THE EFFECT OF pH VALUE, SALT AND PHOSPHATE CONTENT ON WATER-BINDING CAPACITY IN COOKED SAUSAGE

E. PUOLANNE - MARITA RUUSUNEN - M. MATIKKALA

University of Helsinki, Institute of Meat Technology, Helsinki, Finland

The incidence of DFD meat is a serious problem in Finland (see Puolanne and Aalto in this publication), and it is therefore important to know the possible effects of the use of DFD meat on the properties of cooked sausage. Most of the studies on the effect of pH value on the water-binding of meat has been carried out with meat without salt. These studies show that water-binding capacity increased when the pH value was raised from 5.0 to 7.0 (review HAMM 1972). When adding salt to meat HAMM (1962a) found that the water-binding capacity of meat increased to a maximum when the pH value rose to 6.0.

The average human daily intake of common salt in Finland is 12-15 g, which is very much higher than the maximum value recommended by WHO. The average consumption of sausage is very high in Finland, about 80 g per person per day. Consumption varies, of course, and therefore the salt intake from sausages can be considerably higher for some individuals (HANNUKAINEN 1980). For this reason it is necessary to lower salt content of sausages, at the same time monitoring the technological effects this produces. HAMM (1957) and RANKEN (1973) showed that the water-binding capacity of meat increases with increasing salt content up to 4-5 % NaCl, depending on the fat content. SCHULTS and WIERBICKI (1973) achieved maximal binding in hams with a slightly lower salt content. In this study a laboratory sausage method (PUOLANNE and RUUSUNEN 1979) was used to study the effect of pH value, salt and phosphate content on the water-binding capacity and firmness of cooked sausage.

MATERIAL AND METHODS

The laboratory sausage method used in this study is described in detail elsewhere (PUOLANNE and RUUSUNEN 1978, 1979). The method is based on the addition of excess water to the sausage mass, resulting in the separation of water on the surface under the casing. The water-binding capacity is calculated on the basis of the amount water remaining in the cooked and cooled sausage.

To study the effect of pH meat samples with different pH values were taken from the inside rounds of young bulls. Mixtures were prepared containing meat from 2-3 animals. In this way, effects of differences due to other than pH values (HAMM 1962b) were to some extent avoided. Sausage masses from the mixtures were prepared with or without added phosphate using the recipe presented in Table 1.

Table 1. Recipes for the laboratory sausages.

	Water-binding capacity		Firmness	
	Without P_2O_5 (g)	With P_2O_5 (g)	Without P_2O_5 (g)	With P_2O_5 (g)
Beef	50	50	70	60
Pork	40	40	50	40
Water	130	160	80	100
NaCl	4.4	5.0	4.0	4.0
Added phosphate	-	0.75	-	0.6
Pork/beef	0.80	0.80	0.71	0.67
g water/100 g meat	178	144	67	100

The pH values of the raw masses were measured using a Findip pH/mV meter 555 A (Findip Co., Finland).

To study the effect of the salt and phosphate content the meat was taken from the shoulders of young beef animals. The redipe was: 50 g beef (fat content c. 10 %), 40 g pork (fat content c. 50 %) and 120 g water. When the salt content was kept constant, it was 2 %, and with phosphate it was correspondingly 0.3 % (0.17 % P_2O_5). The phosphate used was Sitonal, a commercial sausage phosphate preparation (Research Center of Meat Industry, Finland).

The firmness of the sausages was determined with an Instron TM-100 (Instron Ltd., England) using a lateral pressure or cutting piston. The temperature of the sausages was +8°C at the time of measurement. The sausages for measuring firmness were prepared with low water content (65 g beef, 45 g pork and 90 g water) to avoid water release during cooking.

RESULTS AND DISCUSSION

The water-binding capacity increased sharply in sausages without added phosphate when the pH value rose in the range 5.4-5.9 (Fig. 1). Above pH 5.9 the increase was slower, and maximum water-binding was reached at pH 6.15-6.25. In sausages with phosphate the lowest pH value was 5.8 due to the fact that added phosphate raises the pH value. The water-binding capacity increased to a maximum when the pH rose to 6.25.

Figure 2 shows the results of a test in which the pH of meat of originally different pH values was adjusted by addition of acid or base to various values. The curve taken from Figure 1 (without added phosphate) acts as a control.

It can seen that adjusting the pH value the pH-WHC curves assume almost the same shape, irrespective of the original pH. The main difference when compared with the control curve is that the adjusted curves have no maxima. The meat with a lower original pH (5.5) reached a maximum level at pH 6.0, but the other two also showed a slight increase after pH 6.0. Figure 3 shows the corresponding results for sausages with added phosphate. In this case, too, the curves are quite similar in shape. The curve for the meat with the lowest original pH reached a maximum at pH 5.8.

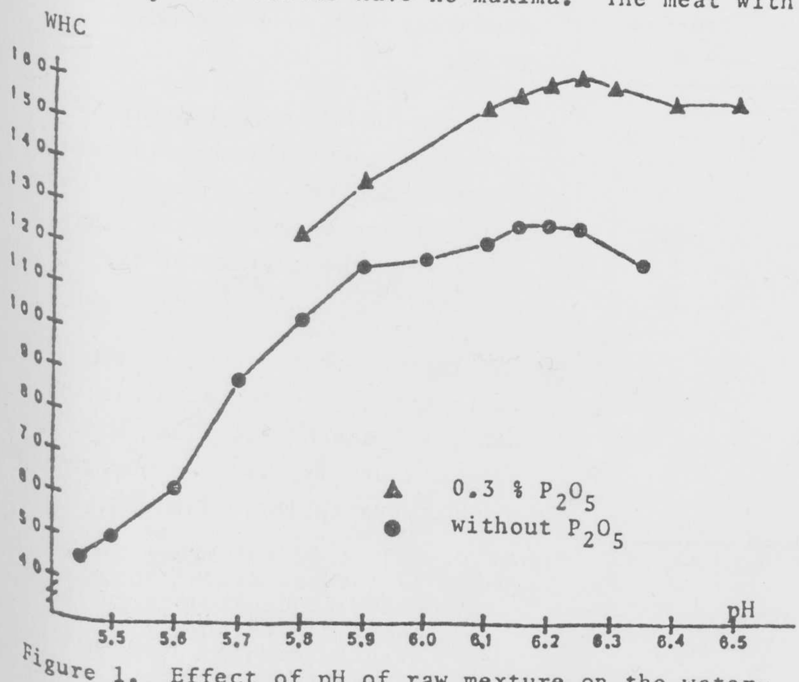


Figure 1. Effect of pH of raw mexture on the water-binding capacity (WHC) of frankfurter-type sausages (WHC, g water/100 g meat).

The effect of pH on the firmness value by lateral pressure was small (Fig. 4). Use of a cutting piston shows that the firmness increases as the pH rises to 5.9, after which the firmness values decreases slightly.

In Figures 2 and 3 the water-binding capacity has been measured using only 5 different pH values for each meat sample. With so few points it is diffucult to determine the maximum. It should also be noted that in extreme cases the acid or base additions may have been large enough to cause some denaturation during the preparation and thus influence the shape of the pH-WHC curve. In practice, the pH of cooked sausage masses seldom varies to this extent. The pH may lie, depending on whether phosphate is used between 5.8 and 6.1 (PUOLANNE et al. 1978). Thus it can be concluded that the use on DFD meat as one of the ingredients is unlikely to cause marked technological changes in cooked sausage.

As the salt content increases there is a marked increase in water binding after 1 % NaCl. The increase continues rapidly up to 3 % NaCl and thereafter slightly more slowly, reaching a maximum at 4 % NaCl (Fig. 5). The corresponding curve for phosphate shows an even sharper initial increase, but the increase slows down earlier. The maximum is reached at 4 % NaCl in this case, too. Figure 5 also shows that added phosphate has its maximum effect at 2 % NaCl.

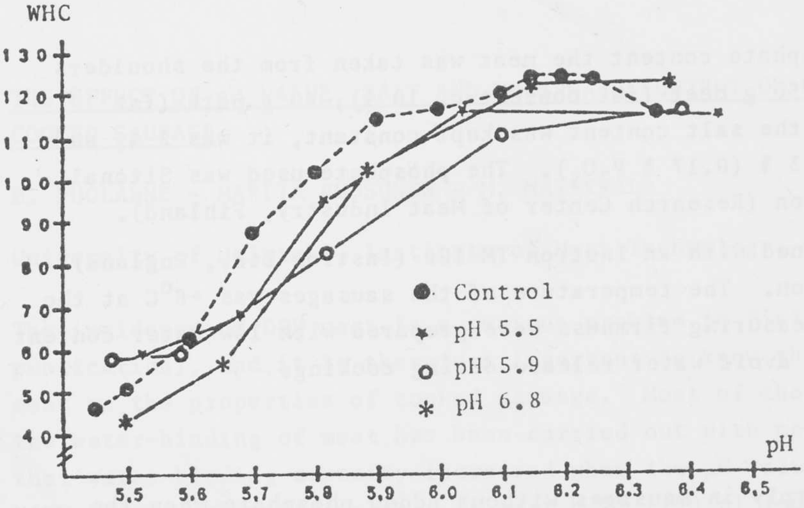
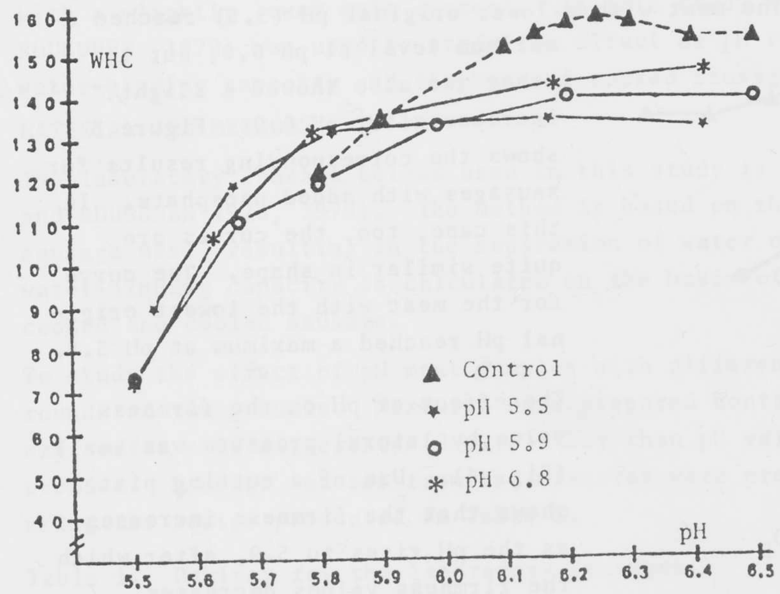


Figure 2. Effect of adjusting the pH of the raw mixture to the water binding capacity (WHC) (WHC, g water/100 g meat) of frankfurter-type sausages when processing beef items with different pH values; no added phosphate.

As the phosphate content increases the water-binding capacity increases to c. 0.2 % P_2O_5, after which the increase is negligible (Fig. 6). In studies currently in progress (PUOLANNE and RUUSUNEN 1980) it has been found that an increase in fat content moved the curves in Figures 4-6 to the left. It can be concluded that the ionic strength in the aqueous phase is the decisive factor, and merely the salt or or phosphate content of the product (see also HAMM 1958 and RANKEN 1973).

From the technological point of view it can be concluded that lowering the salt content to below 2 % causes a marked decrease in water binding and lowers the quality of the sausages.

An alternative to lowering the NaCl content might be to use a mixture of NaCl, KCl and $MgCl_2$. That kind of salt mixture is now as a commercial product available in Finland.



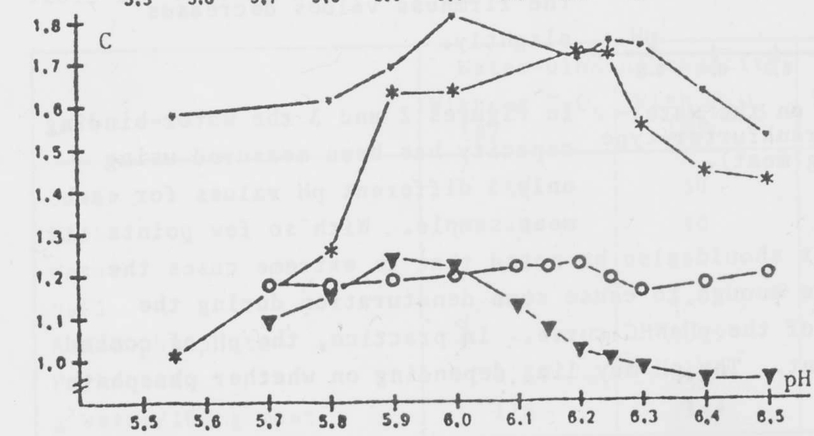


Figure 3. Effect of adjusting the pH of the raw mixture to the water-binding capacity (WHC) (WHC, g water/100 g meat) of frankfurter-type sausages when processing beef items with different pH values; with added phosphate.

Figure 4. Effect of pH of raw mixture on the consistency (C, kg) of frankfurter-type sausage.

no phosphate * lateral pressure
* cutting piston

0.3 % P_2O_5 ○ lateral pressure
▲ cutting piston

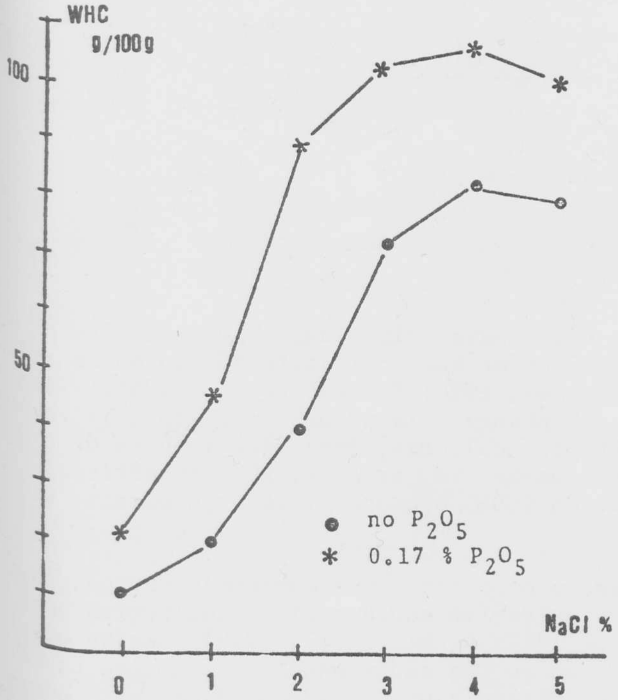


Figure 5. Effect of NaCl content on the water-binding capacity of cooked sausage mass.

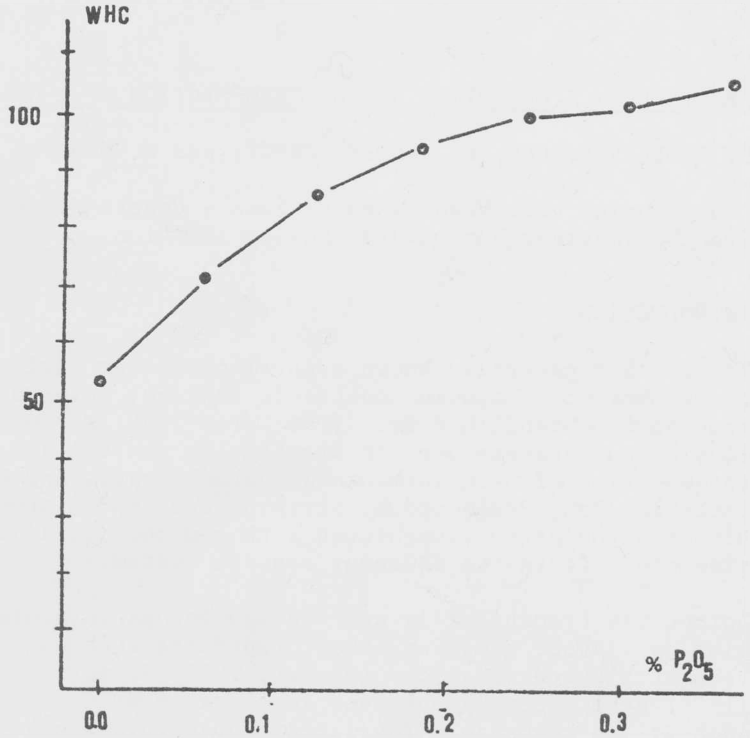


Figure 6. Effect of added phosphate content on the water-binding capacity of cooked sausage mass.

References

HAMM,R. 1962a. Über das Wasserbindungsvermögen des Säugetiermuskels. X. Mitt. Der Einfluss von Salzen auf Proteinladung und Wasserbindungsvermögen. Z. Lebensmittel-Unters. u. -Forschung 116:511-516.

HAMM,R. 1962b. Über das Wasserbindungsvermögen des Säugetiermuskels. XII. Mitt. Über das unterschiedliche,nicht auf pH-Differenzen beruhende Wasserbindungsvermögen des Rindermuskels. Z. Lebensmittel-Untersuch. u. -Forschung 117:415-419.

HAMM,R. 1958. Das Salzen von Fleisch. II. Das Salzen abgehängten Fleisches und seine Bedeutung für das Wasserbindungsvermögen. Fleischwirtschaft 10:700, 773.

HAMM,R. 1972. Kolloidchemie des Fleisches. Paul Parey in Berlin und Hamburg, Leipzig.

HANNUKAINEN,EEVA 1980. Consumption of sausages and meat in Finland during 1904-1979. Reports from Institute of Meat Technology, University of Helsinki. Nr. 249.

PUOLANNE,E., KARIMAA,J., RUUSUNEN,M. & NIINIVAARA,F.P. 1978. Nitriittisuolaesisuolauksen vaikutus keittomakkaran laatuun. Suomen Eläinlääkärilehti 84:325-339.

PUOLANNE,E. & RUUSUNEN,M. 1978. Verfahren zur Untersuchung der Eigenschaften von Brühwurstbrät. Fleischwirtschaft 58:1543-1544.

PUOLANNE,E. & RUUSUNEN,M. 1979. On the water-binding capacity of the ingredients of cooked sausage. Proc. 25th Eur. Meeting of Meat Res. Workers. II:6.16.

PUOLANNE,E. & RUUSUNEN,M. 1980. Effect of water and fat content on the maximum of the salt content — water-binding curve. In preparation.

RANKEN,M.D. 1973. Some effects of added water and salt on the cooking losses of meat. Proc. 19th Eur. Meeting of Meat Res. Workers, Paris I/5.

SCHULTS,G.W. & WIERBICKI,E. 1973. Effects of sodium chloride and condensed phosphates on the water-holding capacity, pH and swelling of chicken muscle. J. Fd. Sci. 38:991-994.