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EFFECT OF VARIOUS TEMPERATURES OF WATER AND SOLUTION OF SODIUM CHLORIDE AND POLYPHOSPHATES ON HYDRATION OF GROUND BEEF

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Water holding capacity of meat is one of the main problems in the field of meat technology, being of scientific, practical and specially economic significance. Juiciness, tenderness, flavour and other quality components of finished products are dependent on meat hydration. In addition, water holding capacity of individual muscles plays a special role in stages of their technological processing: grinding, salting, heat treatment, smoking, freezing, thawing and the like.

Starting from the above mentioned facts, the experiments were conducted to examine some factors which can influence the change in hydration of ground beef. Our examinations were orientated to the temperature range from 4° to 40°C and to the application of sodium chloride and polyphosphates which are usually used in industrial meat processing.

The principal task of the work was to answer the following questions:

- to which extent hydration of ground beef is affected by heating meat and water in ranges from 4° to 40°C, using methods applicable in production; and

- whether sodium chloride and polyphosphates, individually or in combination, influence this complex.

Although there exist numerous data on the above mentioned problem in the literature, our intention was to throw light on the problem not only from the standpoint of science but from the standpoint of practice, too, using methods applicable in the production.

The literature data which are in close relation to this work are presented in the discussion.

EXPERIMENTAL

Beef utilized in the experiments derived from well fed cattle 7 do lo years old. Beef was chilled at 4°C for 48 hours. Prior to sampling, connective and fatty tissues were carefully cut off from beef pieces. Hydration tests were made with longissimus dorsi samples cut from the loth thoracal to the 5th lumbal vertebra and ground in the grinder through Ø 3 mm plate.

pH value and protein percentage were determined for each sample. pH was determined in meat extract (meat: water = 1:4) by means of pH-meter produced by W.G.Pye - Cambridge. Protein percentage was determined by Kjeldahl micromethod.

Average pH value (5.54) and average protein percentage (21.05) were the same in all series of experiments. pH value and protein percentage of samples having maximum, namely minimum water holding capacity are presented in Tables 1 - 4.

Experiments were carried out in 4 series. Each experimental series consisted of 16 samples.

In the first series, ground beef samples were treated with water at 4°, 20° and 40°C.

In the second series, ground beef samples were treated with sodium chloride solution at 4°, 20° and 40°C.

In the third series, ground beef samples were treated with polyphosphate solution at 4°, 20° and 40°C.

In the fourth series, ground beef samples were treated with solution of sodium chloride and polyphosphates at 4°, 20° and 40°C.

Additives utilized in the experiments were the following: sodium chloride p.a. and "Tari-brät" polyphosphate preparation (produced by "Gebrüder Giulini"). Water used in experiments was the distilled one. Additives were dissolved in distilled water.

Each ground beef sample weighed 5 grams. Samples of the first series were treated with 5 ml of distilled water;

In experiments in which additives were utilized, meat was treated with 1.5 percent of sodium chloride, 0.5 percent

of polyphosphate preparation respectively, dissolved in 5 ml of distilled water.

The weighed meat sample was carefully mixed with water, namely with a solution being at 4°, 2o° and 4o°C and in a glass container treated at the mentioned temperatures for 2o minutes.

Experimental temperatures of 2o° and 4o°C were maintained by means of a water bath and 4°C by iced water.

The quantity of bound water in ground meat was determined by centrifugation method. Centrifugation lasted lo minutes at 3ooo r.p.m. After centrifugation, water remained in the centrifuge glass was transferred into the graduated cylinder. Water level in the cylinder was read by means of magnifying glass. The quantity of bound water was calculated by subtracting quantity of remained water from quantity of added one and expressed in percentages related to the weight of meat sample.

The obtained results are presented in Figures 1, 2, 3 and 4, using a statistical method.

RESULTS

I. Hydration of ground beef treated with water at 4°, 2o° and 4o° C

The results of the examinations for each sample as well as the average values are presented in Fig. 1.

The basic fact which could be established by analysing each sample as well as average values is that practically there is not any difference in hydration of meat treated with water at 4°C and at 2o°C. In the first case beef bound 28.37 percents of water on average, and in the second one - 28.35 percents. This was not the case with samples with water at 4o°C, there the average value of bound water was 25.12 percents.

Comparing the results of the first series of experiments, it may be observed that added water holding capacity of meat decreases with temperature increase. The minimum decrease of water holding capacity was established in temperature range from 4° to 2o°C whereby the decrease is more remarkable at temperature range from 2o° to 4o°C.

Analysing differences in hydration of individual samples in each experiment, it is possible to state that they are considerable. Having obtained such data during orientation examinations already, it showed to be necessary to determine some physico-chemical properties of meat samples prior to testing their water holding capacity. Therefore, we examined pH value and protein percentage of each sample. The results are presented in Table 1. but only for meat samples having maximum, namely minimum hydration. The obtained data show that samples having higher pH values and higher protein percentages, heated in the temperature range from

pH VALUES AND PROTEIN PERCENTAGE OF SAMPLES HAVING MAXIMUM AND MINIMUM WATER HOLDING CAPACITY

Ground beef treated with water at various temperatures

Table 1.

Water holding capacity	4°C		20°C		40°C	
	pH	protein (%)	pH	protein (%)	pH	protein (%)
Maximum	5.85	22.55	5.95	22.55	6,10	21.19
Minimum	5.35	21.23	5.55	21.23	5.34	21,62

4° to 40°C, regularly have higher water holding capacity than samples having lower pH values and lower protein percentages.

II. Hydration of ground beef treated with sodium chloride solution at 4°, 20° and 40°C

Treating beef samples with sodium chloride solution resulted in increase of water holding capacity of meat in temperature range from 4° to 20° C; at 4°C, average water holding capacity was 31.37 percents and at 20°C - 34.00 percents. Further heating caused decrease in hydration so that average water holding capacity of meat at 40°C was 32.00 percents.

pH VALUES AND PROTEIN PERCENTAGE OF SAMPLES HAVING MAXIMUM AND MINIMUM WATER HOLDING CAPACITY

Ground beef treated with sodium chloride solution at various temperatures

Table 2.

Water holding capacity	4°C		20°C		40°C	
	pH	protein (%)	pH	protein (%)	pH	protein (%)
Maximum	5.90	22.55	5.90	22.55	5.80	23.09
Minimum	5.35	21.23	5.35	21.23	5.48	20.40

Data of physico-chemical examinations of samples from the second series of experiments match those from the first experimental series: samples with maximum water holding capacity of meat had higher pH values and protein percentages in relation to samples with minimum water holding capacity. There is no need to emphasize that in all cases samples treated with sodium chloride solution show considerably higher water holding capacity in comparison with samples treated with water.

III. Hydration of ground beef treated with polyphosphate solution at 4°, 20° and 40°C

The purpose of the experiments was to establish eventual changes in ground beef hydration treated with polyphosphate solutions at 4°, 20° and 40°C. The obtained

data (Fig.3) show that meat hydration linearly decreases with temperature increase from 4° to 40°C. The highest water holding capacity in the third series of experiments (41.12 percents of bound water) was determined in meat treated at 4°C. The minimum hydration (29.75 percents of bound water) had samples treated with polyphosphate solution at 40°C.

In the experiment there also exist significant differences in hydration of individual samples. Physico-chemical examinations, presented in Table 3, confirm the previous statement: samples having maximum water holding capacity show higher pH values and higher protein percentages than samples having minimum water holding capacity.

pH VALUES AND PROTEIN PERCENTAGE OF SAMPLES HAVING MAXIMUM AND MINIMUM WATER HOLDING CAPACITY

Ground beef treated with polyphosphate solution at various temperatures

Table 3.

Water holding capacity	4°C		20°C		40°C	
	pH	protein (%)	pH	protein (%)	pH	protein (%)
Maximum	6,00	23,09	5,95	19.98	5.95	23.55
Minimum	5,45	21.41	5.48	21.51	5.35	21.23

Samples treated with polyphosphates, compared with samples from two previous series of experiments, showed higher water holding capacity of meat at 4° and 20°C; at 40°C, water holding capacity of meat was lower in samples treated with water and higher in samples

treated with sodium chloride solution in relation to samples treated with polyphosphate solution.

IV. Hydration of ground beef treated with solution of polyphosphates and sodium chloride at 4°, 20° and 40°C

The effect of the solution of polyphosphates and sodium chloride on meat hydration at 4°, 20° and 40°C, presented in Fig. 4, showed to be identical to the effect of polyphosphates themselves: meat hydration decreases with temperature increase.

Average meat hydration values of samples treated with polyphosphates and sodium chloride (fourth series) were lower than those of samples treated with polyphosphates (third series) at 4°C and 20°C; that was not the case with samples treated at 40°C.

Comparing meat hydration of samples of the fourth series of experiments with the second one (sodium chloride), it may be stated that hydration data at 20° and 40°C of the fourth series are very close to those of the second series of experiments; only more remarkable deviations were at 4°C: in the fourth series average water holding capacity was 34.12 percents and in the second, it was 31.37 percents.

On occasion of examining physico-chemical properties, pH value and protein percentage of meat samples, it may be concluded that in this case defferences in hyd-

ration among individual samples match, rather regularly, differences in pH value and protein percentage.

pH VALUES AND PROTEIN PERCENTAGE OF SAMPLES HAVING MAXIMUM AND MINIMUM WATER HOLDING CAPACITY

Ground beef treated with solution of sodium chloride and polyphosphates at various temperatures

Table 4.

Water holding capacity	4°C		20°C		40°C	
	pH	protein (%)	pH	protein (%)	pH	protein (%)
Maximum	6.05	22.55	5.97	23.55	5.80	21.19
Minimum	5.50	21.41	5.35	21.23	5.35	21.23

DISCUSSION

The objective of the work was to investigate the effect of relatively low temperatures on beef hydration: maximum experimental temperature to be slightly over the physiological temperature of alive organism. The experiments were carried out at 4°, 20° and 40°C. In the same temperature range, individual and combined effects of sodium chloride and polyphosphates on beef hydration were also tested.

Results of experiments show that hydration of meat samples treated with water starts to decrease at 40°C. The data correspond to those of Hamm and Deatherage (4). According to their opinion, heating beef from 20° to 30°C causes no marked change of muscle proteins as well as no significant change in meat hydration; between 30° and 40°C denaturation

occurs. By the above mentioned statement, the reduced beef hydration obtained in the experiments could be explained. This is opposite, however, to the statement of Strobl (7) who suggests that reduce of muscle proteins extractability starts at temperatures not lower than 40°-45°C. Namely, it is very difficult to accept the hypothesis that the start of muscle protein denaturation occurs at temperatures lower than the physiological one. In the literature, there exist data that increase of muscle rigidity by heating begins at about 35°C, similarly to coagulation of pure actomyosin. At the same time, it is stated that proteins within the protein complex of muscle tissue are much more resistant to heat than isolated proteins (1, 5).

On the base of the experiments and up to now published data in literature, it is probable that denaturation of proteins does not start at temperatures lower than the physiological one. To our opinion, minimum exceeding of the limit causes start of denaturation. In this way the reduced beef hydration at 40°C, established in the experiments, may be explained.

There were observed difference in hydration of individual samples within the same experiment. It was tried to explain those differences by pH values and protein percentages of samples having minimum, namely maximum hydration (in Tables 1 - 4) although some data from literature state that there does not exist

corresponding correlation between water holding capacity of meat and protein content (2, 9).

Nevertheless, it ought to be emphasized that water holding capacity of meat is variable and it depends on numerous other factors as well: pH, rigor onset, total water content, mineral content, etc. Therefore, better hydration of individual meat samples cannot be explained only by means of protein percentage but by influence of other factorstoo. Examining the effect of differently heated meat with sodium chloride solution on meat hydration, it was established that meat hydration was increased in certain rate when meat was treated with sodium chloride solution at 20°C.

The datum is in favour of the statement that protein denaturation is impossible to happen at 20°C as well as that effect of sodium chloride on beef hydration increases with temperature increase. However, the number of experiments, carried out in the work, is not sufficient for establishment of final conclusion regarding the matter in question. The fact that at 40°C, in experimental conditions, meat hydration is reduced, speaks in the favour of denaturation start.

Differences in hydration among individual samples in these experiments may also be explained by already presented statement on effect of various factors on meat hydration.

In our opinion, the reason for the decrease in hydration of ground beef in the presence of polyphos-

phates at 20°C should not be attributed to the beginning of muscle protein denaturation at this temperature. It is supposed to be possible that this occurence is due to features of salts of weak acids which more considerably increase meat hydration only at pH values higher than 5.5, as presented in the literature (3). In the experiment, a considerable number of samples has the same or lower pH values and consequently the decrease of protein hydration at the above mentioned temperature may be explained in this way as well.

In general, the reason for the decrease of muscle hydration at 40°C is the beginning of protein denaturation.

The obtained results on effect of polyphosphates and sodium chloride show that increase of solution temperature effects the reduction of hydration, as it was the case on occasion of polyphosphates used solitary. Data on the problem, which could be found in the literature (8), state that common effect decreases with the increase of temperature in the range from 0° to 20°C, i. e. they are in correspondance to our results.

In this case, is protein denaturation at so low temperature in question or effect of some other factors? It is supposed that already given statement on the effect of polyphosphates on increase of muscle hydration only at pH values higher than 5.5 is in question. In our experiments, these values were considerably higher only in a few cases because meat cooled for 48 hours, namely aged meat, was examined.

C O N C L U S I O N S

On the base of the obtained results on the effect of low temperatures on ground beef hydration, the following conclusions may be drawn out:

1) If aged ground beef is treated by water at 4^{o}, 20^{o} and $40^{o}C$, the reduction of meat hydration occurs only at $40^{o}C$.

2) If ground beef is treated with 1.5 percents of NaCl, the maximum meat hydration is at $20^{o}C$; at $40^{o}C$, meat hydration is decreased.

3) If ground beef is treated with 0.5 percents of polyphosphates, meat hydration permanently decreases with the temperature increase from 4^{o} to $40^{o}C$.

4) On occasion of common effect of 1.5 percents of NaCl and 0.5 percents of polyphosphate, at temperatures 4^{o}, 20^{o} and $40^{o}C$, beef hydration is also permanently reduc ed with temperature increase.

EFFECT OF VARIOUS TEMPERATURES OF WATER AND SOLUTION OF SODIUM CHLORIDE AND POLYPHOSPHATES ON HYDRATION OF GROUND BEEF

SUMMARY

In meat technology, water holding capacity is one of the main problems which is of scientific, practical and especially economic significance. Juiciness, tenderness, flavour and other components of meat quality are dependent on meat hydration.

In the work it was tried to ascertain in which measure, by techniques applicable in production, ground beef hydration is affected by treating meat with water at 4°, 20° and 40°C and whether sodium chloride (1.5 percents) and polyphosphates (0.5) percents), individually or in combination, influence the whole complex.

In the first series of experiments, ground beef was treated with water at 4°, 20° and 40°C. It was observed that water holding capacity was reduced with temperature increase.

In the second series of experiments ground beef was treated with sodium chloride solution at 4°, 20° and 40°C. The maximum hydration was at 20°C and the minimum one at 4°C.

In the third series of experiments ground beef was treated with polyphosphate solution at 4°, 20° and 40°C. Obtained data show that hydration reduces with temperature increase. The maximum hydration had meat treated at 4°C. The minimum hydration showed samples treated with polyphosphates at 40°C

In the fourth series of experiments ground beef was treated with polyphosphates and sodium chloride at 4°, 20° and 40°C. According to obtained results, it may concluded that ground beef hydration decreases with temperature increase.

Analysing differences in hydration of samples in all experiments, it may be stated that samples with higher pH values and higher protein percentages had better hydration at 4°, 20° and 40°C than samples with lower pH values and lower protein percentages.

EINFLUSS VERSCHIEDENER TEMPERATUREN DES WASSERS UND NATRIUMCHLORID UND POLYPHOSPHAT-LOSUNGEN AUF DIE HYDRATION DES ZERKLEINERTEN RINDFLEISCHES

ZUSAMMENFASSUNG

Auf dem Gebiete der Fleischtechnologie ist das Wasserbindungsvermögen ein von den Grundproblemen, das eine wissenschaftliche, sowie praktische, besonders aber ökonomische Bedeutung hat. Vom Hydrationsgrad des Fleisches sind die Saftigkeit, Zartheit, Geschmack und andere Qualitätskom ponenten der Erzeugnisse abhängig.

Mittels Technik die in Produktion angewendet werden kann, hat man bei dieser Arbeit versucht, festzustellen, im welchem Masse sich durch das Behandeln des zerkleinerten Rindfleisches mit Wasser bei 4°, 20° und 40°C die Hydration ändert, und ob die Anweseheit von Natriumchlorid und Polyphosphat, einzeln oder gemeinsam, einen gewissen Einfluss erwirkt.

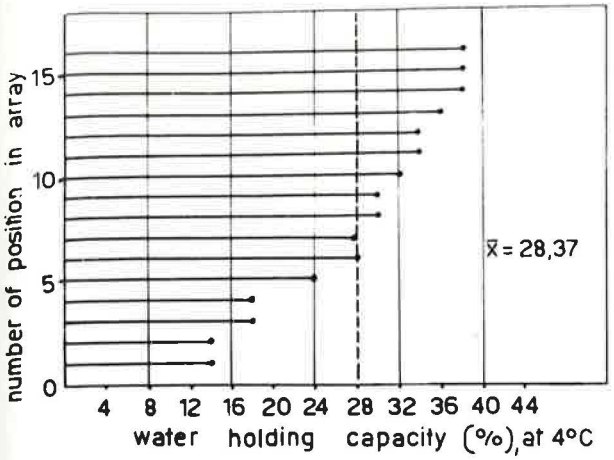
Bei der ersten Versuchsreie wurde das zerkleinerte Rindfleische mit Wasser bei 4°, 20° und 40°C behandelt. Dabei wurde wahrgenommen dass das Wasserbendungsvemögen mit dem Temperatursteigerung abnimmt.

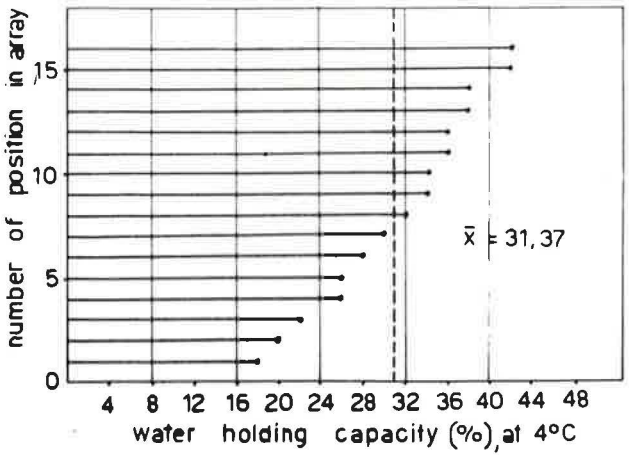
Bei der zweiten Versuchsreie behandelte man das zerkleinerte Rindfleisch mit Natriumchlorid-Lösung bei 4°, 20° und 40°C. Der Höchste Hydrationsgrad wurde bei 20°C, hingegen der minimaler bei 4°C erreicht.

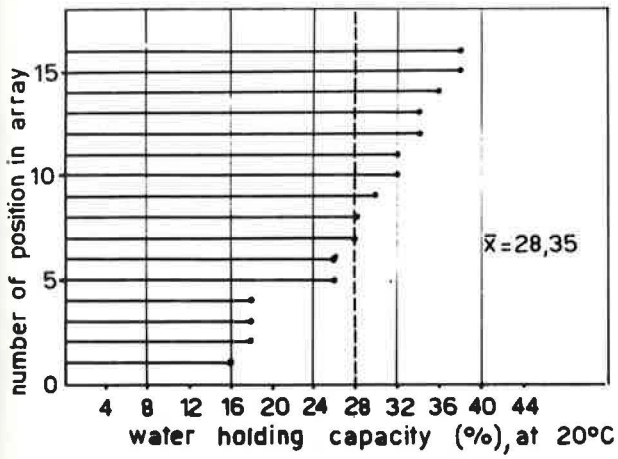
Bei den dritten Versuchsreie wurde das zerkleinerte Rindflesch mit Polyphosphatlösung bei 4°, 20° und 40°C behandelt. Die Ergebnisse zeigten, dass Hydrationsgrad mit Temperatursteigerung abnimmt. Der höchste Hydrationsgrad wurde während Behandlung bei 4°C erreicht. Den niedrigsten Hydrationsgrad zeigten die mit Polyphosphat behandelten Proben bei 40°C.

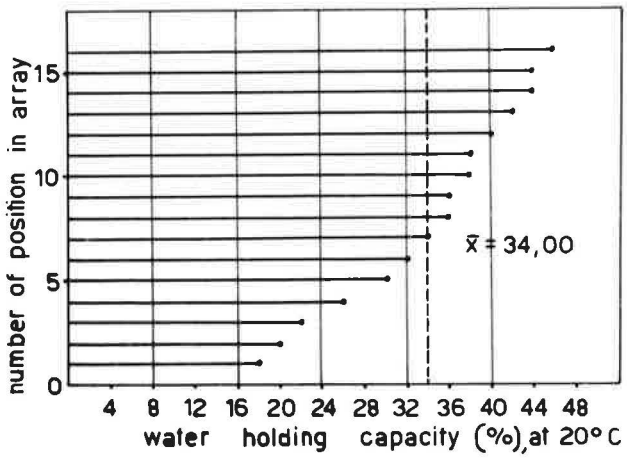
Bei der vierten Versuchsreie wurde das zerkleinerte Rindfleisch mit der Phosphat und Natriumchlorid-Lösung bei 4°, 20° und 40°C behandelt. Auf Grund der Erreichten Ergebnisse kann man beschliessen das die Hydration von 4° bis 40°C senkt.

Die Unterschiede des Wasserbindungsvermögens bei den Proben in allen Versuchreien analisierend, konnte man merken, dass die Proben mit höherem pH und höherem Eiweissprozentsatz bei Erhitzung von 4°, bis 20° und 40°C, im Regel, höheren Hydrationsgrad als Proben mit niedrigerem pH und niedrigerem Eiweissgehalt haben.









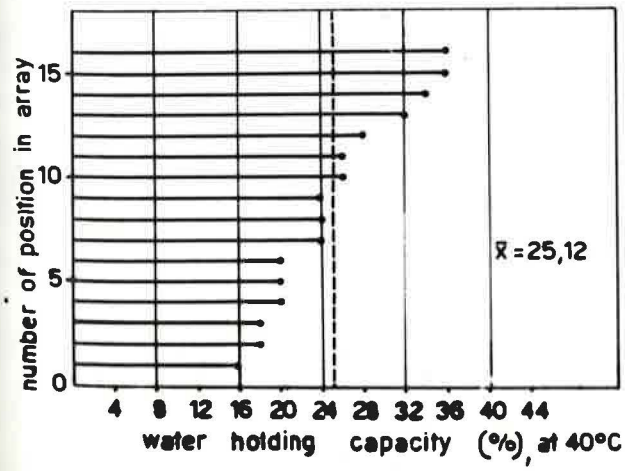


Fig. 1. Graphical representation of 16 determinations of water holding capacity of meat samples treated with water at various temperatures

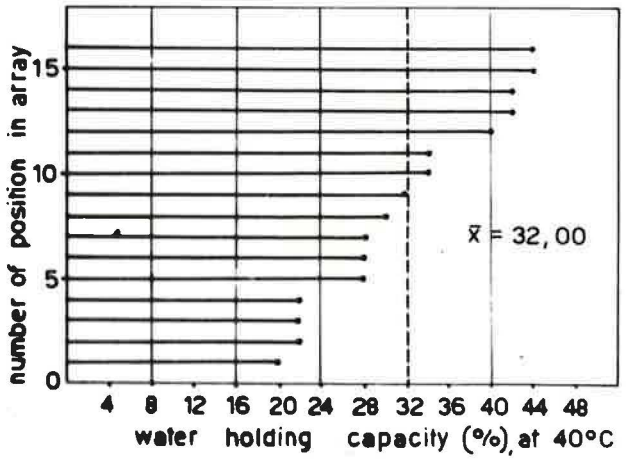
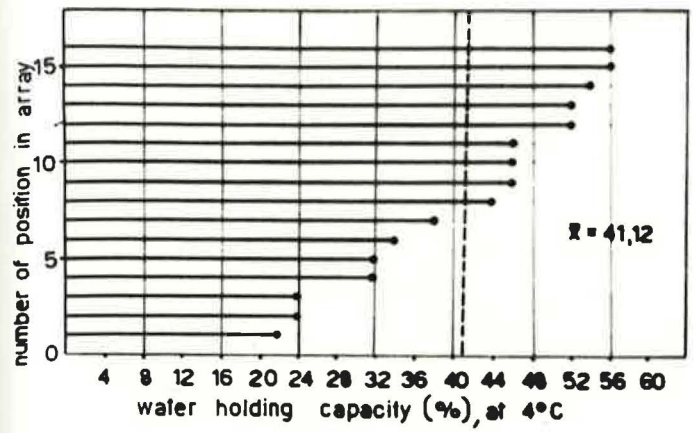
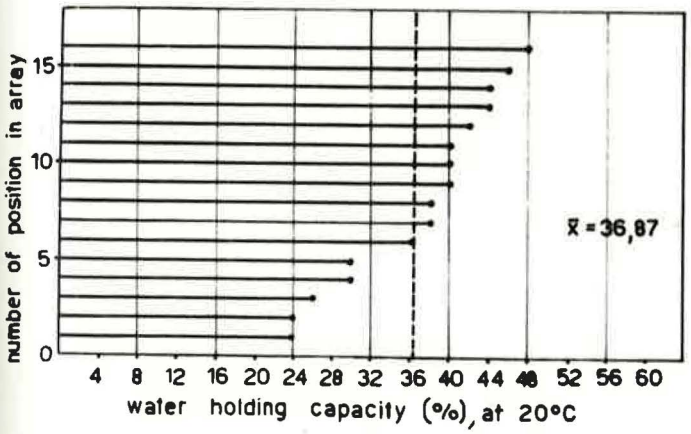


Fig. 2. Graphical representation of 16 determinations of water holding capacity of meat samples treated with sodium chloride solution at various temperatures





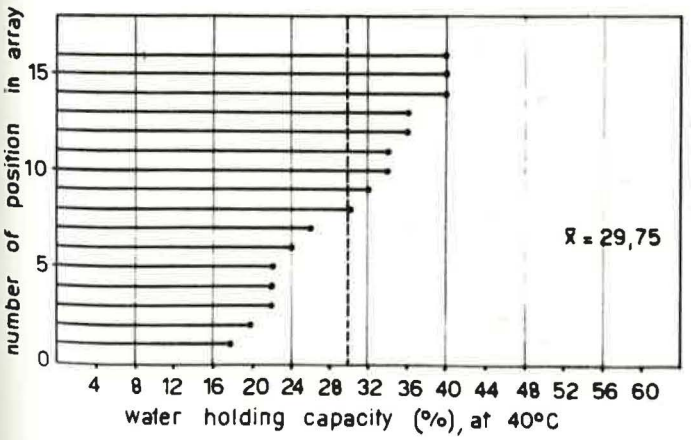
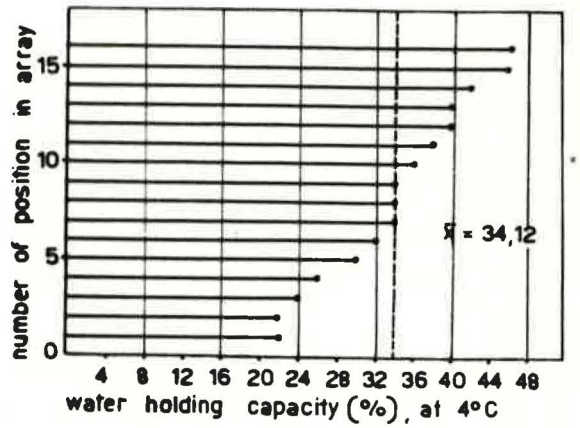
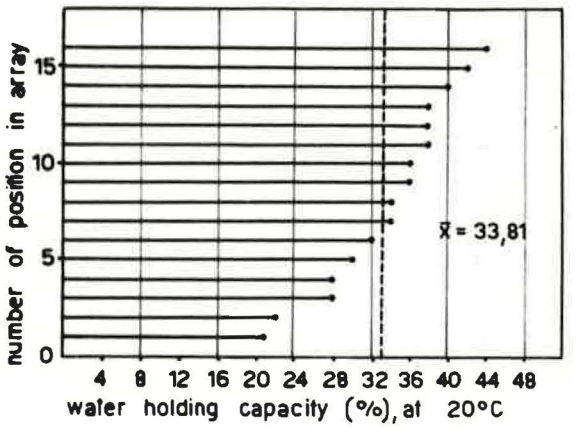


Fig. 3. Graphical representation of array of 16 determinations of water holding capacity of meat samples treated with polyphosphates solution at various temperatures





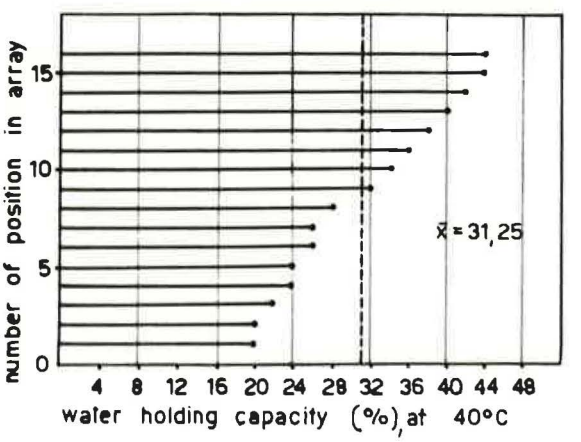


Fig. 4. Graphical representation of array of 16 determinations of water holding capacity of meat samples treated with solution of sodium chloride and polyphosphates at virious temperatures

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