Methods of Examination of Fresh Cucumber Pickle [1] [2]

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THE commercially prepared fresh cucumber pickle described in a previous publication[3] has met with considerable success since being placed on the market. A similar product, called sliced cucumber pickle, has been made by housewives for many years and has been served as a tasty relish, particularly with meats. The latter product does not have, however, the quality and uniformity of a properly manufactured commercial fresh cucumber pickle. The wholesome appeal of the characteristic crispness and fresh appearance of the commercial fresh cucumber pickle, comparable to the natural fruit, make it a most desirable relish and is especially suited for those wishing something totally different in a cucumber pickle. Also, this product has found favor because of the moderate content of sugar, vinegar and spice usually employed in manufacture.

Features that make the fresh cucumber pickle so desirable, namely, the moderate sugar and acid content and the use of fresh, uncured cutting stock, may in turn encourage the deterioration of the product with a loss of keeping quality evidenced by changes in structure of the slices and the development of "off" flavors brought about by growth of microorganisms. Hence, to insure the product against such deterioration, particularly that due to microorganisms, adequate pasteurization must be employed as well as care exercised in keeping equipment clean during manufacture to guard against the introduction of large numbers of microorganisms. During pasteurization care must be taken against overheating which will result in marked loss in crispness of the slices and development of cooked flavors.

Cucumbers (1200-1800 count size*) as they come into the plant after having been grown on sandy loam soil may have on their surface many millions of microorganisms. The majority of the organisms at this stage are aerobic spore-forming types. Also present, and of prime interest to those engaged in manufacture of fresh cucumber pickle, are the yeasts, acid-forming bacteria and molds, which are responsible for the deterioration and spoilage of inadequately pasteurized cucumber pickle. Pasteurization, properly controlled and carried out at 160° F. for 20 min. or 165° F. for 15 min.[4], has been found adequate to kill the bacteria, yeasts and molds capable of fermenting or otherwise deteriorating the pickle. Only the resistant spore-forming types survive and these tend to remain in the same numbers or decrease slightly throughout the storage period.

Commercial formulae for the manufacture of fresh cucumber pickle usually call for heating the product in closed jars to relatively high temperatures (around 180° F.) for varying periods of time, 15 to 30 min., and in some instances suggest a pre-heating of the slices in the liquor prior to filling into the jars. There is little or no doubt that these procedures will preserve the product from microbial activity; but they probably will under most conditions of manufacture bring about a marked loss of crispness of the slices initially followed by further progressive loss of texture during storage. Also, the use of relatively high temperatures for pasteurization, if not followed by prompt cooling of the jars, will result in further changes in the slices attributed to "cooking."

The material to be presented will deal with (1) the bacteriological study of fresh cucumber pickle, (2) the keeping quality of sealed jars and (3) the keeping quality of opened jars. Particular emphasis is placed on the bacteriological study as it was originally carried out with a two-fold purpose in mind: First, the development of a suitable method for the examination of fresh cucumber pickle, including the technic and bacteriological media to be employed for finding the predominating microorganisms and the organisms likely to cause deterioration and spoilage; and second, future application of the results as a basis for selecting a minimum pasteurizing temperature which would destroy all microbial life responsible for spoilage, yet allow the maximum amount of crispness to be retained by the slices.

Experimental Procedure

INASMUCH as the plant at which the experimental work was carried out had but limited experience with the manufacture of fresh cucumber pickle at the time the work was begun, the material obtained for the first bacteriological analyses could be called experimental lots. However, the work on these pickles served as a preliminary study for working out the bacteriological methods of analyses.

In general the preparation of the fresh cucumber

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[2] In cooperation with the Dept. of Horticulture, N. C. Agric. Expt. Station. Food Research Division Contribution No. 501.
[3] Rate of Heat Penetration During the Pasteurization of Cucumber Pickle. FRUIT PRODUCTS JOURNAL, 18 (3) 68-70, Nov. 1938.
* Number per 45 gallon cask.

[4] Method and equipment for pasteurizing fresh cucumber pickle (developed and reported subsequent to the work described above) may be found in THE FRUIT PRODUCTS JOURNAL, Vol. 18, No. 8, pp. 68-70, 1938.

pickle was as follows: Pickling cucumbers, 1200-1800 count size, very firm stock, were trucked in from Virginia inasmuch as the experimental work was carried out in August when there was no available stock in North Carolina. The cucumbers were thoroughly washed and sliced by hand, the slices being approximately ¼ in. thick. They were then placed in barrels, covered by 30° brine and left for 24 to 48 hours. The slices were then removed to 24-oz. jars and covered with hot liquor (170 to 180° F.), the ratio of slices to liquor being about 5 to 3; the liquor was made up to finish at 1.5-1.7% acetic acid and 15-17 degrees Baume and included tumeric for coloring. A level teaspoonful of mustard and celery seeds (ratio, 2 to 1) was added to each jar for spice.

The jars were sealed by use of a closure consisting of an inner, rubberized lined cap turned down by a screw cap. The jars to be pasteurized were placed in low, rectangular trays which would give ample circulation of water and capable of holding 1 dozen jars. The trays were loaded into a processing tank with an approximate capacity of 500 gallons. After loading was complete the trays of jars were covered with water and steam let in from the bottom of the tank. Pasteurization was carried out at 160° F. for a holding period of 20 minutes; during the holding period the water was circulated by a motor-driven propellor. At the conclusion of the holding period the water was removed as soon as possible by opening the plugs in the bottom of the tank. The jars were removed from the tank and allowed to cool in the open at 80-85° F.

The trays of 24-oz. jars to be used for experimental purposes were numbered before pasteurization from 1 to 10, each jar in a tray being given the same tray number; thus a representative case of 10 jars made up after heating would contain jars from 10 different locations in the pasteurizing tank. A case of these jars from the different locations were analysed at intervals dating from the first day after manufacture to an elapsed storage period of approximately 8 months. Three experimental lots were prepared and were followed in this manner.

Variations in the three experimental lots were as follows: Lots Nos. B-1 and B-2 were prepared in a similar manner; in the case of Lot No. B-1 the slices were soaked 24 hours longer in 30° brine. Lot No. B-2H differed from the others inasmuch as it had two pasteurizations at 24 hour intervals; the jars used were a portion of Lot No. B-2. During the storage period all jars were kept at room temperature (68-76° F.).

Bacteriological counts of the jars were made after shaking the jars and plating suitable dilutions (usually 1-10 and 1-20 for the pasteurized and up to 1-1 million for unpasteurized) on nutritive caseinate agar (Difco). This medium contained 8 cc. of 0.4% solution of brom-cresol-purple indicator per liter, added at the time of preparation of the medium. The physiological growth reactions of colonies upon this medium can be determined as follows: Acid-forming colonies show a precipitated zone of casein and a yellow color about the colony; peptonizing (soil group) colonies show a dissolved zone of casein and a purple color about the colonies. The dissolved casein zone is more clearly observed if the plate is flooded with 5.0% acetic acid.

Yeast counts which were made on later studies following the preliminary work were made by plating the liquor or dilutions of the liquor, depending on whether the sample was pasteurized or not, on tartaric acid agar.[5] This medium was prepared as follows: Ordinary dextrose agar was prepared in the usual manner, 100 cc. amounts were melted to which were added 5 cc. amounts of sterile 5.0% tartaric acid; the flasks were then cooled to pouring temperature and plates made. The addition of the tartaric acid resulted in a medium having a pH value of approximately 3.7 which was well below that tolerated by the other organisms in the plated liquor, the exception being molds, which will grow out on this medium, if present in the liquor.

Plates made with the nutritive caseinate agar were incubated 48-72 hours at 35° C. and counted; plates made on the tartaric acid agar were incubated 5 days at 35° C. and counted.

Duplicate control jars were plated at each examination. These were autoclaved jars (autoclaved at 15 lb. for 15 min.) for control on the technic of opening the jars and unpasteurized controls for studying the effect of pasteurization.

Observations were made at each plating interval on the keeping quality of the pickle with respect to crispness, flavor and general appearance of the cucumber slices. The observations are representative of usually 4 persons. Crispness was determined by biting or chewing a number of slices, crispness being a relative value approximating that of the natural, sliced fruit, lower values indicating a proportionally lower degree of crispness. Flavor, inasmuch as it deals with individual likes and dislikes was scored primarily upon the product being free from "off", "cooked" or other undesirable flavors. Other observations as to appearance were made visually with respect to the whiteness of the slices, whether they gave the characteristic fresh appearance so desirable in a quality pack of fresh cucumber pickle.

At the conclusion of the study of the keeping quality of the sealed jars it was decided to carry out an investigation of limited nature with respect to the keeping quality of opened jars of fresh cucumber pickle as some question had been raised as to the nature of the turbidity developed when jars were opened. Whether this was due to microorganisms, oxidation changes due to the entrance of air or other chemical changes, was not fully known. Observations were made with respect to bacterial counts, crispness and turbidity in opened jars at both room and refrigerator temperatures. Two jars from each of the three experimental lots were opened and one-third of the slices removed with a clean fork (after the manner of a purchaser of pickles). One autoclaved jar was included for a control. The sets of jars were placed at room temperature and observations made weekly for one month. One sealed jar from each batch served as turbidity controls. A duplicate set was prepared, this being

[5] Laboratory Manual (Methods of Analysis of Milk and Its Products) International Assn. of Milk Dealers, p. 81 (1933).

kept at refrigerator temperature. Crispness of both sets was determined as previously described and turbidity was determined by comparison of the jars with the unopened controls at room and refrigerator temperatures. Plate counts were made to determine the number of organisms per cc. of liquor as previously described.

Discussion of Results

TABLE 1 shows the bacterial counts of the jars that received no pasteurization, the only heat applied being that obtained from the hot liquor (approx. 170° F.) poured on the slices prior to pasteurization. The resulting fermentations in both lots are shown by the high counts per cc. after 1 month's storage. The initial counts are composed principally of resistant spore-forming types; however, as the fermentation began, the predominating microorganisms in these fermentations were found by microscopic examination to be yeasts. Also found in lower numbers (approx. 1/10th) were the acid-forming bacteria. The resistant spore-forming types evidenced little change in numbers during the fermentation. In general, after the peak of the fermentation (after 1 month), the counts decreased so that by the end of 8 months, counts of 100 and 150 per cc. remained. In observations of other fermentations of unpasteurized samples the predominating organisms were found to be acid-forming bacteria. Also, some fermentations have shown practically equal numbers of yeasts and acid-forming bacteria. The type of fermentation resulting in unpasteurized jars depends to a great extent on the number and type of organisms surviving the application of hot liquor, with exception of the soil types which in general show little or no change during the fermentation due to the acidity of the liquor. It is evident that autoclaving the jars at 15 lb. for 15 min. was sufficient to kill all microbial life as indicated by the plate counts.

The results of the plate counts of the three experimental lots of pasteurized fresh cucumber pickle during storage are shown in Table 2. The figures shown represent the mean value for 10 jars, from 10 different areas in the pasteurizing tank, examined at each plating interval for each experimental lot, representing a total of 2400 jars examined during the storage period. An additional 20 jars were plated initially, 10 for each lot to obtain the counts prior to pasteurization.

The initial counts for Lots B-1 and B-2 are shown at the bottom of the table (indicated by two asterisks). B-1 shows a mean value of 1800 organisms per cc., the range being from 1100 to 4000; for B-2 the mean value was 2500 per cc., the range being from 1000 to 5000. The initial figures for Lot B-2H are the same as for B-2, as B-2H was of the same initial stock, the difference being in treatment, the latter having received two pasteurizations at 24 hour intervals.

In general, the results show that pasteurization reduced the initial counts so that only the heat resistant, spore-forming types of microorganisms survived and these tended to decrease further during storage. Lots B-1 and B-2 showed little difference throughout the storage period; B-2H, that receiving two pasteurizations, showed slightly lower counts initially and at 1 week but as the storage period progressed there was little or no difference.

While no routine platings on tartaric acid agar for yeasts counts were made on the experimental lots discussed in Tables 1 and 2, they were carried out later on lots prepared under similar conditions of manufacture. The generalized results showed that in 5 experimental lots the yeast populations per cc. were as follows: (1) In the brine in which the slices had soaked over night, range of 650 to 25,000; (2) in unpasteurized samples receiving only hot liquor (approx. 170° F.), 0 to 300; (3) in paste rized (160° F. for 20 min.) samples, none were observed initially or during storage period approximating those i Table 2.

(Keeping quality)

THE averaged observations on keeping quality of the three experimental lots of pasteurized fresh cucumber pickle during storage are shown in Table 3. Crispness,

TABLE 1. *Growth of Microorganisms in Unpasteurized Fresh Cucumber Pickle During Storage*

Experimental Lot	Microorganisms per cc. during storage period: Initial	1 month	3 months	4 months	5 months	6 months	8 months
Unpasteurized B-1*	1200	150,000	5,000	1,000	520	700	100
Unpasteurized B-2*	1900	192,000	3,000	800	400	320	150
Autoclaved controls*	0	0	0	0	0	0	0

* Jars plated in duplicate at each time interval.

TABLE 2. *Incidence of Microorganisms in Pasteurized Fresh Cucumber Pickle During Storage*

Experimental Lot	Microorganisms per cc. during storage period*: 1 day	1 week	1 month	3 months	4 months	5 months	6 months	8 months
Pasteurized B-1**	330	250	140	66	40	67	81	25
Pasteurized B-2**	340	300	280	150	160	140	110	55
Pasteurized B-2H†	190	95	130	33	50	80	30	50

* Figures shown represent the mean value for 10 jars examined at each plating interval for each experimental lot.
** Initial counts per cc. before pasteurization were 1800 and 2500 (mean value for 10 jars) for B-1 and B-2 respectively; figure for B-2H same as for B-2.
† Lot receiving 2 pasteurizations.

flavor and general appearance were scored individually by 4 or more persons at each examination interval and the average results recorded. The data would indicate that as the storage period progressed there was some loss in crispness. Also, during storage the slices showed a loss of whiteness from the center outward. There was little or no detectable change in flavor during storage. After approximately eight months the pickle was reasonably attractive, with good flavor and with a major portion of the original crispness remaining.

TABLE 3. *Examination of Pasteurized Fresh Cucumber Pickle with Respect to Crispness, Flavor and General Appearance during Storage**

Storage period	Degree of crispness	Remarks on flavor and appearance
1 day	++++	Excellent flavor, sufficient sugar and acid. Attractive, characteristic fresh appearance with white slices in amber liquid.
1 week	++++	do.
1 month	++++	Very similar to 1 day and 1 week observations.
3 months	++++	Similar to above examinations, no difference noted as to flavor and general appearance.
4 months	++++	Flavor and appearance similar to above. Slices losing some of their whiteness.
5 months	+++	Flavor very good, some jars slightly better than others. General appearance of jars fresh looking.
6 months	+++	Flavor and appearance good. Tendency for the slices to take on a solid, translucent appearance denoting loss of air or whiteness.
8 months	+++	No significant changes over the 6 months' examination.

* Table represents the average of the observations of the experimental lots followed.

Table 4 shows observations on the unpasteurized and autoclaved fresh cucumber pickle with respect to crispness, flavor and appearance. The jars receiving no pasteurization (Table 4, part A) show evidence of the fermentation indicated in the discussion of Table 1. There was marked loss in crispness accompanied by softening of the slices. The slices had a definite fermented taste. sharp odor and were charged with gas (carbon dioxide). There was no detectable evidence of proteolytic decomposition as demonstrated by off flavor and odor, the spoilage evidently being brought about by yeasts and acid-forming bacteria. The autoclaved controls (Table 4, part B) showed the effect of high temperature (250° F.) upon the slices.

(Keeping quality—opened jars)

THE results on the keeping quality on the opened jars of fresh cucumber pickle with respect to the degree of turbidity, bacterial counts and degree of crispness are shown in Table 5. The comparison sets of jars were made up from experimental Lots B-1, B-2 and B-2H, including the autoclaved controls; duplicate sets were stored at room and refrigerator temperatures.

Turbidity of the liquor of the different lots was scored on a basis from 1 plus (least) to 4 plus (greatest). The initial turbidity of all jars of both sets, those held at room temperature and those refrigerated, was given the value of 1 plus. Upon standing, the turbidity of Lot B-1 remained more or less constant while in Lots B-2 and B-2H the cloudiness increased after 1 week.

This difference in behavior may be explained in part by the difference in treatment previously received by Lot B-1 and Lots B-2 and B-2H. As indicated previously (in procedure) Lot B-1 cucumber slices were immersed in the 30° brine for 48 hours at the beginning of the processing period, while for Lots B-2 and B-2H these slices were immersed in 30° brine for 24 hours. Accordingly a greater portion of soluble constituents of the slices in the case of Lot B-1 had been withdrawn into the brine and consequently less were available to be withdrawn into the liquor to be acted upon by the air.

After one week the refrigerated jars showed flocculent, suspended material in a relatively clear liquor in all jars, including the autoclaved controls and the sealed turbidity controls. This was not a wholly desirable change as it detracted somewhat from the general appearance of the product, and was considerably more noticeable than the turbidity of the jars kept at room temperature described above.

The bacterial counts were sufficiently low in numbers to be considered of little or no significance. At both room and refrigerator temperatures the counts were similar and showed no evidence of active fermentation. It

TABLE 4. *Examination of Unpasteurized Fresh Cucumber Pickle and Autoclaved Fresh Cucumber Pickle with Respect to Crispness, Flavor and General Appearance During Storage*

A. Unpasteurized			B. Autoclaved		
Storage period	Degree of crispness	Remarks on flavor and appearance	Storage period	Degree of crispness	Remarks on flavor and appearance
Initial	++++	Excellent flavor, attractive characteristic fresh appearance.	Initial	—	Bitter, cooked flavor. Slices soft and brownish in color. Very unpleasant taste.
1 month	++	Fermented taste, sharp odor. Marked softening of the slices. Considerable gas.	1 month	—	do.
3 months	+	Same as above with more loss in crispness. Much gas.	3 months	—	do.
4 months	+	Fermented taste, sharp odor. Loss of white areas in slices. Slight gas.	4 months	—	do.
5 months	+	do.	5 months	—	do.
6 months	+	do.	6 months	—	do.
8 months	+	do.	8 months	—	do.

TABLE 5. *Examination as to Turbidity, Bacterial Count per cc. and Crispness of Pasteurized Fresh Cucumber Pickle during One Month's Storage at Room and Refrigerator Temperatures After Having Been Opened and One-Third of the Slices Removed Prior to Initial Analyses*.*

	Experimental lot	Degree of Turbidity				Bacterial count per cc.				Degree of crispness	
		Initial	1 week	2 weeks	1 month	Initial	1 week	2 weeks	1 month	Initial	1 month
Room temperature	B-1	+	+	+	+	20	350	50	20	++	+
	B-2	+	++	++	++	55	450	750	450	+++	++
	B-2H	+	++	+++	+++	40	150	200	200	+++	++
	A-2**	++	+++	+++	+++	0	0	0	50	—	—
Refrigerator temperature 43° F.	B-1	+	f	f	f	30	200	20	50	++	++
	B-2	+	f	f	f	80	250	200	350	+++	+++
	B-2H	+	f	f	f	75	600	1600	600	+++	+++
	A-2**	++	f	f	f	0	200	0	0	—	m

* Initial indicates examination as to turbidity, bacterial content and crispness at the start of experiment, prior to placing jars at room and refrigerator temperatures.

** Autoclaved jars, autoclaved at 15 lb. pressure for 15 minutes.

f Flocculent, suspended material in the liquor, the latter being but slightly turbid.

m No crispness observed, but slices more firm than when placed in refrigerator at start of experiment.

can therefore be assumed that the microbial population was not responsible for the turbidity in the jars stored at room temperature or for the flocculent material in the refrigerated jars.

It should be pointed out, however, that the counts shown should not be taken as conclusive evidence that all jars opened would behave in a similar manner. The microbial population during storage of opened jars (particularly those kept at room temperature) would depend greatly upon the numbers and types of organisms introduced during the opening of jars and during the removal of a portion of the slices. The ability of the introduced organisms to ferment the constituents would be evidenced by active fermentation, resulting in deterioration of the product (see Table 4, part A).

At room temperature there was a tendency for a loss in crispness during the 1 month storage period. The refrigerated jars showed no perceptible difference as to crispness during storage; however, the effect of refrigeration was to give a more firm slice. This is shown in the case of the autoclaved controls where slices which were initially soft became more firm after storage in the refrigerator.

Since it has been assumed that the bacterial content in the jars stored at room temperature could not have been responsible for the increase in turbidity it is suggested that this condition was brought about by oxidation changes, due to entrance of air, upon the components of the liquor covering the slices.

The flocculent material developed in the refrigerated jars, as near as could be determined, was in part an agglomeration of finely divided suspended material in the liquor and material brought out of solution by loss in solubility due to temperature change. Tests on a filtered sample of the liquor from a jar just opened showed that the material would flocculate when placed in the refrigerator for 24-48 hours. The flocculent material when tested for proteins by Millon's reagent gave a positive reaction. When the protein was removed from the liquor by use of lead acetate and the liquor stored in the refrigerator, no flocculation or clouding could be observed.

Summary and Conclusions

METHODS for the examination of fresh cucumber pickle are outlined with respect to the following: (1) Bacteriological analyses of pasteurized and unpasteurized pickle, (2) keeping quality of sealed and opened jars of pickle.

Unpasteurized jars of pickle underwent fermentation brought about principally by yeasts and acid-forming bacteria. This action resulted in spoilage of the product.

Pasteurized jars of pickle retained their fresh appearance and a major portion of their crispness over a period of several months' storage. Pasteurization (160° F. for 20 min.) in accordance with the equipment and procedure described was effective in reducing the microbial content so that only the more resistant types of organisms survived, and these tended to decrease during the storage period.

In general, it may be said, that the bacteriological methods described are suitable for determining the correct pasteurizing temperatures and holding periods to employ for the preservation of fresh cucumber pickle, particularly where formulae and various phases of manufacture warrant investigation before adopting a definite procedure.

Other observations reported, those dealing with keeping quality, are applicable in obtaining information as to the quality of the finished product as influenced by storage.

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