ARTICLE 44-68
MAY 1962

VARIETY RESPONSE TO SOME VARIABLES IN FRESH CUCUMBER PICKLE PRODUCTION

By R. C. NICHOLAS and I. J. PFLUG
FOOD SCIENCE DEPARTMENT

A NUMBER OF DIFFERENT QUALITY FACTORS in fresh cucumber pickles, such as texture, appearance, flavor, internal damage, and stability of the raw product have been studied as a function of such manufacturing variables as variety, and the times and temperatures of holding, heat treatment, and storage.[1] No one study, understandably, has embraced all possible combinations of these factors and variables. Some manufacturing variables, such as storage temperature, can be controlled, at least to some extent, but it seems unlikely that the manufacturer can have much choice of heat treatment. Therefore, the present study has concentrated on the response of several varieties to the heat treatment. Holding time, but not temperature, was varied for all varieties, but storage was constant.

REVIEW OF LITERATURE

Jones and Etchells (4) examined fresh cucumber pickles on the basis of crispness and skin texture, among other factors, and found distinct quality differences, depending on variety. They also noted in the same study wide variations among varieties in their resistance to deterioration during storage.

Cook et al. (2) studied the effect on one variety of the holding time and temperature. Their evaluations based on color and general appearance of the finished product showed quality degradation with longer holding times and higher holding temperatures.

Esselen and Anderson (3) investigated storage time and temperature in combination with holding times and temperatures. They ex-

[1] Holding refers to the period from harvest to the beginning of the heat treatment, and, therefore, always implies the raw product, cucumbers; storage refers to the period after processing and, of course, implies the finished product, pickles.

Reprinted from the QUARTERLY BULLETIN of the Michigan Agricultural Experiment Station, Michigan State University, East Lansing.
Vol. 44, No. 4, pages 739 to 750, May 1962

amined the finished product (one variety) subjectively for texture and flavor and odor and concluded that pickles made from cucumbers stored at warm temperatures for extended periods ". . . may become soft and develop off-flavor during processing and subsequent storage."

Nicholas and Pflug (8) suggested, as the result of another investigation of the effects of storage time and temperature, predominantly of one variety, a storage time-temperature relationship predicting loss in appearance, subjectively measured.

Labbee and Esselen (5) determined the heat treatment required to prevent development of off-flavors, determined subjectively and related quantitatively to residual peroxidase activity in the finished product as a function of storage time.

Nicholas and Pflug (9) measured quantitatively for a single variety the loss of firmness, inactivation of peroxidase, and the extent of internal damage as a function of the severity of the heat treatment over a wide range of times and temperatures and as a function of storage time.

EXPERIMENTAL

Raw Product

Six 20-bushel pallet boxes of each of three cucumber varieties[2] grown in different parts of Michigan and picked on August 16, 1960 were stored outdoors in a shaded receiving bay until ready for packing. Prior to delivery to the plant, these cucumbers were graded into two sizes at a receiving station, three boxes of each size of each variety: No. 2 cucumbers 1 1/16 in. to 1 5/16 in. in diameter for whole pickle products; No. 3 cucumbers 1½ in. to 2-in. in diameter for spear and sliced products.

Part of the raw product evaluation consisted of force measurements, made with a Magness-Taylor fruit pressure tester (6), 5/16 in. tip, of 10 cucumbers of each size of each of the three varieties on the second and third days after picking. In addition, a record was made of the amount of stock that fell below plant standards for whole pickles. The inspection table and reject boxes were cleared before each 18-bushel lot was run over the table for inspection by plant personnel. The difference between pallet box capacity (20 bu.) and the amount inspected is accounted for by cucumbers removed

[2] In recognition of the fact that environment may be more influential than variety per se, authors choose to refer to these varieties simply as A, B, and C.

for processing, a slight underfill of the boxes, and trash and undersized cucumbers screened out before reaching the inspection table.

No. 2 Size Whole Cucumber Pickle Tests

Heat Treatments

The test packs for the heat treatments were prepared under commercial conditions in a pickle processing plant. Each day for 3 days after harvest, cucumbers for the test pack were taken from the top of the pallet boxes. They were washed, blanched, packed by hand in 26-oz. jars, brined, spiced, capped, and heat processed at 190°F for different lengths of time from 10 to 68 minutes in a special temperature controlled water bath. The jars were cooled for several minutes in a 100°F water bath, transferred to a 60°F water bath, and further cooled to an internal temperature of 90°F or lower. All the test packs were stored in the plant for about 3 weeks, then brought to East Lansing and stored in a 78°F room until examined.

Evaluation

The pickles were evaluated during the period from 44 days to 60 days after harvest. For pressure tests, 15 pickles were selected from the combined contents of two jars from each treatment (number of days after harvest-heating time-variety) and tested with a mechanical recording pressure tester (10) fitted with a Magness-Taylor fruit pressure tester $\frac{5}{16}$-in. tip.

All the pickles in another pair of jars from each treatment were cut into about a dozen slices and examined for internal damage. The various defects seen were classified as carpel separation: a separation of two or all of the three carpels; seed cavity: any fracture restricted to the seed cavity; lense: any hole or other separation in the flesh, but neither in the seed cavity nor between carpels (a so-called lense defect occasionally involved two carpels); wall: a hole or separation just under the skin which followed the skin contour; miscellaneous: insect, fungal, and bacterial damage as well as any defect not obviously one of the others.

The covering brines from each pair of jars for each treatment were combined and tested for peroxidase activity (1). Replicate peroxidase determinations were obtained by testing the brines from the pickles for cutting and the brines from the pickles for pressure testing. The activity is determined by comparison against a set of potas-

sium dichromate color standards arranged on a scale from 1 to 10 which is approximately linear with the logarithm of the potassium dichromate concentration; 10 is high activity. A distilled water blank was run with each set of samples, but since the color scale is logarithmic, no adjustment to the activity numbers was made. The water blanks, in every case, were 1.5 or less. Peroxidase activity in the raw product is generally off-scale by this test and was not determined.

No. 3 Size, Fresh Cucumber Spear Tests

Fresh cucumber spears (cucumbers cut lengthwise into 5 equal wedges) were prepared according to plant procedures from each of the three varieties on each of four successive days after the cucumbers were harvested. Six jars from each variety-day combination were brought to East Lansing and stored at about 78°F until evaluated by pressure test and taste panel 10 months after processing.

The pressure tests were made with the mechanical recording pressure tester (10) fitted with a 5/16-in. diameter plunger (plunger speed 6.48 in./min.) on each of 10 spears from each variety-day combination. Each spear was placed on a wooden, V-shaped trough (cut surfaces against the trough sides) which had a 3/8-in. diameter hole cut in the center to allow the plunger to pass entirely through the pickle spear.

The 12 variety-day treatment combinations were presented to a 7-member panel for evaluation on the basis of appearance, odor, and flavor. In the case of appearance and flavor, the panel was asked to rank the 12 samples, and, in the case of odor, to rate each sample on a one (best)-to-five hedonic scale.

RESULTS

Raw-product texture measurements are given in Table 1. The data for each size were separately analyzed by the analysis of variance, which showed no significant difference among varieties or between days for No. 2 cucumbers, but did show a significant difference both between days and among varieties (variety B was significantly lower) for the No. 3 cucumbers. Although no initial differences were demonstrated in No. 2's, subsequent tests of the finished pickles showed differences among both varieties and days. Variety A, which showed the lowest pressure in the No. 2 size, was the highest in the No. 3 size.

Unfortunately, these raw-product pressures, measured with the

TABLE 1—Average pressure (a) lb., to puncture the raw cucumbers (Magness-Taylor Tester, 5/16" tip)

Size	Days after picking	Variety		
		A	B	C
No. 2	2	18.8	18.8	21.0
	3	19.4	19.7	20.0
No. 3	2	26.2	22.8	24.9
	3	27.4	24.0	26.0

(a) of 10 cucumbers.

Magness-Taylor tester, are not comparable with the results from the mechanical recording pressure tester which was used on the finished pickles (7); therefore, total pressure loss between raw product and finished product is not known. Increased pressure to puncture the raw cucumbers would normally be associated with a loss of quality; under the conditions usually prevailing between picking and packing the cucumbers become dehydrated and tough-skinned (3). The reverse is true of the finished pickle: higher pressures are associated with a firmer pickle. (There is no problem of dehydration with the finished pickle.)

The amount of product rejected for whole and spear pickles is given in Table 2. There were no striking differences between sizes or among varieties, so the results for variety and size were combined. Variety A showed somewhat more down-graded stock, both relish and rejected stock, than B and C. The cucumbers down-graded to relish were not a total loss, but they were bought at a higher price than cucumbers originally intended for relish. The added costs of

TABLE 2—Raw product down-graded for whole and spear pickles, percent, (all varieties and sizes combined)

Day	Relish	Rejected stock	Total
1.....	4.0	0.0	4.0
2.....	6.9	1.7	8.6
3.....	7.7	5.7	13.4

handling and disposal make the loss on rejected stock higher than just the product cost.

At a heat-processing time of 10 minutes (all heating was at 190°F.), some of the jars showed bacteriological spoilage; these data are given in Table 3. None of the jars processed at longer times spoiled. There seemed to be no difference in spoilage among varieties, although the lack of spoilage on the first day suggests a lower bacterial load. Whether the difference among days, if real, is in the processing plant conditions or in the cucumbers cannot be determined.

TABLE 3—Number of spoiled jars out of six heated for 10 minutes at 190°F.

Days after picking	Variety		
	A	B	C
1.....	0	0	0
2.....	2	3	1
3.....	0	2	4

The average pressure required to puncture the pickles is given in Table 4. These data were analyzed by variety (See Table 5). The variance of variety B was significantly larger than A and C. If pressure is related to degree of maturity, and if the varieties have different length-to-diameter ratios, the grading of the cucumbers by diam-

TABLE 4—Average pressure (a) lb., to puncture fresh cucumber pickles (mechanical recording tester, 5/16" plunger)

Variety	Days after picking	Heating time, minutes					
		10	15	20	33	48	68
A	1	16.0	15.2	14.4	12.6	10.5	11.1
	2	14.9	15.3	15.4	13.7	13.1	10.5
	3	15.8	14.8	14.6	13.2	12.1	10.1
B	1	19.5	16.6	16.7	15.5	13.3	11.3
	2	17.8	16.2	16.0	15.5	13.4	11.9
	3	15.5	15.8	15.4	13.6	12.2	9.7
C	1	16.6	14.7	17.3	15.0	12.1	11.8
	2	17.2	15.6	16.8	14.0	13.6	11.4
	3	17.3	15.3	15.2	13.4	12.4	11.0

(a) of 15 pickles.

TABLE 5—Analyses of variance (mean squares of pressure), lb., to puncture whole fresh cucumber pickles (see Table 4)

Source	Degrees of freedom	Variety		
		A	B	C
Days	2	6.66	82.3**	10.3**
Heating times	5	179.**	260.**	215.**
Interaction	10	7.72*	6.47	6.78
Error	252	3.70	5.62	4.15

* Significant at the 5% level.
** Significant at the 1% level.

eter could have introduced a selective effect that showed up as a wider variation in texture. The difference could also be due to variety or environment.

A number of interesting comparisons can be made of the data in Table 4 (a difference between items of about 1.5 lb. is required for significance). In general, the tendency is to a decrease in pressure with an increase in heating time. For varieties B and C, the average pressures (all heating times combined) were significantly lower on the third day after the cucumbers were harvested. On the first day after harvest, the varieties seemed to be different, B, C, and A, in order of decreasing pressure; however, the differences became smaller, until, by the third day, there was no difference in pressure among varieties.

The net effect of heating as measured by the difference in pressure of pickles heated 10 minutes and pickles heated 68 minutes was about the same for each of the three times after harvest, but since the general tendency was for the raw product to be somewhat lower in pressure as the days after harvest increased, the finished product pressures tended to be lower also. Nevertheless, there is some evidence that raw product pressure is not a good indicator of finished product pressure. For example, variety B, No. 2 size cucumbers (Table 1) show no significant difference in raw product pressure between the second and third days (in fact, the third day pressure is slightly higher), but the finished product pressures (Table 4) were uniformly lower at all heating times on the third day as compared with the second day, significantly lower in several instances.

The peroxidase activity average for all treatments and both determinations is given in Table 6. From these data, it appears that

TABLE 6—Peroxidase number (all heating times combined)

Variety	Days after picking		
	1	2	3
A.....	4.2	5.0	5.1
B.....	4.1	4.6	4.9
C.....	4.7	4.9	5.2

as the days increased, the peroxidase activity increased even though the combination of heat treatments was held constant. The analysis of variance of the data shows that the increase with days is not significant, but that the interaction between days and heating times is highly significant.

If the average activities are divided according to length of heat treatment, as shown in Table 7, the increased activity with days is seen to be confined to the 10- and 15-minute heat treatments, treatments, incidentally, that would be regarded as inadequate by the authors. It is possible to believe that whatever the source of peroxidase in pickles, the system(s) continue to be elaborated while the cucumbers sit waiting to be processed. If two (or more) systems are present, with different thermal inactivation requirements, one of which continues to be elaborated after the fruit is harvested and one which does not, then the data presented will explain such assumptions. But, these data are not adequate to prove such a theory.

The data on the defects are summarized in Tables 8 and 9. The percentages are all calculated on the basis of the total number of cucumbers in each pair of jars; therefore, the jars with few cucumbers are necessarily, and perhaps unfairly, weighted more heavily. Of the 200 defective cucumbers, 10 had two defects; these 10 defects

TABLE 7—Peroxidase number (all varieties combined)

Heating time, minutes	Days after picking		
	1	2	3
10 and 15.....	6.8	8.2	9.1
20.....	5.4	6.0	5.1
33, 48, and 68.....	2.4	2.2	2.3

were treated as if they belonged to an extra 10 cucumbers. The total number of cucumbers examined was 391, 325, and 343 for varieties A, B and C, respectively, not very likely a chance difference in the average number of cucumbers a jar.

Since the number of jars of each variety was the same, this difference in number of cucumbers means either that variety B, for instance, tends to be a larger cucumber or that fewer cucumbers can be packed in a jar because their geometry is unfavorable. Variety B seems to be a standout for defects, but if the defects at the 10-minute heating time are assumed not to be heat-associated, then the residual percents defective at the longer heating times make variety B look better with respect to heat-associated defects. On this assumption, variety C would be the most resistant to heat-associated defects. There is evidence that both carpel separation and seed cavity defects are heat-associated and also that both defects increase with the number of days after picking (see Table 8).

TABLE 8—Percent defective pickles by type of defect (all varieties and heat treatments combined)

Days after harvest	Defect					Total
	Carpel separation	Seed cavity	Lense	Wall	Misc.	
1	8.2	2.7	3.6	1.8	0.0	16.3
2	10.2	4.4	5.3	1.0	0.5	21.4
3	10.5	9.2	3.0	0.0	1.2	23.9

It may be significant that in variety B (data not shown) the carpel separation defect remained essentially constant from the first to the third day, but the seed cavity defect increased from 2 to 19 percent in the same period. In varieties A and C, the amount of seed cavity defect remained fairly constant, but carpel separation increased with days. Carpel separation, although variable from cucumber to cucumber, was generally confined to one end; in about half the cases only 1/4 or less of the cucumber was involved and, in the remaining cases, ½ or less (the whole cucumber was involved in only one case). No record was made of whether just two or all three carpels were separated. About 80 percent of the carpel separation cases involved the flower end.

TABLE 9—Percent defective pickles by variety (all types of defect and days combined)

Heating time, minutes	Variety		
	A	B	C
10.....	0	16	10
15.....	5	16	8
20.....	13	20	23
33.....	11	16	25
48.....	17	39	26
68.....	36	53	33

Table 10 gives the average pressures of the sweet fresh cucumber spears. The analysis of variance shows a highly significant difference among varieties, in order of increasing pressure, B, C, A. This same order is shown by the whole pickles (see Table 4) heated for 33 minutes (a time comparable with regular plant heating time).

TABLE 10—Average (a) pressure, lb., to puncture sweet fresh cucumber pickle spears

Days after harvest	Variety		
	A	B	C
1.....	12.8	16.4	14.8
2.....	10.7	14.7	15.4
3.....	10.4	15.6	11.8
4.....	9.3	17.8	14.2
Average...	10.8	16.1	14.1

(a) of 10 spears.

The results of ranking on the basis of appearance showed varieties B and C, on the fourth day after harvest, to be superior, and variety A, on the first and second days after harvest, to be inferior to all the other pickles (5 percent level of significance). According to the judges, there was no significant difference in flavor among the pickles, but on the basis of odor, variety A on the fourth day was significantly preferred over both variety A on the first day and variety B on the third day. It was discovered after the taste panel tests that all jars except those packed on the fourth day had dry garlic chips as part of the flavoring.

DISCUSSION

Although some of the changes in quality presented here were anticipated, one conclusion is clear: no one variety tested was superior in every property investigated. For example, variety A showed the fewest defects and the least change in texture during holding, but it was the least firm of the three varieties and had a higher proportion of rejected stock. The difference in defects (Table 9) among varieties may be a real one and is worth further study by processors. These varieties are genetically related, and there are probably environmental factors, as well as varietal, involved in defects. Varieties could, no doubt, be bred for resistance to heat-associated defects. No implication is intended that the several defects described necessarily have different causes. It is entirely possible that two or more kinds of defects may be manifestations of the same causative agent, or, on the other hand, that two or more causative agents or precursor defects yield the same defect in the finished pickle.

Total defects and the amount of down-graded stock both increased with increasing delay between harvesting and packing. Moreover, pickles held for 3 days in the receiving bay were yellow and shriveled, and the spine spots had darkened. Therefore, the cucumbers should be packed as soon as possible. If the increase with days in the amount of spoilage (Table 3) is significant, then there is an additional reason for processing as soon as possible.

Some of the factors investigated are beyond close control by the processor and very likely change from season to season for a particular variety.

SUMMARY

Three cucumber varieties grown in Michigan were compared on the basis of some measurable changes in both raw and finished product as a function of the time between picking and packing and the severity of the heat treatment. Raw-product comparisons were made on the basis of texture and the amount of rejected product. Finished pickles were compared on the basis of texture changes, peroxidase activity, and the type and extent of internal defects. Differences were found among varieties and as a function of the time from harvest to packing. Although no one variety was superior in all properties examined, quality decreased generally with holding time.

LITERATURE CITED

1. Anderson, E. E., L. F. Ruder, W. B. Esselen, E. A. Nebesky, and M. Labbee (1951). Pasteurized fresh whole pickles. II. Thermal resistance of microorganisms and peroxidase. Food Technol. 5:364-368.
2. Cook, J. A., I. J. Pflug, and S. K. Ries (1957). Effect of cucumber holding time and temperature on the quality of pasteurized fresh whole pickles. Food Technol. 11:216-218.
3. Esselen, W. B., and E. E. Anderson (1956). Effect of handling and storage of raw material on quality retention in fresh pack pickle spears during storage. Glass Packer 35(12):41, 42, 68.
4. Jones, I. D., and J. L. Etchells (1950). Cucumber varieties in pickle manufacture. Canner 110(1):34, 36, 38, 40.
5. Labbee, M. D., and W. B. Esselen (1954). Effect of peroxidase concentration, acidity, and storage temperature on the development of off-flavors in fresh pack pickles. Food Technol. 8:50-54.
6. Magness, J. R., and G. F. Taylor (1925). An improved type of pressure tester for the determination of fruit maturity. U. S. Dept. Agr. Circular 350.
7. Nicholas, R. C. (1960). Some observations on the use of fruit pressure testers. Mich. Agr. Expt. Sta. Quart. Bul. 43:312-326.
8. Nicholas, R. C., and I. J. Pflug (1960). Effects of high temperature storage on the quality of fresh cucumber pickles. Glass Packer 39(4): 35, 38, 39, 65.
9. ———————— (1962). Over- and underpasteurization of fresh cucumber pickles. Food Technol. 16: 104-108.
10. Pflug, I. J., F. M. Joffe, and R. C. Nicholas (1960). A mechanical recording pressure tester. Mich. Agr. Expt. Sta. Bul. 43:117-121.

ACKNOWLEDGMENT

The authors wish to thank the Croswell Pickle Division of Aunt Jane's Foods, Inc., Croswell, Michigan for providing pickles and plant facilities for this study.