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THE RATE OF SALT PENETRATION
INTO CUCUMBERS OF VARIOUS SIZES

Thesis for the Degree of M. S.
MICHIGAN STATE COLLEGE

Roland C. Fulde
1950

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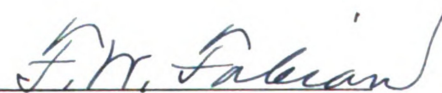
The Rate of Salt Penetration of Salt
into Cucumbers of Different Sizes.

presented by

Roland C. Fulde

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THE RATE OF SALT PENETRATION
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SIZES

By

ROLAND C. FULDE

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INTRODUCTION

In order to preserve cucumbers intelligently, it is necessary to understand the important part which salt plays in the process. (1) When salt is added to fresh cucumbers, it withdraws a part of the water together with the soluble nutrients from the cucumber due to the physical process of osmosis. Whenever any cell is placed in a solution having a concentration of salt greater than that of the cell, the flow of the water is always from the lesser to the greater concentration until equilibrium has been established. When the water leaves the cells of the cucumber, it carries with it the soluble food material which is present in the cucumber cells.

Consequently, the resulting solution contains not only salt but also food for microorganisms which are present in abundance on the cucumbers. They immediately start to use this food, and, if the proper kind of microorganisms are present, they produce acid and acid and gas.

It is at this point that salt plays another important part in cucumber pickling. It not only withdraws the nutrients from the cucumbers, but it controls largely the kind of bacteria which can survive and use the food. It inhibits temporarily all types of bacteria except the desirable ones, the acid-producing bacteria, which are able to adjust themselves to the salt and soon start an active fermentation provided other conditions such as temperature and moisture are favorable. The undesirable bacteria, those causing soft or decayed cucumbers, are inhibited and remain

dormant or die out entirely after a time, since they are unable to adjust themselves to the concentration of salt commonly used in preserving cucumbers. The acid produced by the acid-forming bacteria still further reduces the ability of the spoilage bacteria to survive; so that, theoretically at least, they should cause no further trouble.

In the early days of the pickle industry, the subject of salting was not so important because it was customary to "dry salt" the cucumbers. In this method, sufficient salt was added to cover the cucumbers. The salt concentration was so high that the cucumbers were shriveled due to the sudden withdrawal of the water by osmosis. The shriveled pickle did not present the problem then that it does now, for by the use of alum and the proper treatment with water, the pickles could easily be "plumped".

However, this method was gradually abandoned in favor of the present brine method. In the brine method it is necessary to use a brine which has a salt concentration sufficient to permit fermentation and to prevent shrinking of the cucumbers. Experience has shown that the lowest salt concentration which may be used with any degree of safety in making salt stock pickles is about eight per cent and the highest about 10 per cent at the beginning of the fermentation. Genuine dill pickles are fermented in as low as four per cent salt brine but they are canned and used within a comparatively short time, six to nine months, in most cases.

A very important factor to take into consideration in salting is

the size of the cucumber. The smaller the cucumber the faster the water will be withdrawn from it. LeFevre (2) found that cucumbers weighing about 100 gms lost 10 per cent of their weight in about two days while for those weighing about 400 gms it required five days. After the cucumbers had lost 10 per cent of their weight during the initial salting period, there was no change in their weight for three days. After this, they gradually regained their original weight. It required 43 days for the small cucumbers and 44 days for the large ones to regain their original weight in his laboratory experiments.

The experienced pickle packer always takes into consideration the size of the cucumbers with which he is working in determining the amount of salt which he should add to a vat of cucumbers to cure them properly.

In the salting of fresh cucumbers it is important to know the rate at which the salt penetrates them in order to avoid excessive shrinkage. This information is also useful in knowing just how much and how fast to add salt to different size cucumbers in order to maintain the desired salinity. In general it is known by the cucumber salter that you can not add salt at the same rate to large cucumbers as you can to small cucumbers without excessive shriveling. Important as this information is, no scientific studies have been made of the rate of salt penetration into cucumbers of different sizes. The only reference to this in the literature is by

Campbell (3) who found that during the 36 hours after cucumbers are placed in brine they absorb from six to eight per cent salt.

METHODS OF SALTING

Two methods of salting cucumbers were chosen for these experiments: 1. Very low salting which is the method used in making genuine dill pickles. (4) In this method fresh cucumbers are salted in a 15 to 20 degree salometer brine. 2. The second method is the one used to make salt stock pickles in which the fresh cucumbers are salted in a 30 to 40 degree salometer brine.

In the salting of genuine dill pickles brine testing 30 to 40 degrees salometer is made and with a ratio of 17 gallons of brine to 28 gallons of pickles, a final salometer test of 15 to 20 degrees is obtained after equalization since the water in the cucumbers dilutes or reduces the salt concentration about half.

In the salting of dill pickles vinegar is sometimes added to fermenting dill pickles in order to prevent possible spoilage by undesirable bacteria due to the low salt concentration. In this respect it is desirable to know just when this low salt concentration is reached so that the proper precaution against spoilage may be taken if necessary. It is evident that if the equalization took place over a long time the danger period, suspected of having past, could still present conditions for spoilage.

In making salt stock pickles 40 degree brine is used with the

addition of 9.5 pounds of salt per 100 pounds of cucumbers. This quantity (9.5 lbs.) is added to the fresh cucumbers to compensate for the water withdrawn from the cucumbers so as to maintain the tank at 40 degrees. After one week enough salt is added to increase the salt concentration one degree per week until a final concentration of 55 or 60 salometer is reached. With this method of salting many salting stations frequently find spoilage in some tanks while in others, salted the same day and with the same technique, yielded pickles of superior quality. One salter questioned said that he thought the reason for spoilage in certain tanks and not in others was due to the lowering of the salt concentration while adding pickles to the tank.

In high salting the addition of 9.5 pounds of salt per 100 pounds of cucumbers to the 40 salometer brine yields a brine that is not inhibiting for the desirable bacteria but checks the undesirable bacteria. These experiments were designed to study the rate of salt penetration into various sizes of cucumbers using 20 and 40 degree salometer brine, 5.3 and 10.5 per cent respectively. This relationship is of importance to the pickle industrial especially in hot weather and in the warmer climates where a low concentration for any length of time greatly increases the possibility of spoilage. (5) Then too, a prolonged high salt concentration would favor other undesirable bacteria such as the Aerobacter. (6)

EXPERIMENTAL

The size of cucumbers chosen for this experiment was the sizes which are most generally salted in the commercial field. In practice size 1800* is considered standard size for a genuine dill although larger sizes such as 600-800 are frequently used. (Very seldom sizes larger than 600) For the experiments in salting genuine dills sizes 600-800 and 1800 were chosen. (Tables 1-6) For making salt stock pickles all sizes of cucumbers are used, again however, very seldom sizes larger than 600. (Tables 7-12).

The cucumbers selected for this experiment were measured by hand and compared with the diagramatic chart designed by the National Pickle Packers Association. The measuring was so carried out that a cucumber differing by more than 1/8 inch from that of the desired size was discarded.

Forty degree brine was made in a 20 gallon container according to the ratio of 0.98 pounds of salt per gallon of water. The brine was further adjusted by a salometer (hydrometer) to as close as possible to 40 degrees. The final salt concentration was determined by volumetric titration and calculated as per cent by volume.

The rate of absorption of the salt by the cucumbers from the brine was determined by volumetric titration. Specifically one ml of the

*The numbers pertaining to the size of cucumbers are in terms of number of cucumbers in a 45 gallon cask.

brine was taken at stated intervals and diluted with about 15 ml of distilled water. Two drops of dichlorofluorescein were added and the whole titrated with 0.1711 N AgNO_3 . When this normality of the AgNO_3 was used, the per cent salt was read directly from the burette. The end point of this system was a salmon pink color.

A preliminary test in salting was run using size 600-800 and 1800 cucumbers. The sorted cucumbers were placed in a 5 gallon crock and filled to within a few inches of the top to allow room for a false head. Wood lath fastened securely was used as the false head and was soaked in 40 degree brine so as to reduce the error of this material absorbing salt. Brine was then added until it just covered the cucumbers. The salt concentration of the brine was determined at intervals of 15 minutes at first or as thought necessary and total salt concentration of brine recorded directly. In this preliminary test it was found that the final salometer of the brine after equalization was 5.9 per cent (22.5 salometer) using 7,895 gms cucumbers to 9,000 ml of 40 degree brine with size 1800 pickles. This ratio of cucumbers to brine and this technique was used for the remainder of the salting experiments. After the preliminary test, however, glass was placed on top of the crocks to prevent evaporation of water. The glass was removed and a sample taken at stated intervals.

The dill salting experiment was the first to be done and this was repeated three times (Tables 1-6). Two of the determinations were

made using the exact technique described while in the third the ratio of cucumbers to brine was changed.

The salt stock experiments were then done using the ratio of 7,895 gms of cucumbers to 9,000 ml of 40 degree brine and differed from the dill salting experiment only by the addition of 9.5 pounds of salt per 100 pounds of cucumbers. (Tables 7-12). This amount of salt was added to the 9,000 ml of brine before the additions of the cucumbers. This ratio compares favorably with that used in commercial salting and enabled the test to be run with greater accuracy. In this method the per cent salt in the brine at the beginning was the 40 degree brine plus the 9.5 lbs. of salt per 100 pounds of cucumbers. The final salometer of this brine was found to be 66.

DISCUSSION

The rate of salt penetration is considerably faster than has been previously thought. In commercial salting of salt stock the practice is to add a small quantity of 40 salometer brine to the bottom of the tank to act as a cushion for the cucumbers as they are added. Sufficient salt is also added as the tank is filled with cucumbers to maintain the salt concentration at 40 degrees salometer. The rate of adding salt has always been left to the judgment of the salter and experience has dictated the rate. It is known by all salters, however, that by using 40 salometer brine and adding salt at the rate of 9.5 lbs. per 100 lbs. of cucumbers a final salometer of 40 degrees will be obtained after equalization. One fact not taken into consideration by most salters is that smaller additions of salt actually effect a slower rate of salt penetration.

Due to the rapid rate at which the smaller size cucumbers absorb salt, commercial salting practices could follow a pattern similar to that used in this experiment on salting salt stock. Using a brine having an initial salt concentration of 17.4 per cent (66 salometer) and filling the tank exactly as described for the high salting method, a final salt concentration of 40 salometer would be obtained in 19 hours. Practical salters doubtless would be interested in a method such as this because of the labor involved in distributing the thousands of pounds of salt required in maintaining a salometer of 40

since it would not require extra labor in preparing a brine of higher salometer. The Lixate method (7) of salting cucumbers could be used to advantage in making a high salometer brine.

From the results it is evident that the concentration of salt, the ratio of brine to cucumbers and the size of cucumber affects the rate of salt penetration into the cucumbers.

In the low salting experiment equalization took place in about 4.5 days (Table 1) using a 42 salometer brine. Using a 41 salometer brine with the same size cucumbers and the same ratio of cucumbers to brine, 93.6 per cent of equalization took place in the same time. (Table 2). It required eight days for complete equilibrium to take place. Therefore, it required 3.5 days longer for the cucumbers to absorb the 0.3 per cent salt required to establish equilibrium. Although equalization took place faster using the higher salometer it is believed that the increased salt concentration was not sufficient to cause this increased speed. It is believed that the condition of the cucumbers rather than the salt concentration accounted for this difference. Even though the pickles used in this experiment were representative of the pickles salted at a typical salting station, variation of this type can be expected and should be taken into consideration.

In another experiment (Table 3) the ratio of cucumbers to brine was altered by using 9,000 ml brine to 6,895 gm of cucumbers. Due to

1000 grams less cucumbers equalization of 600-800 size took place in about 4 days although the final salometer (26 degrees) was higher than in the previous experiment.

Size 1800 cucumbers (Table 4) equalized in about 1.5 days in one experiment and in another experiment (Table 5) in about 2.5 days. The same reasons for differences with size 600-800 apply to this size so it can be said that size 1800 cucumbers equalize in 1.5 to 2.5 days. When the quantity of the cucumbers was reduced by 1000 grams, equalization of size 1800 took place in about 1.5 days (Table 6). The final salt concentration was higher than in the other two (Tables 4 and 5) and equalized again at 26 degrees salometer.

In high salting the ratio, again, 9,000 ml of 40 degree salometer brine to 7,895 gm cucumbers was used adding salt at the rate of 9.5 lbs. per 100 lbs. of cucumbers. Six representative sizes were salted in order to determine the rate of salt penetration in the different size cucumbers. They ranged from the large 600 size to the small 30,000 size. There are larger and smaller cucumbers but they are exceptions rather than the normal run.

From tables 7 to 12 inclusive it is evident that approximately 90 per cent of the salt enters the cucumbers within a comparatively short time depending on the size of the cucumber. The range is from approximately three days for the largest size 600 to two hours for the smallest size, 30,000.

Another point to note, however, is the length of time required for the final 10 per cent to enter the cucumbers. It enters the cucumbers so slowly and in such small amounts that it is difficult to determine such small amounts of salt accurately. In order not to confuse the picture, 90 per cent of the total amount of the salt that would enter the cucumbers was taken as the point of comparison. If this is done the amount of salt which is absorbed by the cucumbers is of such magnitude that it can be measured in most cases more easily. However, with the small size cucumbers the salt goes into the cucumbers so rapidly at the beginning that in a short time the amount being absorbed is difficult to measure. The length of time required for the 600 to 800 to absorb 90 per cent of the salt was three days (Table 7); the 1800 size required 29 hours (Table 8); the 3,000 size 10 hours (Table 9); the 4,500 size five hours (Table 10); the 10,000 size four hours (Table 11); and the 18,000 to 30,000 sizes less than two hours (Table 12).

Since it was not possible to make the salt determinations on the exact minute for the entire series of experiments, it was found necessary for the sake of comparison to construct a graph (Fig. 1) in which the percentage of salt entering the different size pickles was plotted against time so the relationship between the three factors, time, size and amount of salt absorbed can be readily seen. This calculation was based on the amount of salt entering the pickles

in 8.87 days as being 100 per cent. These data obtained from the adjusted graph are tabulated in Table 14. These data show more clearly that the smaller the size cucumber the more rapid the penetration of salt.

Under the condition of these experiments, the following conclusions seem justified:

1. The concentration of salt, the size of cucumbers and the ratio of the brine to the cucumbers affect the rate of salt penetration into the cucumbers.
2. Cucumbers salted according to the low 20 degree salometer brine method reached equilibrium in approximately eight days for the 600 to 800 size and in about two days for the 1800 size.
3. In the high salting method when the amount of salt absorbed by the different size cucumbers was adjusted by calculation to the same time interval, 90 per cent of the amount of salt, which was absorbed in 8.87 days, was absorbed by the 600 to 800 size cucumbers in three days; by the 1800 size in about 27 hours; by the 3,000 size in 10.5 hours; by the 4,500 size in six hours; by the 10,000 size in four hours and by the 18,000 to 30,000 size in about 1.75 hours.
4. The time required for the cucumbers to absorb the final 10 per cent of salt, when salted according to the high salting method, varied with the different size cucumbers. The amount of salt absorbed at the different time intervals was so small that it was difficult to determine accurately even by titration. However, since the small

size cucumbers absorbed 90 per cent of the salt in such a short time, the final 10 per cent was absorbed much faster as compared with the final 10 per cent absorbed by the large size cucumbers.

5. Irrespective of size, cucumbers salted by the high salt method contained practically the same amount of salt, 7.2 to 7.6 per cent, when they reached equilibrium.

TABLE 1 Rate of penetration of salt into 600-800 size cucumbers in 20 salometer brine. Ratio of brine to pickles - 9,000 ml. to 7,895 gm.

Time	<u>Salt in brine</u> Degrees Salometer Baume'		% Salt in brine titration	% salt in pickles	% total salt in brine	% total salt in pickles	% in pickles based on maximum absorption
0 min.	42	11.0	11.2	0	100	0	0
15 min.	42	11.0	11.2	0	100	0	0
75 min.	42	11.0	11.2	0	100	0	0
2.25 hr.	38	10.0	10.0	1.2	89.3	10.7	23.52
4.5 hr.	35	9.2	9.3	1.95	83.0	17.0	37.36
6.0 hr.	34	9.0	9.0	2.2	80.4	19.6	43.08
15.75 hr.	29.5	7.8	7.7	3.5	67.7	31.3	68.79
29.38 hr.	26.5	7.0	7.0	4.2	62.5	37.5	82.42
1.64 day	26	6.9	6.8	4.4	60.7	39.3	86.37
2.08 day	25	6.7	6.5	4.7	58.0	42.0	92.31
2.24 day	24.5	6.5	6.4	4.8	57.1	42.9	94.29
2.64 day	24	6.4	6.3	4.9	56.2	43.8	96.26
3.25 day	24	6.4	6.3	4.9	56.2	43.8	96.26
4.25 day	23	6.1	6.1	5.1	54.5	45.5	100
5.25 day	23	6.1	6.1	5.1	54.5	45.5	100
6.25 day	23	6.1	6.1	5.1	54.5	45.5	100
7.25 day	23	6.1	6.1	5.1	54.5	45.5	100
8.25 day	23	6.1	6.1	5.1	54.5	45.5	100

TABLE 2 Rate of penetration of salt into 600-800 size cucumbers in 20 salometer brine. Ratio of brine to pickles - 9,000 ml to 7,895 gm.

Time	<u>Salt in brine</u> Degrees Salometer Baume'		% Salt in brine Titration	% salt in pickles	% total salt in brine	% total salt in pickles	% in pickles based on maximum absorption
0 min.	41	10.7	10.7	0	100	0	0
30 min.	41	10.7	10.7	0	100	0	0
90 min.	40	10.5	10.6	.1	99.07	.93	2.12
2.5 hr.	39.5	10.4	10.4	.3	97.20	2.80	6.37
3.5 hr.	38.5	10.1	10.1	.6	94.39	5.61	12.77
5.5 hr.	38	10.0	9.9	.8	92.52	7.48	17.02
7.9 hr.	36	9.5	9.4	1.3	87.85	12.15	27.66
17.8 hr.	32	8.5	8.4	2.3	78.50	21.50	48.94
22.25 hr.	31	8.2	8.2	2.5	76.64	23.36	53.18
28.42 hr.	30	7.9	7.8	2.9	72.90	27.10	61.69
1.76 days	27	7.2	7.1	3.6	66.36	33.64	76.58
2.17 days	26	6.9	6.8	3.9	63.55	36.45	82.97
2.68 days	25.5	6.8	6.7	4.0	62.62	37.38	85.09
3.68 days	24	6.4	6.3	4.4	58.88	41.12	93.60
4.68 days	24	6.4	6.3	4.4	58.88	41.12	93.60
5.68 days	23.5	6.1	6.1	4.6	57.01	42.99	97.86
7.68 days	23.5	6.1	6.1	4.6	57.01	42.99	97.86
8.68 days	23	6.1	6.0	4.7	56.07	43.93	100.

TABLE 3 Rate of penetration of salt into 600-800 size cucumbers in 20 salometer brine. Ratio of brine to pickles - 9,000 ml. to 6,895 gm.

Time	<u>Salt in brine</u> Degrees Salometer Baume'		% salt in brine titration	% salt in pickles	% total salt in brine	% total salt in pickles	% in pickles based on maximum absorption
0 min.	41	10.7	10.9	0	100	0	0
60 min.	41	10.7	10.8	.1	99.08	.92	2.33
1.92 hr.	41	10.7	10.8	.1	99.08	.92	2.33
2.50 hr.	40	10.5	10.5	.4	96.33	3.67	9.30
3.50 hr.	39.5	10.3	10.4	.5	95.42	4.58	11.61
4.42 hr.	39	10.2	10.3	.6	94.49	5.50	13.94
12.0 hr.	36.5	9.6	9.6	1.3	88.07	11.93	30.24
13.0 hr.	36	9.5	9.4	1.5	86.24	13.76	34.88
13.2 hr.	35	9.2	9.3	1.6	85.32	14.68	37.21
16.83 hr.	34	9.0	8.9	2.0	81.65	18.35	46.51
20.0 hr.	32.5	8.5	8.5	2.4	77.98	22.02	55.82
23.3 hr.	31	8.2	8.2	2.7	75.23	24.77	62.79
24.75 hr.	31	8.2	8.1	2.8	74.31	25.69	65.12
32.12 hr.	30	7.9	7.9	3.0	72.45	27.52	69.76
2.47 days	26.5	7.0	7.0	3.9	64.22	35.78	90.70
3.02 days	26	6.9	6.9	4.0	63.30	36.70	93.03
3.48 days	26	6.9	6.8	4.1	62.40	37.60	95.31
4.96 days	25	6.7	6.6	4.3	60.55	39.45	100.
8.97 days	26	6.9	6.9	4.0	63.30	36.70	100.

TABLE 4 Rate of penetration of salt into 1800 size cucumbers in 20 salometer brine. Ratio of brine to pickles - 9,000 ml. to 7,895 gm.

Time	<u>Salt in brine</u> degrees Salometer Baume'		% Salt in brine titration	% salt in pickles	% total salt in brine	% total salt in pickles	% in pickles based on maximum absorption
0 min.	42	11.0	11.2	0	100	0	0
15 min.	42	11.0	11.2	0	100	0	0
75 min.	35	9.2	9.3	1.9	83.04	16.96	35.84
2.25 hr.	32	8.5	8.5	2.7	75.89	24.11	50.95
4.5 hr.	29.5	7.8	7.7	3.5	68.75	31.25	66.04
6.0 hr.	28.5	7.5	7.5	3.7	66.96	33.04	69.82
15.75 hr.	25	6.7	6.5	4.7	58.04	41.96	88.67
29.38 hr.	24	6.4	6.2	5.0	55.36	46.64	98.56
1.64 days	22	5.8	5.9	5.3	52.68	47.32	100.
2.08 days	22	5.8	5.9	5.3	52.68	47.32	100.
2.24 days	22	5.8	5.9	5.3	52.68	47.32	100.
2.64 days	22	5.8	5.9	5.3	52.68	47.32	100.
3.25 days	22	5.8	5.9	5.3	52.68	47.32	100.
4.25 days	22	5.8	5.9	5.3	52.68	47.32	100.
5.25 days	22	5.8	5.9	5.3	52.68	47.32	100.
6.25 days	23	6.1	6.0	5.2	53.57	46.43	100.
7.25 days	23	6.1	6.0	5.2	53.57	46.43	100.
8.25 days	23.5	6.2	6.1	5.1	54.56	45.54	100.



TABLE 5 Rate of penetration of salt into 1800 size cucumbers in 20 salometer brine. Ratio of brine to pickles - 9,000 ml. to 7,895 gm.

Time	<u>Salt in brine</u> Degrees Salometer Baume'		% salt in brine titration	% salt in pickles	% total salt in brine	% total salt in pickles	% in pickles based on maximum absorption
0 min.	41	10.7	10.7	0	100	0	0
30 min.	39	10.2	10.3	.4	96.26	3.74	8.89
90 min.	37	9.7	9.7	1.0	90.65	9.35	22.23
2.5 hr.	34	9.0	9.0	1.7	84.11	15.89	37.77
3.5 hr.	33	8.7	8.8	1.9	82.24	17.76	42.23
5.5 hr.	32	8.5	8.3	2.4	77.57	22.43	53.33
7.9 hr.	30	7.9	7.8	2.9	72.90	37.10	88.21
17.8 hr.	26	6.9	6.8	3.9	63.55	36.45	86.66
22.25 hr.	26	6.9	6.7	4.0	62.62	37.38	88.87
28.42 hr.	25	6.7	6.6	4.1	61.68	38.32	91.11
1.76 days	24	6.4	6.4	4.3	59.81	40.19	95.55
2.17 days	24	6.4	6.4	4.3	59.81	40.19	95.55
2.68 days	24	6.3	6.3	4.4	58.88	41.12	97.77
3.68 days	24	6.3	6.3	4.4	58.88	41.12	97.77
4.68 days	24	6.3	6.3	4.4	58.88	41.12	97.77
5.68 days	24	6.3	6.3	4.4	58.88	41.12	97.77
7.68 days	24	6.3	6.3	4.4	58.88	41.12	97.77
8.68 days	23	6.2	6.2	4.5	57.94	42.06	100.

TABLE 6 Rate of penetration of salt into 1800 size cucumbers in 20 salometer brine. Ratio of brine to pickles - 9,000 ml. to 6,895 gm.

Time	<u>Salt in brine</u> Degrees Salometer Baume'		% salt in brine titration	% salt in pickles	% total salt in brine	% total salt in pickles	% in pickles based on maximum absorption
0 min.	41	10.7	10.9	0	100	0	0
15 min.	41	10.7	10.9	0	100	0	0
60 min.	40.5	10.6	10.7	.2	98.17	1.83	4.64
75 min.	40	10.5	10.5	.4	96.33	3.67	9.30
1.92 hr.	38	10.0	10.0	.9	91.74	8.28	20.99
2.50 hr.	37	9.7	9.7	1.2	88.99	11.01	27.91
3.50 hr.	36	9.5	9.4	1.5	85.24	13.76	34.88
4.42 hr.	35	9.2	9.3	1.6	85.32	14.68	37.21
12.00 hr.	30	7.9	7.9	3.0	72.48	27.52	69.76
13.00 hr.	30	7.9	7.9	3.0	72.48	27.52	69.76
13.2 hr.	30	7.9	7.9	3.0	72.48	27.52	69.76
16.83 hr.	29	7.7	7.5	3.4	68.81	31.19	79.06
20.0 hr.	27	7.2	7.2	3.7	66.06	33.94	86.03
23.3 hr.	26.5	7.0	7.0	3.9	64.22	35.78	90.69
24.75 hr.	26.5	7.0	7.0	3.9	64.22	35.78	90.69
32.12 hr.	25	6.7	6.6	4.3	60.55	39.45	100.
2.47 days	25	6.7	6.6	4.3	60.55	39.45	100.
3.02 days	25	6.7	6.6	4.3	60.55	39.45	100.
3.48 days	25	6.7	6.6	4.3	60.55	39.45	100.
4.96 days	25.5	6.8	6.7	4.2	61.47	38.53	100.
8.97 days	26	6.9	6.8	4.1	62.39	37.61	100.

TABLE 7 Rate of penetration of salt into 600-800 size cucumbers in 40 salometer brine plus 9.5 lbs. of salt per 100 lbs. of cucumbers. Ratio of brine to pickles - 9,000 ml. to 7,895 gm.

Time	<u>Salt in brine</u> Degrees Salometer Baume'		% Salt in brine Titration	% salt in pickles	% total salt in brine	% total salt in pickles	% in pickles based on maximum absorption
0 min.	66	16.7	17.4	0	100	0	0
24 min.	66	16.7	17.4	0	100	0	0
64 min.	65.5	16.6	17.3	.1	99.42	.58	1.38
1.65 hr.	65.5	16.6	17.3	.1	99.42	.58	1.38
2.15 hr.	64	16.2	17.0	.4	97.7	2.3	5.48
2.65 hr.	63	16.0	16.6	.8	95.40	4.6	10.97
4.15 hr.	61	15.5	16.1	1.3	92.52	7.48	17.83
4.65 hr.	60	15.3	15.9	1.5	91.38	8.62	20.54
5.15 hr.	59	15.1	15.6	1.8	89.66	10.34	24.65
7.15 hr.	57	14.6	14.9	2.5	85.63	14.37	34.26
9.65 hr.	57	14.6	14.9	2.5	85.63	14.37	34.26
10.65 hr.	55	14.1	14.4	3.0	82.76	17.24	41.09
18.98 hr.	52	13.4	13.6	3.8	78.16	21.84	52.06
24.06 hr.	51	13.2	13.4	4.0	77.01	22.99	54.80
29.31 hr.	48	12.5	12.6	4.8	72.41	27.59	65.77
1.33 days	47	12.2	12.4	5.0	71.26	28.74	68.51
1.43 days	47	12.2	12.4	5.0	71.26	28.74	68.51
1.55 days	46	12.0	12.1	5.3	69.54	30.46	72.61
1.95 days	44	11.5	11.7	5.7	67.24	32.76	78.09
2.13 days	43	11.2	11.3	6.1	64.94	35.06	83.58
2.39 days	42	11.0	11.0	6.4	63.21	36.79	87.70
3.01 days	41	10.7	10.8	6.6	62.07	37.93	90.42
3.89 days	40	10.5	10.5	6.9	60.34	39.66	94.54
4.87 days	40	10.5	10.4	7.0	59.77	40.23	95.90
8.87 days	38	10.2	10.1	7.3	58.05	41.95	100.

TABLE 8 Rate of penetration of salt into 1800 size cucumbers in 40 salometer brine plus 9.5 lbs. of salt per 100 lbs. of cucumbers. Ratio of brine to pickles - 9,000 ml. to 7,895 gm.

Time	<u>Salt in brine</u> Degrees Salometer Baume'		% Salt in brine titration	% salt in pickles	% total salt in brine	% total salt in pickles	% in pickles based on maximum absorption
0 min.	66	16.7	17.4	0	100	0	0
27 min.	64	16.2	16.0	1.4	91.95	8.05	18.67
67 min.	57	14.6	15.0	2.4	86.20	13.80	32.01
1.7 hr.	57	14.6	15.0	2.4	86.20	13.80	32.01
2.2 hr.	56	14.4	14.7	2.7	84.48	15.52	36.00
2.7 hr.	54	13.9	14.2	3.2	81.61	18.39	42.66
4.2 hr.	51	13.2	13.4	4.0	77.01	22.99	53.32
4.7 hr.	49	12.7	12.8	4.6	73.56	26.44	61.33
5.2 hr.	49	12.7	12.8	4.6	73.56	26.44	61.33
7.2 hr.	48.5	12.6	12.7	4.7	72.98	27.02	62.68
9.7 hr.	46	12.0	12.1	5.3	69.54	30.46	70.65
10.7 hr.	45	11.7	11.9	5.5	68.39	31.61	73.32
19.03 hr.	41	10.7	10.9	6.5	62.64	37.36	86.66
24.12 hr.	41	10.7	10.9	6.5	62.64	37.36	86.66
29.36 hr.	40	10.5	10.5	6.9	60.34	39.66	91.99
1.33 days	39	10.2	10.3	7.1	59.19	40.81	94.66
1.43 days	39	10.2	10.3	7.1	59.19	40.81	94.66
1.55 days	39.5	10.3	10.4	7.0	59.77	40.23	94.80
1.95 days	38.5	10.1	10.2	7.2	58.62	41.38	95.99
2.13 days	38.5	10.1	10.2	7.2	58.62	41.38	95.99
2.39 days	38	10.0	10.1	7.3	58.05	41.95	97.31
3.01 days	38.5	10.1	10.2	7.2	58.62	41.38	97.31
3.89 days	38	10.0	10.1	7.3	58.05	41.95	97.31
4.87 days	38.5	10.1	10.2	7.2	58.62	41.38	97.31
8.87 days	37	9.7	9.9	7.5	56.89	43.11	100.

TABLE 9 Rate of penetration of salt into 3,000 size cucumbers in 40 salometer brine plus 9.5 lbs. of salt per 100 lbs. of cucumbers. Ratio of brine to pickles - 9,000 ml. to 7,895 gm.

Time	<u>Salt in brine</u> Degrees Salometer Baume'		% salt in brine titration	% salt in pickles	% total salt in brine	% total salt in pickles	% in pickles based on maximum absorption
0 min.	66	16.7	17.4	0	100	0	0
29 min.	52	13.4	13.7	3.7	78.73	21.27	49.35
69 min.	52	13.4	13.7	3.7	78.73	21.27	49.35
1.73 hr.	50	12.9	13.2	4.2	75.86	24.14	54.01
2.23 hr.	47	12.2	12.2	5.2	70.11	29.89	69.35
4.23 hr.	43	11.2	11.4	6.0	65.51	34.49	80.02
4.73 hr.	44	11.5	11.5	5.9	66.09	33.91	78.68
5.23 hr.	42	11.0	11.1	6.3	63.79	36.21	84.01
7.23 hr.	42	11.0	11.1	6.3	63.79	36.21	84.01
9.73 hr.	41.5	10.8	10.9	6.5	62.64	37.36	86.68
10.73 hr.	40.5	10.6	10.7	6.7	61.49	38.51	89.35
19.06 hr.	38.5	10.1	10.2	7.2	58.62	41.38	96.01
24.15 hr.	38.5	10.1	10.2	7.2	58.62	41.38	96.01
29.31 hr.	38.5	10.1	10.2	7.2	58.62	41.38	96.01
1.33 days	38.5	10.1	10.2	7.2	58.62	41.38	96.01
1.43 days	39	10.2	10.3	7.1	59.20	40.80	94.66
1.55 days	38.5	10.1	10.2	7.2	58.62	41.38	96.01
1.95 days	38.5	10.1	10.2	7.2	58.62	41.38	96.01
2.13 days	38.5	10.1	10.2	7.2	58.62	41.38	96.01
2.39 days	38.5	10.1	10.2	7.2	58.62	41.38	96.01
3.01 days	38.5	10.1	10.2	7.2	58.62	41.38	96.01
3.89 days	38.5	10.1	10.2	7.2	58.62	41.38	96.01
4.87 days	38	10.0	10.1	7.3	58.04	41.96	97.35
8.87 days	38	10.0	9.9	7.5	56.90	43.10	100.

TABLE 10 Rate of penetration of salt into 4,500 size cucumbers in 40 salometer brine plus 9.5 lbs. of salt per 100 lbs. of cucumbers. Ratio of brine to pickles - 9,000 ml. to 7,895 gm.

Time	<u>Salt in brine</u> Degrees Salometer Baume'		% salt in brine titration	% salt in pickles	% total salt in brine	% total salt in pickles	% in pickles based on maximum absorption
0 min.	66	16.7	17.4	0	100	0	0
32 min.	51	13.2	13.5	3.9	77.59	22.41	54.15
72 min.	49	12.7	13.0	4.4	74.71	25.29	61.12
1.78 hr.	46.5	12.1	12.3	5.1	70.68	29.32	70.86
2.28 hr.	46	12.0	12.0	5.4	68.97	31.03	74.98
2.78 hr.	45	11.7	11.9	5.5	68.39	31.61	76.39
4.78 hr.	42.5	11.1	11.2	6.2	64.37	35.63	86.10
5.28 hr.	42	11.0	11.0	6.4	63.22	36.78	88.88
7.28 hr.	40	10.5	10.6	6.8	60.91	39.09	94.47
9.78 hr.	39.5	10.3	10.4	7.0	59.77	40.23	97.22
10.78 hr.	39.5	10.3	10.4	7.0	59.77	40.23	97.22
19.12 hr.	39	10.2	10.3	7.1	59.20	40.80	98.60
24.2 hr.	39	10.2	10.3	7.1	59.20	40.80	98.60
29.31 hr.	39	10.2	10.3	7.1	59.20	40.80	98.60
1.33 days	39	10.2	10.3	7.1	59.20	40.80	98.60
1.43 days	39	10.2	10.3	7.1	59.20	40.80	98.60
1.55 days	39	10.2	10.3	7.1	59.20	40.80	98.60
1.95 days	39	10.2	10.3	7.1	59.20	40.80	98.60
2.13 days	39	10.2	10.2	7.2	58.62	41.38	100.
2.39 days	39	10.2	10.2	7.2	58.62	41.38	100.
3.01 days	39	10.2	10.2	7.2	58.62	41.38	100.
3.89 days	39	10.2	10.2	7.2	58.62	41.38	100.
4.87 days	39	10.2	10.2	7.2	58.62	41.38	100.
8.87 days	39	10.2	10.2	7.2	58.62	41.38	100.

TABLE 11 Rate of penetration of salt into 10,000 size cucumbers in 40 salometer brine plus 9.5 lbs. of salt per 100 lbs. of cucumbers. Ratio of brine to pickles - 9,000 ml. to 7,895 gm.

Time	<u>Salt in brine</u> Degrees Salometer Baume'		% salt in brine titration	% salt in pickles	% total salt in brine	% total salt in pickles	% in pickles based on maximum absorption
0 min.	66	16.7	17.4	0	100	0	0
35 min.	48	12.5	12.6	4.8	72.41	27.59	63.13
75 min.	47	12.2	12.3	5.1	70.69	29.31	67.10
1.83 hr.	42.5	11.1	11.2	6.2	64.37	35.63	81.57
2.33 hr.	41	10.7	10.8	6.6	62.07	37.93	86.84
2.83 hr.	40.5	10.6	10.7	6.7	61.49	38.51	88.16
4.33 hr.	40	10.5	10.5	6.9	60.34	39.66	90.80
4.83 hr.	39.5	10.3	10.4	7.0	59.77	40.23	92.10
5.33 hr.	39.5	10.3	10.4	7.0	59.77	40.23	92.10
7.33 hr.	39	10.2	10.3	7.1	59.20	40.80	93.41
9.83 hr.	39	10.2	10.3	7.1	59.20	40.80	93.41
10.83 hr.	38.5	10.1	10.2	7.2	58.62	41.38	94.73
19.16 hr.	38.5	10.1	10.2	7.2	58.62	41.38	94.73
24.25 hr.	38.5	10.1	10.2	7.2	58.62	41.38	94.73
29.50 hr.	38	10.0	10.1	7.3	58.05	41.95	96.04
1.33 days	38	10.0	10.1	7.3	58.05	41.95	96.04
1.43 days	38	10.0	10.1	7.3	58.05	41.95	96.04
1.55 days	38	10.0	10.1	7.3	58.05	41.95	96.04
1.95 days	38	10.0	10.1	7.3	58.05	41.95	96.04
2.13 days	38	10.0	10.1	7.3	58.05	41.95	96.04
2.39 days	38	10.0	10.1	7.3	58.05	41.95	96.04
3.01 days	38	10.0	10.0	7.4	57.47	42.53	97.41
3.89 days	38	10.0	10.0	7.4	57.47	42.53	97.41
4.87 days	37.5	9.8	9.9	7.5	56.89	43.11	98.70
8.87 days	37	9.7	9.8	7.6	56.32	43.68	100.



TABLE 12 Rate of penetration of salt into 18,000 - 30,000 size cucumbers in 40 salometer brine plus 9.5 lbs. of salt per 100 lbs. of cucumbers. Ratio of brine to pickles - 9,000 ml. to 7,895 gm.

Time	<u>Salt in brine</u> Degrees Salometer Baume'		% salt in brine titration	% salt in pickles	% total salt in brine	% total salt in pickles	% in pickles based on maximum absorption
0 min.	66	16.7	17.4	0	100	0	0
42 min.	43	11.2	11.4	6.0	62.52	34.48	83.33
82 min.	42.5	11.1	11.2	6.2	64.37	35.63	86.10
1.95 hr.	41.5	10.9	10.9	6.5	62.64	37.36	90.30
2.45 hr.	40.5	10.6	10.7	6.7	61.49	38.51	93.06
2.95 hr.	40	10.5	10.6	6.8	60.92	39.08	94.44
4.45 hr.	40	10.5	10.6	6.8	60.92	39.08	94.44
4.95 hr.	40	10.5	10.6	6.8	60.92	39.08	94.44
5.45 hr.	40	10.5	10.6	6.8	60.92	39.08	94.44
7.45 hr.	40	10.5	10.6	6.8	60.92	39.08	94.44
9.95 hr.	40	10.5	10.5	6.9	60.92	39.08	94.44
10.95 hr.	40	10.5	10.5	6.9	60.92	39.08	94.44
19.28 hr.	39	10.2	10.3	7.1	59.20	40.80	98.60
24.36 hr.	39	10.2	10.3	7.1	59.20	40.80	98.60
29.61 hr.	39	10.2	10.3	7.1	59.20	40.80	98.60
1.33 days	39	10.2	10.3	7.1	59.20	40.80	98.60
1.43 days	38.5	10.1	10.2	7.2	58.62	41.38	100.
1.55 days	38.5	10.1	10.2	7.2	58.62	41.38	100.
1.95 days	38.5	10.1	10.2	7.2	58.62	41.38	100.
2.13 days	38.5	10.1	10.2	7.2	58.62	41.38	100.
2.39 days	38	10.	10.1	7.3	58.05	41.95	100.
3.01 days	38.5	10.1	10.2	7.2	58.62	41.38	100.
3.89 days	38.5	10.1	10.2	7.2	58.62	41.38	100.
4.87 days	38.5	10.1	10.2	7.2	58.62	41.38	100.
8.87 days	38.5	10.1	10.2	7.2	58.62	41.38	100.

Fig. 1 Rate of salt penetration into different size cucumbers when salted according to the high salt method.

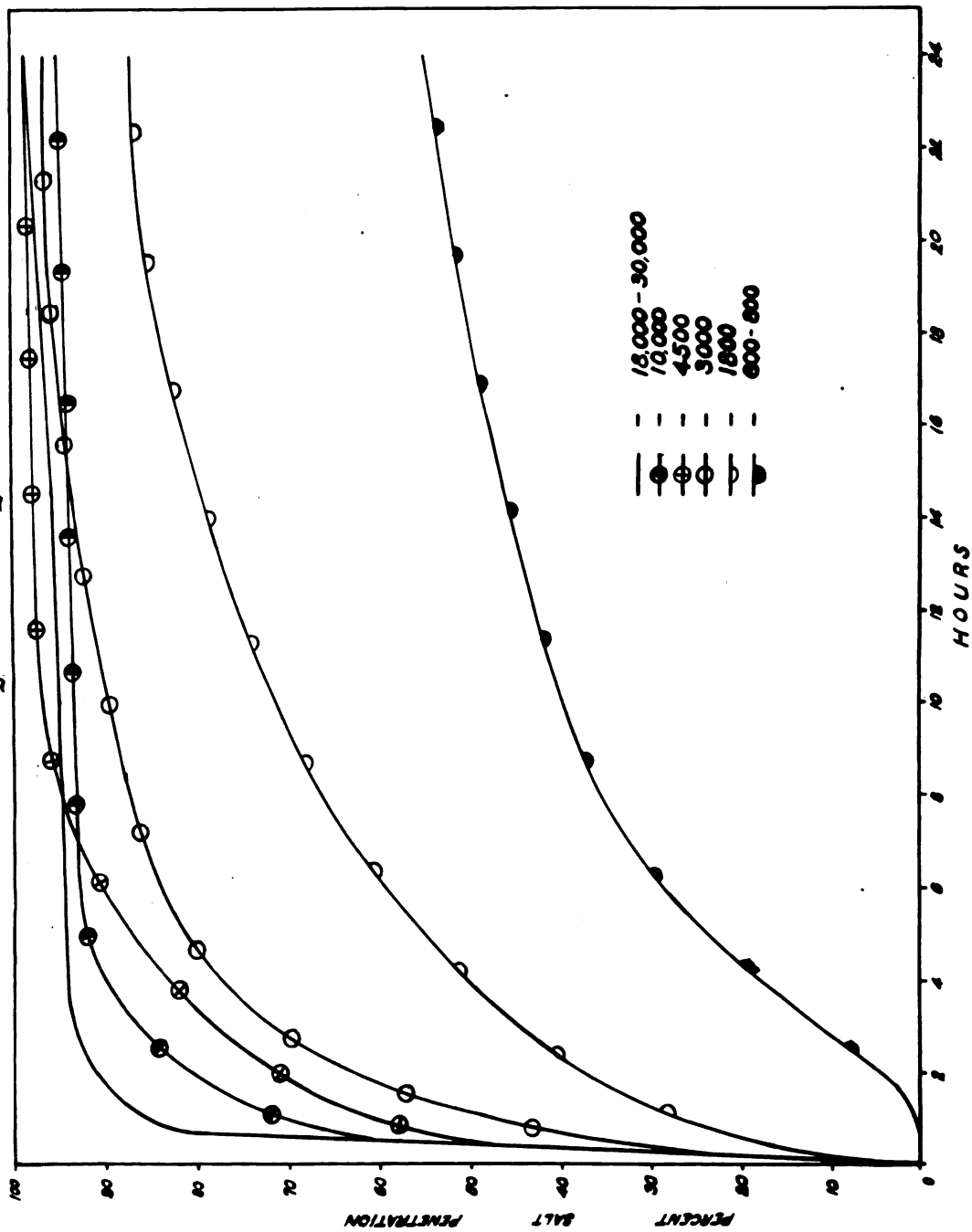


TABLE 13 Data based on adjusted graph giving per cent of the total salt penetrating the different size pickles at stated intervals.

Time	600-800	1800	3000	4500	10,000	18,000- 30,000
0 min.	0	0	0	0	0	0
24 min.	0	16.1	30.08	44.4	58.0	60.5
64 min.	1.38	28.0	48.8	61.5	71.5	86.2
1.65 hr.	1.38	34.3	58.5	68.5	78.2	89.8
2.15 hr.	5.48	38.5	64.7	77.6	82.2	91.7
2.65 hr.	10.97	42.2	69.3	76.0	85.0	93.0
4.15 hr.	17.83	51.0	78.3	84.0	90.05	94.2
4.65 hr.	20.54	53.6	80.02	86.0	91.60	94.3
5.15 hr.	24.65	55.4	81.7	88.0	92.2	94.3
7.15 hr.	33.0	63.7	86.1	93.4	93.0	94.5
9.65 hr.	34.26	70.06	89.3	96.5	93.5	95.0
10.65 hr.	40.06	72.80	90.03	97.1	93.5	95.2
18.98 hr.	50.09	85.0	95.7	98.2	94.6	97.1
24.0 hr.	54.5	87.0	96.0	98.5	94.8	98.5
29.3 hr.	65.8	91.9	96.0	98.6	96.0	98.6
1.33 days	68.5	94.7	96.0	98.6	96.0	100.
1.43 days	68.5	94.7	96.0	98.6	96.0	100.
1.55 days	72.6	94.8	96.0	98.6	96.0	100.
1.95 days	78.1	95.9	96.0	98.6	96.0	100.
2.13 days	83.6	95.9	96.0	100.	96.0	100.
2.39 days	87.7	97.3	96.0	100.	96.0	100.
3.01 days	90.4	97.3	96.0	100.	97.4	100.
3.89 days	94.54	97.3	96.0	100.	97.4	100.
4.87 days	95.9	97.3	97.4	100.	98.7	100.
8.87 days	100.	100.	100.	100.	100.	100.

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