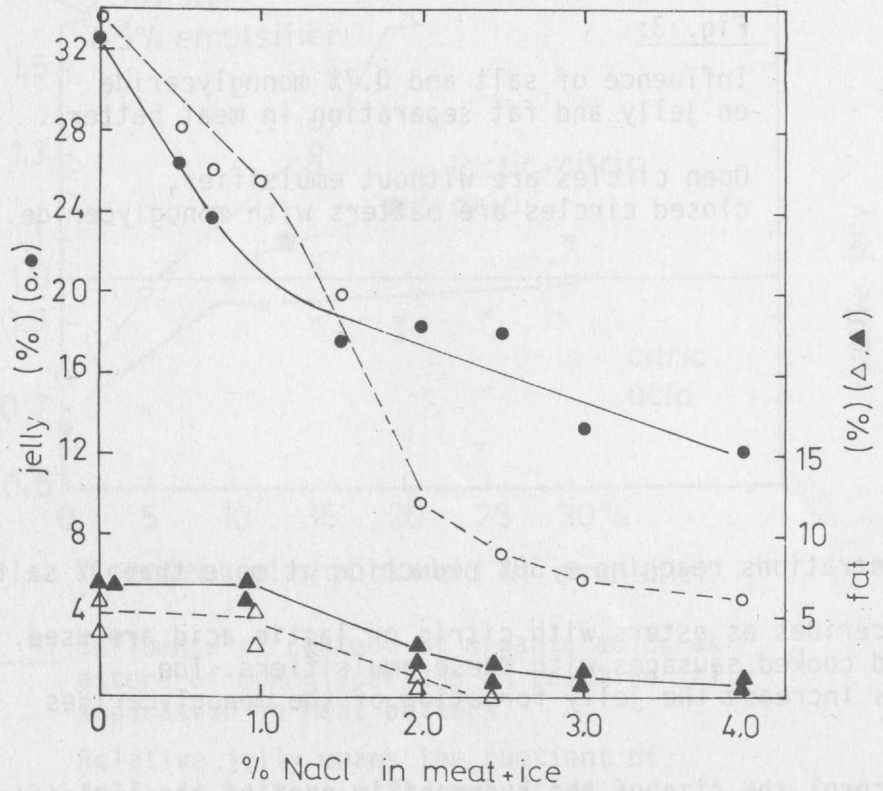

Fig. 2:

Influence of salt and 0.7% lecithin on jelly and fat separation in meat batters.

Open symbols are without lecithin, closed symbols are batters with lecithin.

At low salt concentrations (below 1.5% in meat + ice) the jelly separation in the fat containing batters reduced slightly on cooking. In batters with more than 2% salt in meat and ice (equivalent to more than 1.5% salt in the sausage batter as a whole) the addition of lecithin increased the jelly separation as expected. Fat rendering increased in any case by the addition of lecithin. This dependence of the action of lecithin on the salt concentration in batters supports the idea that lecithins interact with meat proteins.

Action of Mono- and Diglycerides

Monoglycerides (Glycero-1-stearate, glycero-1-palmitate), however, behave somewhat different. They decrease the jelly separation over the whole range of salt concentration studied, whereas in agreement with lecithin they increase slightly the fat separation (fig. 3).

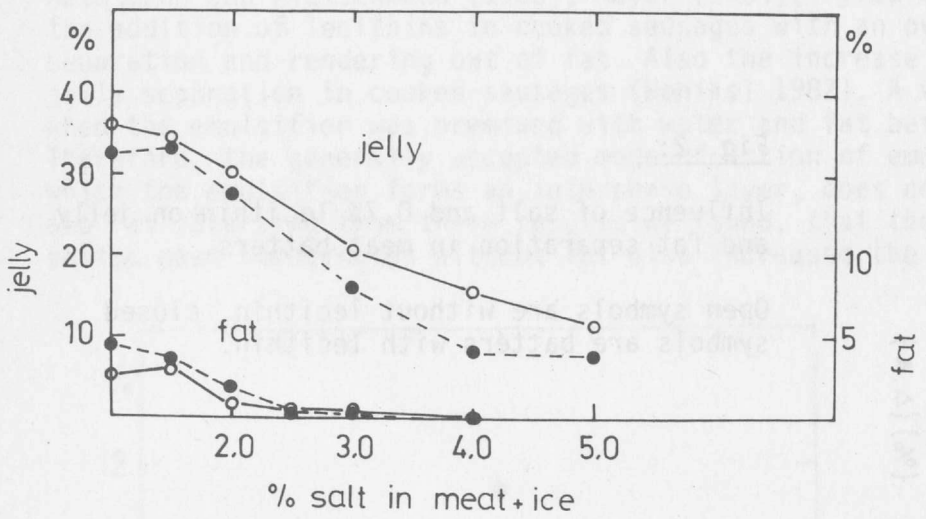

Fig. 3:

Influence of salt and 0.7% monoglyceride on jelly and fat separation in meat batters.

Open circles are without emulsifier, closed circles are batters with monoglyceride.

The jelly reducing effect increased at higher salt concentrations reaching a 30% reduction at more than 3% salt.

In meat industry besides monoglycerides very often glycerides as esters with citric or lactic acid are used. Under the conditions described in fig. 4 we manufactured cooked sausages with these emulsifiers. The increasing content of these organic acids in emulsifiers increases the jelly formation of the monoglycerides (fig. 4).

By forming an ester between these organic acids and glycerol the size of the hydrophilic part of the emulsifier increases and in the case of citric acid the neutral glycerol unit as the hydrophilic part is receiving negative chages by the carboxylate anions of the citric acid.

These monoglycerides and their derivatives are different in their hydrophilic part of the molecule, in the lipophilic part they contain mainly palmitic or stearic acid residues.

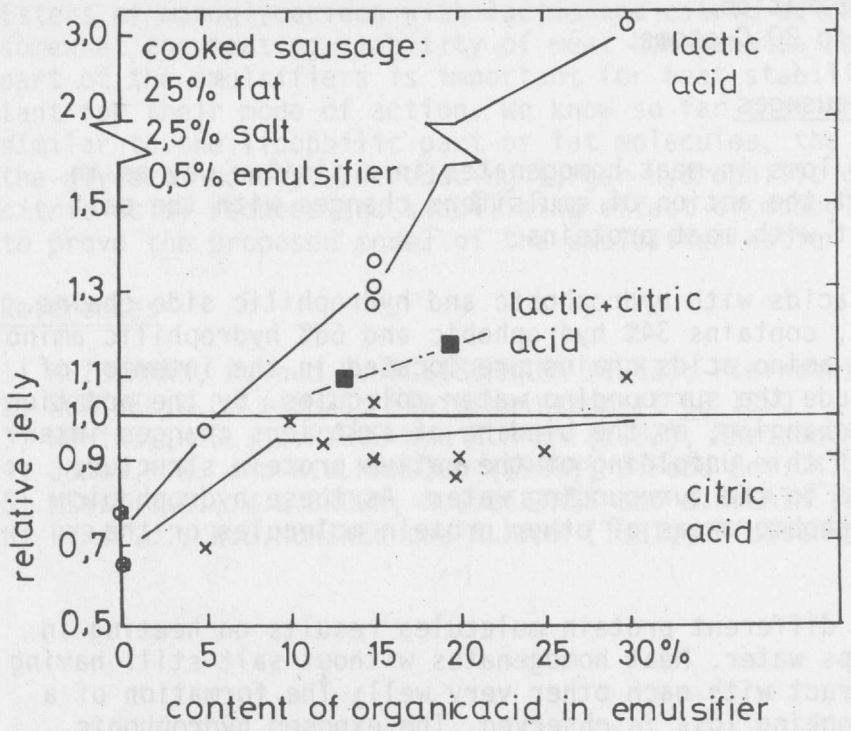

Fig. 4: Influence of content of organic acids as esters of monoglycerides on relative jelly separation in meat batters.

Relative jelly means the quotient of jelly in batters with emulsifier and batters without emulsifier; values below 1 show reduction of jelly separation in batters containing emulsifier.

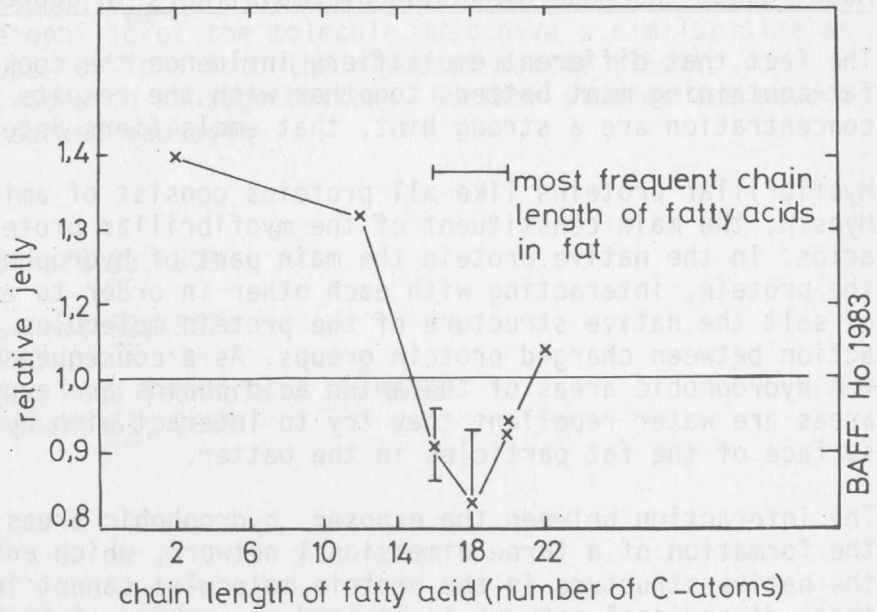

Fig. 5:
Relationship between chain length of fatty acid ethyl esters on relative jelly separation.
Relative jelly see fig. 4,

Changing the chain length of the lipophilic part of the molecule also changes the action. We used ethyl-esters of various fatty acids with chain lengths between 2 and 22 C-atoms (fig. 5). Only the esters with 16 to 20 C-atoms showed a jelly reducing effect, emulsifiers with a lower or higher number of C-atoms in the fatty acid chain had an increasing effect on the jelly separation.
The most frequent fatty acids in animal fat have also 16 to 20 C-atoms.

Model about the mode of action of emulsifiers in cooked sausages

The fact that different emulsifiers influence the cooking loss in meat homogenates in a similar way as in fat-containing meat batters together with the results that the action of emulsifiers changes with the salt concentration are a strong hint, that emulsifiers interact with meat proteins.

Myofibrillar proteins like all proteins consist of amino acids with hydrophobic and hydrophilic side chains. Myosin, the main constituent of the myofibrillar proteins, contains 34% hydrophobic and 66% hydrophilic amino acids. In the native protein the main part of hydrophobic amino acids chains are located in the interior of the protein, interacting with each other in order to exclude the surrounding water molecules. By the addition of salt the native structure of the protein molecules is changing, as the binding of salt ions changes interaction between charged protein groups. As a consequence of this unfolding of the native protein structure the hydrophobic areas of the amino acid chains are exposed to the surrounding water. As these hydrophobic areas are water repellent they try to interact with hydrophobic areas of other protein molecules or the surface of the fat particles in the batter.

The interaction between the exposed hydrophobic areas of different protein molecules results on heating in the formation of a three dimensional network, which entraps water. Meat homogenates without salt still having the native structure in the protein molecules cannot interact with each other very well; the formation of a three dimensional network is limited on cooking. A high cooking loss is observed. The exposed hydrophobic areas of salted meat proteins interact with the surface of the hydrophobic fat particles forming a protective layer around the fat particles. This model is also proposed by Jones and Mandigo (1982). Heating of these protected fat particles prevents the fat rendering out on cooking. Concluding from these results it appears that hydrophobic areas of unfolded swollen and/or dissolved myofibrillar proteins play a decisive role in water and fat binding in meat batters.

Emulsifiers, which consist of hydrophilic and hydrophobic areas within the molecule, can also interact with the hydrophobic areas of proteins. The more exposed these hydrophobic areas are i.e. the more salt is added, the more emulsifier molecules can interact with the hydrophobic areas of the proteins. If the lipophilic part of the emulsifiers interact with hydrophobic side chains of amino acids then these areas loose their hydrophobicity and there is no longer a possibility for interactions between the hydrophobic areas of the protein molecules and protein and lipid surface. In unheated meat homogenates and fat containing batters this

results in reduced viscosity and higher swelling of meat proteins as we observed. With lecithins this also results on heating in increased cooking losses and fat rendering out at high salt concentrations (fig.1,2). Esters of monoglycerides with lactic and citric acid behave similar (fig. 4). Monoglycerides, however, improve somewhat the heating stability of meat homogenates and batters (fig. 3). Also the chain length of the lipohilic part of the emulsifiers is important for heat stability. Therefore the structure of emulsifiers must be important for their mode of action. We know so far that the lipophilic part of the emulsifier molecules must be similar to the lipophilic part of fat molecules, the hydrophilic part of the molecule must have a similar size as the glycerol moiety. Introducing larger hydrophilic groups or ions into the glycerol moiety (lactic or citric acid) reduces the stabilising effect of monoglycerides on sausage batters. Further studies are needed to prove the proposed model of the emulsifier action in cooked sausages.

References

1) HEIDTMANN, R. and O. FLEISCHMANN (1963); Fleischwirtschaft 15, 503
2) HONIKEL,K.O. (1982); Fleischwirtschaft 62 1390
3) HONIKEL,K.O., J.PYRCZ and R.HAMM (1982); Fleischwirtschaft 62, 507
4) JONES,K.W. and R.W.MANDIGO (1982); J.Food Sci. 47, 1930
5) MEYER,J.A., W.L.BROWN, N.E.GILTNER and J.R.GAIM (1964); Food Technology 18, 1796
6) PYRCZ,J., K.O.HONIKEL and R.HAMM (1981); Fleischwirtschaft 61, 1875