No. 21

215

4th Meeting of European Meat Research Workers
Cambridge: Sep.15-19th, 1958.

ON CORRELATIONS BETWEEN THE pH VALUE OF MEAT AND THE DIFFUSION OF SALTS.

by L.Körmendy and Gy.Gantner

Meat Res.Dept.of the Institute for Research in Canning, Meat Packing and Refrigeration, Budapest /Hungary/.

In their papers Banfield and Callow have made interesting observations on the correlations between the pH value of meat and its electric resistance /1,2/. Amongst other facts they have found that a high electric resistance in meat corresponds to a high pH value. They attribute this phenomenon to the fact that an increase in pH results in swelling of the muscle fibres, as a consequence of which the gaps between cells and fibres through which ions can freely migrate, diminishes. Callow distinguishes "open" structures of compact consistency on the one hand and "stringy", "flaccid" "closed" structures, which are dry to the touch on the other hand. The above phenomena are - according to Callow and Ingram /3/ - also correlated with the ability of the meat to be cured. Meat of lower pH value /which has lower dielectric resistance/, is also more easily permeable to brines. From this it naturally follows that it is advisable to select, treat and store the raw materials used for meat curing so that they have an acid pH; such raw material being certainly more suitable for curing.

The test results of Gibbons and Rose /4/ deserve special mention; startint from raw materials of lower pH values they found in picking a somewhat more favourable development of colour; they obtained, however, no close correlation between the pH value and the salt content. It is true that - as they mention themselves in their paper - their test contidions not having been uniform /e.g. the samples tested differed from each other in thickness etc./ they were usable to give a satisfactory, certain reply to the letter question.

In our preceding paper /5/ we have already reported on the results of our tests when studying the behaviour of fresh, warm, raw meat of high pH value in respect of the possibility

of curing. We have established that there was no sensible difference between fresh raw meat /1,5 - 2 hours after slaughtering/ and meat stored for 24 hours or longer in respect of change of salt penetration as regards time. This was so in spite of the fact that very essential differences were found as regards pH value, texture, etc. We had naturally also to take into account that fresh Beef of high pH value has to be considered from a biochemical angle as being in a "labile" condition. Biochemical changes decomposition of glycogen and A.T.P., formation of lactic acid, etc./ set in very rapidly during the 24 hours after slaughtering; during subsequent cold storage, changes in the physico-chemical properties, consistency, and pH value of the meat are considerably slower. It is therefore obvious that during early curing, particularly within the first 24 hours, such changes are taking place simultaneously with salt penetration. We do not know, however, in what way the above mentioned processes are influenced by the penetration of salt into the tissues.

In this paper we wish to relate experiments in which we studied the correlation between the ease of curing and the pH value on specimens of meat which had been allowed to stand for at least 48 hours, during which their pH value changed at a comparatively slow rate. Such samples were therefore, biochemically relatively "stable".

Materials and methods

In order to ensure uniformity of the test material we always used pork /loin/ with our tests. We endeavoured to ensure the reproducibility of the tests - knowing the parameters influencing curing of meat /5, 6/ - by strictly adhering to a given procedure. The pork loins used for the experiments, had been cold stored at +2-+6° C for 2 to 6 days we bored cylindrical samples using a 5 cm inner diameter steel tube sharpened at one end; we had found, in fact, that relatively uniform diameters can be obtained in this way. The cylinders of meat were bored parallel to the direction of the fibre axis. Pices of meat, freed from fat

216

and coarse connective tissue elements were used for our tests. After boring, we cut the cylinders each time so as to obtain a length of 1o cm. As shown on Fig.1 we obtained - inspite of all endeavours - sample pieces of different weight according to the quality of the meat, i.e. of different diameters, the lengths being identical.

The weight of the 1o cm long cylinders /1o2 pieces/ varied between 122 and 2oo g /mean value 158 g/. The standard deviation /S = ± 14,4 /9,1 per cent// was in any case not excessive. Fig. 1 also shows that the probit analysis indicated an approximately normal distribution. Curing time necessary for reaching a given average concentration of salt being roughly proportionate to the square of the diameters, i.e. in this case to the weight of the cylinders. We tried to eliminate the influence of weight fluctuations on the speed of the curing process by calculating the partial correlation coefficients /7/.

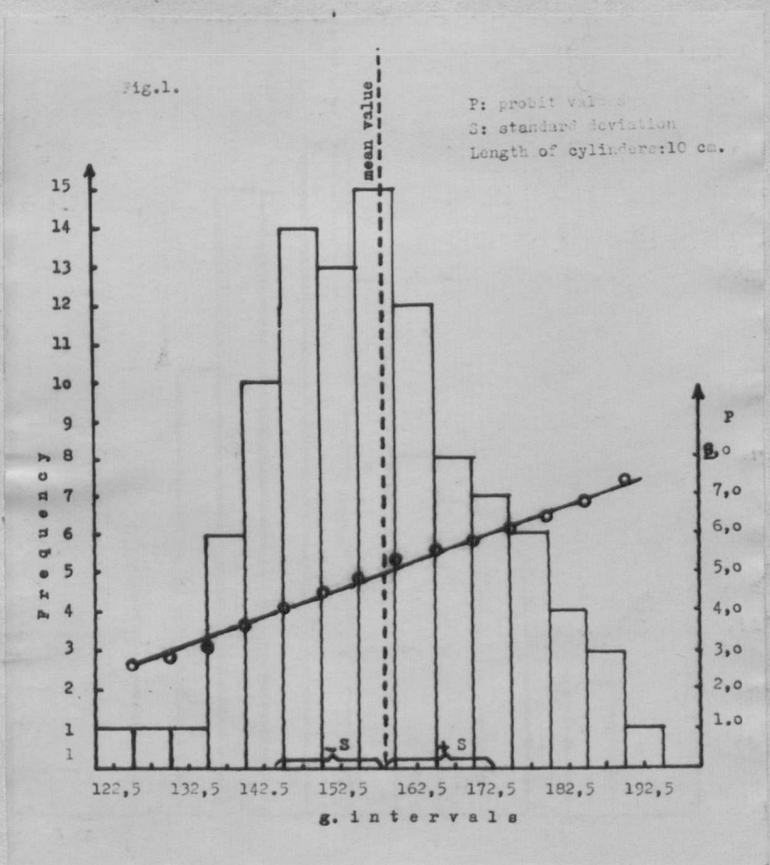

Fig. 1 Distribution diagram of weights of cylinders of meat

Following the operating practice we always used as ratio between pickle and meat 1 : 1 .

The composition of the pickle used was 2o.4 ± o,2 g NaCl + o.4 ± o,o3 g KNO_3 per 1oo ml.

We put the sample pieces prepared for the tests, which had been stored previously /at + 2 - + 5° C/ in a refrigerating box, into 4oo ml beakers, then added from a graduated cylinder the necessary volume of pickle having a temperature of +2 - +5° C, covered the beakers with watch glasses and stored them at +2 - +5° C for exactly 24 hours in an ice-box. During the test the pickle was absolutely at rest. After 24 hours we removed the cylinders from the pickle and determined the salt concentration of the pickle. The average salt concentration of the meat was determined on basis of the correlation below:

$$C_{24} = p\,/d_o - d_{24}/$$ where

p = volume ratio pickle/meat; ml of pickle/ml of meat

The value of p is given by the following correlation:

$$p = p' S_o = p' \cdot 1{,}067 = 1{,}067$$ where

p' = pickle/meat ratio; ml of pickle/g of meat/ with our present tests 1,o/

S_o = average specific gravity of salt-free meat; g/ml /on basis of our earlier tests /6/ 1,o67/

C_{24} = average salt concentration of the meat after 24 hours; g/1oo ml

d_o = initial salt concentration of the pickle; 2o,4 g/1oo ml

d_{24} = salt concentration of pickle after 24 hours; g/1oo ml.

The above correlation is strictly valid only if there is no change of volume during the diffusion process. As shown, however, by our tests; a 3 to 5 per cent. swelling of the meat appeared after 24 hours curing. In view of the well defined identical external circumstances - the tests being comparative - we disregarded the systematical error involved.

We considered specially the optimum time for determining the salt contents. It may be demonstrated by a calculation

217

of errors /6/ that, with diffusion processes, the value of the diffusion constant can be determined with the minimum error of measurement at the central period of the process; in the case of prolonged diffusion times, determinations will become inaccurate in the vicinity of the equilibrium concentration. As shown by Fig. 2 the salt concentration values found by us after 24 hours with the 10 cm long sample pieces are situated rather far from the equilibrium concentration.

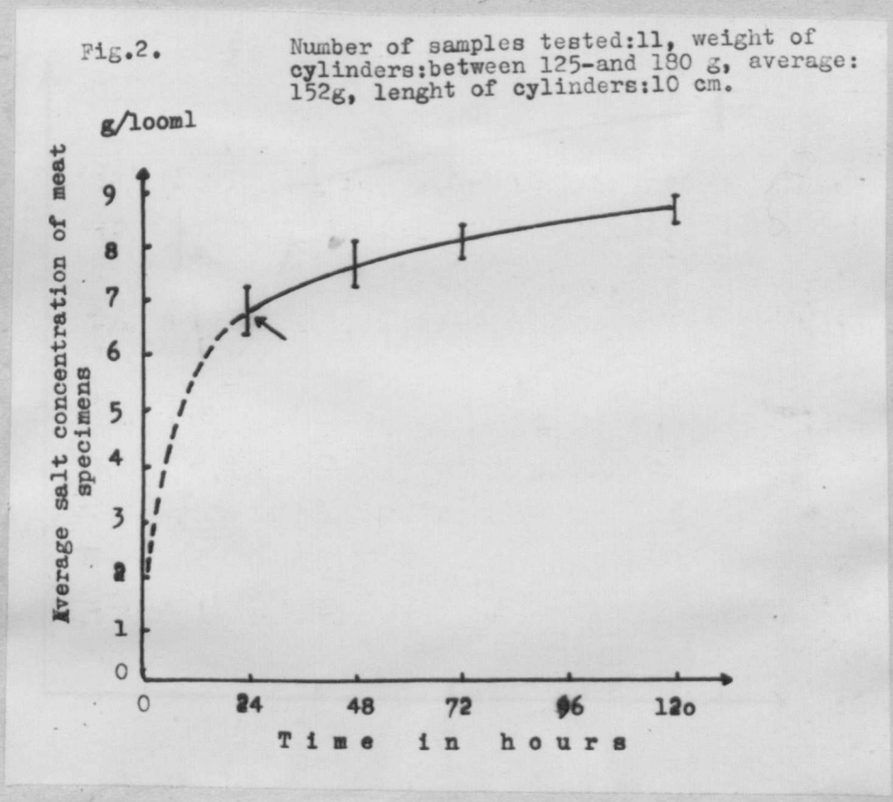

Fig. 2 - Change of salt concentration in cylinders of meat as function of the time of curing

Hence, for our comparative work, the salt concentration reached after 24 hours /C_{24}/ could be considered as giving a good approximate measure of the speed of diffusion.

We did not pay particular attention to investigating the phenomena of colour development.

We determined the pH value from the raw meat free of salt by using a quinhydrone electrode. We did not follow the change of the pH value during the curing process.

Results and conclusions.

1o2 sample pieces of different quality have been tested. The results are shown in Figs 3. and 4.

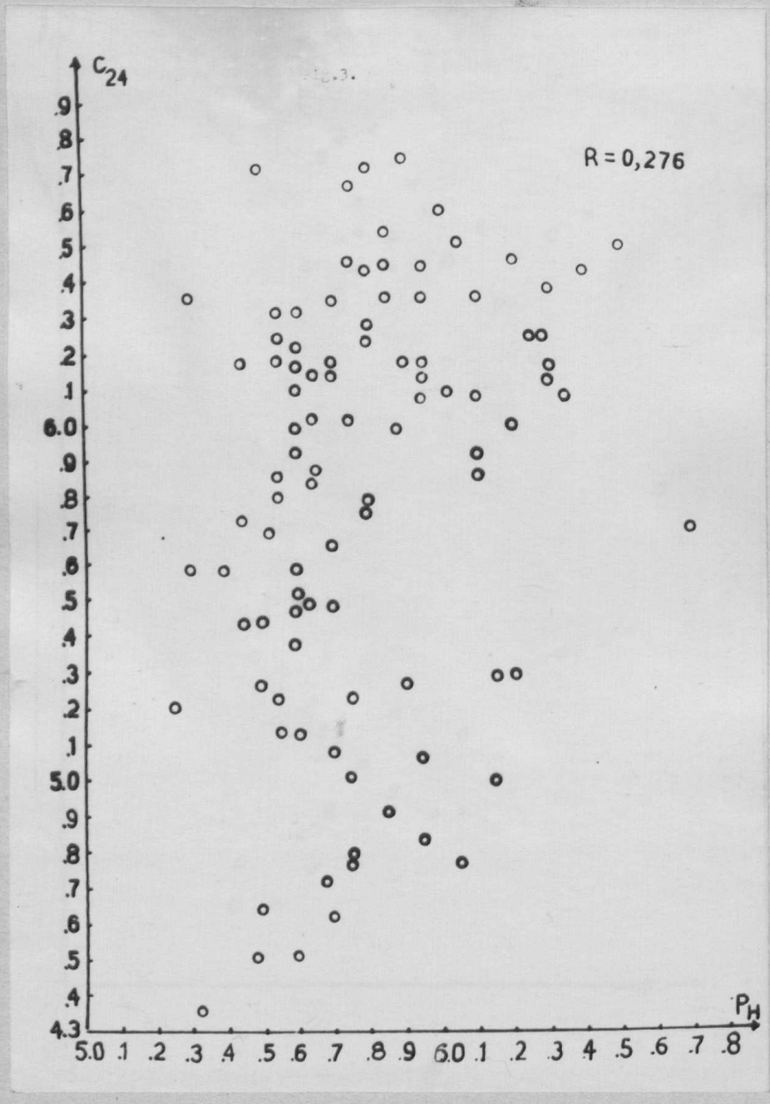

Fig. 3 - Correlation between the pH value of meat and the speed of curing /C_{24}/.

The following conclusions may be drawn from the results of the correlation calculation:

1. There is no close correlation between the pH value of the meat and speed of salt penetration /C_{24}/ - without taking into consideration the fluctuations in diameter. The value of the correlation coefficient /$R_{C_{24},pH}$ = o,276/ is very low though it appeared highly significant.

2. A rather close correlation exists between the speed of salt penetration /C_{24}/ and the weight /g/ of the cylinders proportionate to the square of the diameters.

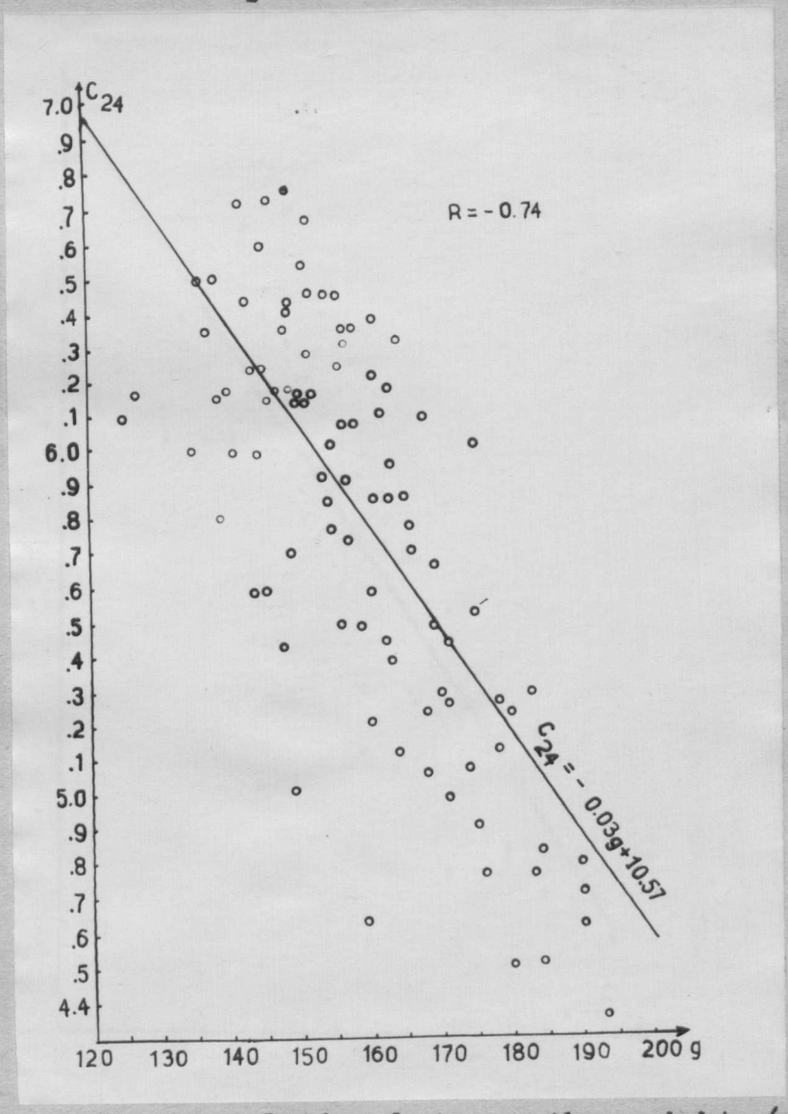

Fig. 4 - Correlation between the weight /g/ and the speed curing /C_{24}/ of the meat showing the line of regression

The value of the correlation coefficient /$R_{c_{24}, g} = -0.74$/ is relatively high and very highly significant.

3. Even eliminating the fluctuations of diameter /assuming constant diameters/ there is no correlation between the pH value of the meat and the speed of salt penetration. The partial correlation coefficient /$R_{c_{24}, pH\ \bar{g}} = 0,19$/ is not significant !

4. Eliminating the fluctuations between pH values /with samples of identical pH values/ there continues to be a very highly significant, close correlation between the speed of salt permeation and the weight of the pieces of meat. /$R_{c_{24}\ g, \bar{pH}} = 0,727$/

There is probably no linear connection between the C_{24} and g values. The cylinder diameters having, however, fluctuated within not too wide limits /see Fig. 1/ in the range tested by us, the linearity test did not indicate this.

Summarizing our test result we can state that under experiment conditions described above we were unable to demonstrate a close, also statistically supported correlation between the pH values of the meat specimens tested and the permeability to salt solutions of the muscle tissue. We should also add, however, that the samples tested fluctuated between a relatively narrow pH interval. There was not one sample piece within the range of pH = 6,8 - 7.0.

Literature

/1/ Bate-Smith: Adv. in Food Res. I. 1948 /Academic Press. Inc. Publishers. New York, N.I./

/2/ Callow: Brit.Journ.Nutrition 1, 269.1947

/3/ Ingram: Ann. Inst. Pasteur 75. 139. 1948

/4/ Gibbons-Rose: Can. J.Res. 28.F. 438, 1958

/5/ Körmendy-Gantner: Élelmiszervizsgálati közlemények II. 179 1956.

/6/ Körmendy-Gantner: Ztschr.Lebensm.Unters.Forsch.107. 313, 1958.

/7/ Weber, E.: Grundriss der biologischen Statistik /Jena, 1956/

Errata

ad Körmendy-Gantner's paper

Page, Paragr, Line			Error	Correct
1	1.	3	electric	electrical
1	1	4	electric	electrical
1	1	14	dielectric	electrical
1	2	2	startint	starting
1	2	3	picking	pickling
1	2	8	usable	unable
1	1	4	during	after
1	2	7	we	We