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Effect of Household Processing and Storage on Quality of PICKLED VEGETABLES and FRUITS

Home Economics Research Report No. 28

Agricultural Research Service

UNITED STATES DEPARTMENT OF AGRICULTURE

CONTENTS

<p>SUMMARY..... 1</p> <p>PURPOSE OF THE INVESTIGATION..... 1</p> <p>SCOPE OF THE WORK..... 2</p> <p>EXPERIMENTAL PROCEDURES..... 2</p> <p style="padding-left: 20px;">Purchase of Samples..... 2</p> <p style="padding-left: 20px;">Formulas and Preparation Procedures..... 2</p> <p style="padding-left: 20px;">Fermentation..... 2</p> <p style="padding-left: 20px;">Heat Penetration Measurements..... 2</p> <p style="padding-left: 20px;">Storage..... 3</p> <p style="padding-left: 20px;">Titratable Acids..... 3</p> <p style="padding-left: 20px;">Salt Content..... 3</p> <p style="padding-left: 20px;">pH Measurements..... 3</p> <p style="padding-left: 20px;">Lactic Acid Content..... 3</p> <p style="padding-left: 20px;">Soluble Solids..... 3</p> <p style="padding-left: 20px;">Reflected Color..... 3</p>	<p>Page</p>	<p>EXPERIMENTAL PROCEDURES—Con. 3</p> <p style="padding-left: 20px;">Shear Force..... 3</p> <p style="padding-left: 20px;">Peroxidase..... 3</p> <p style="padding-left: 20px;">Palatability Evaluation..... 3</p> <p>RESULTS AND DISCUSSION..... 6</p> <p style="padding-left: 20px;">Fermentation..... 6</p> <p style="padding-left: 20px;">Heat Penetration and Lethality Values..... 7</p> <p style="padding-left: 20px;">pH Values..... 7</p> <p style="padding-left: 20px;">Acid Content..... 10</p> <p style="padding-left: 20px;">Salt Content..... 10</p> <p style="padding-left: 20px;">Soluble Solids..... 10</p> <p style="padding-left: 20px;">Texture..... 10</p> <p style="padding-left: 20px;">Color and Appearance..... 16</p> <p style="padding-left: 20px;">Flavor..... 18</p> <p>LITERATURE CITED..... 20</p>	<p>Page</p>
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TABLES

<p>1.—Number of replications of tests and number of panel ratings on pickled vegetables and fruits..... 4</p> <p>2.—Changes in acid and salt content and pH of brine of dilled cucumbers, fermented at controlled and room temperatures..... 6</p> <p>3.—Changes in acid and salt content and pH of sauerkraut during fermentation..... 7</p> <p>4.—Lethality values of processed pickled vegetables and fruits..... 8</p> <p>5.—pH of pickled vegetables and fruits..... 9</p> <p>6.—Acid content of pickled vegetables and fruits..... 11</p>	<p>Page</p>	<p>7.—Salt content of pickled vegetables and fruits.. 13</p> <p>8.—Soluble solids in pickled vegetables and fruits.. 14</p> <p>9.—Shear values of pickled vegetables and fruits.. 15</p> <p>10.—Panel texture scores of pickled vegetables and fruits..... 16</p> <p>11.—Color-difference meter values for pickled vegetables and fruits..... 17</p> <p>12.—Panel color scores of pickled vegetables and fruits..... 18</p> <p>13.—Panel flavor scores of pickled vegetables and fruits..... 19</p>	<p>Page</p>
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EFFECT OF HOUSEHOLD PROCESSING AND STORAGE ON QUALITY OF PICKLED VEGETABLES AND FRUITS

by

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SUMMARY

An investigation of various pickled products was made to determine household processing requirements for safety from spoilage due to micro-organisms (bacteriological safety) and for maintaining high quality of the food. (The term "processing," as used in this report, refers to heating in water bath or with steam under pressure, to destroy food-spoilage organisms.) The effects of processing and storage time on quality of the pickled products were also investigated. Included in this study were fermented dilled cucumbers, sauerkraut, fresh-pack dilled cucumbers, crosscut cucumber slices, sweet gherkins, dilled green beans, corn relish, horseradish, pepper-onion relish, piccalilli, tomato-apple chutney, tomato-pear chutney, pickled peaches, and pickled pears.

When the pickled products were treated by the methods used in this investigation, the lethality values (total equivalent minutes at 160° F.) exceeded, in all cases, those considered necessary for bacteriological safety of the products. The pH values of all pickled products studied were below 4.6, the minimum that permits growth of *Clostridium botulinum* spores and the production of toxin. More than 90 percent of the acid in fermented (brined) dilled cucumber pickles was lactic acid, indicating nearly complete fermentation. Acid values of fermented and fresh-pack dilled cucumbers and crosscut cucumber slices ranged from about 0.7 to 1 percent. A 0.7-percent acid concentration is considered sufficient for preservation. Sweet gherkins, horseradish, and pepper-onion relish were relatively high in acid, ranging from 0.8 to 2.8 percent.

Values for pH and acid changed very little as the result of processing or storage of the pickled products.

A salt brine of about 3 to 6 percent sodium chloride for fermented dilled cucumbers aided in the rapid formation of a high amount of acid and a low pH. The salt content of the pickled products was about the same as that of the brine. There were only slight changes in salt content as the result of processing or storage.

A high soluble solids content is of value because of its preservative action and its influence on flavor. Soluble solids content of fermented dill pickles ranged from 7.1 to 7.9 percent. Values for fermented and fresh-pack dilled cucumbers and dilled green beans decreased slightly with storage. Crosscut cucumber slices, sweet gherkins, pickled peaches, pickled pears, and tomato-apple chutney all had soluble solids values ranging from 30 to 45 percent. The values were not greatly influenced by processing or storage time.

After storage for periods up to 6 months, processed fermented dill pickles were superior in color and texture to the unprocessed pickles. Color and texture of the other pickled products did not appear to be greatly influenced by processing. Processed pickles were generally superior in flavor to unprocessed pickles during the first 6 months of storage. Destruction of peroxidase activity by heat was, no doubt, a factor in the superior flavor of the processed pickles. After 9 months of storage, there was little flavor difference between processed and unprocessed pickles.

PURPOSE OF THE INVESTIGATION

The investigation reported here was made to determine whether pasteurization requirements and procedures used by commercial pickle proces-

sors could be adapted to home conditions, and whether the use of those procedures would result in a bacteriologically safe product without harm

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to quality. Since other factors such as pH (19),³ acidity (4), salt content (9, 16), and sugar content (3) all significantly affect the safety, palatability, and keeping quality of pickled products, these factors were also investigated.

Review of pamphlets from the U.S. Department of Agriculture and the Agricultural Extension Services indicates considerable variation in pickling procedures recommended for home use, particularly in regard to processing (5, 20, 21, 22). The procedures used are important because of their effect on the palatability and maintenance of quality of the pickled products and because of the possibility of spoilage resulting from improper processing.

SCOPE OF THE WORK

Work was carried out on four general classes of pickled vegetables and fruits: Fermented or brined pickles, fresh-pack pickles, relishes, and fruit pickles. Fermented pickles were dilled cucumbers and sauerkraut. The fresh-pack pickles were dilled cucumber slices, sweet gherkin cucumbers, and dilled green beans. Relishes were corn, horseradish, pepper-onion, piccalilli, tomato-apple chutney, and tomato-pear chutney. Fruit pickles were peach and pear.

Processed and unprocessed samples of most of these pickled products were compared before and

Etchells and Jones (9) demonstrated that unfermented, partially fermented, and fully fermented pickle products should be preserved by pasteurization to prevent further growth of organisms or action of fermentation byproducts that might cause softening during storage. Esselen and others (7) reported on temperature necessary to prevent spoilage and development of off-flavors due to enzymatic activity in commercial packs of fresh whole dill and fresh-pack pickles. Townsend and others (19) studied pH levels necessary to prevent the growth of *Clostridium botulinum* spores and the production of toxin. Esselen (6) observed that peroxidase might be responsible for off-flavors developed during storage.

after storage for 2 to 9 months at room temperature.

Heat penetration during processing was determined, and lethality values were calculated. Other determinations made on most of the products investigated were: pH, acid, salt, peroxidase, shear force, reflected color, soluble solids, and palatability evaluations of texture, flavor, and appearance. In some cases, plate counts were made to detect the presence of yeasts and molds.

EXPERIMENTAL PROCEDURES

Purchase of Samples

The cucumbers used in the investigation during the 1961 season were obtained from a local market and from the Experimental Farms of the University of Maryland. In 1962, the cucumbers were obtained from the Horticulture Department, University of Maryland. All other products were purchased from local markets.

Formulas and Preparation Procedures

Formulas and procedures for preparing the various pickled products were as described in Home and Garden Bulletin No. 92 (22). The number of replications of the determinations, such as acid, salt, pH, ranged from 1 to 8, as shown in table 1. The number of evaluations of quality made by a trained panel are also shown in table 1.

Fermentation

For each lot of fermented dilled cucumbers, 20 pounds of washed cucumbers, 4 to 6 inches in

length, were placed in a 6-gallon crock and covered with brine containing 5.2 percent salt and 0.3 percent acetic acid. Whole pickling spices and fresh dill plant were added. Fermentations were carried out either at controlled temperature (72° to 75° F.) or at room temperature (72° to 90° F.) for 3 to 5 weeks. During fermentation, the brine was analyzed three times each week for pH, acidity, and salt content. Determinations were made on both brine and pickles after fermentation was complete.

For the fermentation of sauerkraut, the cabbage was shredded and then mixed with about 2.4 percent salt. The mixture was packed into a jar, covered, and allowed to ferment at room temperature (68° to 72° F.) until fermentation was complete in 5 to 6 weeks. The progress of fermentation was followed by determining acid and salt content of both brine and solids three times a week. Peroxidase activity was also investigated.

Heat Penetration Measurements

Heat penetration during processing was measured with copper constantan thermocouples attached to a 16-point potentiometer, recording at 2-second intervals. The thermocouples were

³ Italic numbers in parentheses refer to Literature Cited, p. 20.

placed at different points inside the filled jars, to determine the slowest heating and fastest cooling zones. Lethality rates were calculated as proposed by Esselen and others (8), assuming a Z value of 18 for the spoilage organism.

The results of studies by Esselen and others (8) were adapted to home-processing conditions by converting the recorded time-temperatures to equivalent minutes at 160° F. Factors considered in arriving at optimum processing time were: Fastest and slowest heating rates; fastest and slowest cooling rates; avoidance of overprocessing (as too much heat and too long processing can result in a cooked flavor and soft texture); and allowance for the additional lethality provided by slow cooling of glass jars. The total lethality (total equivalent minutes at 160° F.) was calculated by a summation procedure described by Patashnik (14) and Esselen (8).

Storage

Processed and unprocessed pickles in sealed glass jars were stored at 72° to 75° F. from 2 to 9 months.

Titrateable Acids

Samples of the solids were prepared by blending 100 grams of the product with 300 milliliters (ml.) of water for 3 minutes in a Waring Blendor.⁴ Brines were diluted with water before analysis. Aliquots were then titrated with 0.1 N sodium hydroxide, with phenolphthalein being used as an indicator. Acid values were calculated as acetic acid except those for the fermented products—dilled cucumbers and sauerkraut—which were calculated as lactic acid.

Salt Content

Salts were determined on aliquots of the above-mentioned samples; the mercuric nitrate procedure of Schales and Schales (16) as modified by Schonherz (17) was used.

pH Measurements

A Beckman Model G pH meter was used to determine the pH on aliquots of the above-mentioned samples.

Lactic Acid Content

The method of Stark and others (18) was used for chromatographic separation of lactic acid, and

⁴ Trade names are used in this publication solely for providing specific information. Mention of a trade name does not constitute a guarantee or warranty of the product by the U.S. Department of Agriculture or an endorsement by the Department over other products not mentioned.

the procedure of Barker and Summerson (1) for colorimetric determination.

Soluble Solids

Soluble solids were determined with a Bausch & Lomb Abbe-3L Refractometer (2).

Reflected Color

Gardner Color-Difference Meter readings (10) were taken; the *L* scale was used. (*L* expresses visual lightness; *a_L*, redness or greenness; and *b_L*, yellowness or blueness.) Five readings were taken, and the samples were turned 72° between readings. The color standards used were as follows:

Product	<i>L</i>	<i>a_L</i>	<i>b_L</i>
Fermented and fresh-pack cucumber pickles.....	50.0	-25.7	+7.3
Dilled green beans.....	29.1	-.5	+14.7
Corn relish.....	71.0	-.5	+47.6
Pickled peaches.....	51.8	-3.4	+30.5
Pickled pears.....	78.2	-1.7	+82.6

Shear Force

Texture was measured on an L-E-E Kramer Shear Press (12), equipped with a standard cell. A 1,000-pound proving ring was used for pickled peaches and pears; a 3,000-pound ring, for all other products.

A 100-gram sample was used. Fermented dilled cucumbers, fresh-pack dilled cucumbers, sweet gherkin cucumbers, and pickled pears were cut into ¼-inch crosswise slices, and placed flat in the cell. Measurements were made before pickling, before and after processing, and after storage periods.

Peroxidase

The guaiacol procedure of Joslyn (11) was used to detect peroxidase activity. Five grams of chopped pickle was mixed with 5 ml. of water, 1 ml. of 1.0 percent guaiacol, and 1 ml. of 0.5 percent hydrogen peroxide. A brown discoloration after 5 minutes was considered a positive test for peroxidase.

Palatability Evaluation

Products were evaluated for appearance, texture, and flavor by panels of from 14 to 19 persons. A 5-point scale was used for each quality characteristic; a score of 5 was considered optimum. (See p. 4 for total number of panel ratings on each pickled product.)

TABLE 1.—*Number of replications of tests and number of panel ratings on pickled vegetables and fruits*

Product	Number of test replications					Number of panel ratings after storage for—			
	Before processing	After storage for—				0 days to 1 week	2 to 3 months	6 months	9 months
		0 days to 1 week	2 to 3 months	6 months	9 months				
Fermented products:									
Dilled cucumbers:									
Processed:									
Solids.....		2	2-6	3-6	4	26	89	87	65
Brine.....		2	2-6	3-6	4				
Unprocessed:									
Solids.....	2-4		2-6	2-5	4	26	89	71	48
Brine.....	2-6		2-6	2-5	4				
Sauerkraut:									
Processed:									
Solids.....		1				4			
Brine.....		1							
Unprocessed:									
Solids.....	1	1				4			
Brine.....	1	1							
Fresh-pack pickles:									
Dilled cucumbers:									
Processed:									
Solids.....	2-3		3-7	6	4		101	90	59
Brine.....	3-7		3-7	6	4				
Cresscut cucumber slices:									
Processed:									
Solids.....	2	1	2	2	1		28	26	15
Brine.....	2	1	2	2	1				
Sweet gherkin cucumbers:									
Processed:									
Solids.....	1-2	1	3	1	1		46	15	14
Brine.....	1-4		3	1	1				
Unprocessed:									
Solids.....	2		2	2			30	30	
Brine.....	4		2	2					
Dilled green beans:									
Processed:									
Solids.....		2	1			15	15		
Brine.....		1	1						
Unprocessed:									
Solids.....			2	1			30	11	
Brine.....	2	5	2	1					
Relishes:									
Corn:									
Processed:									
Solids.....	6	8	7	5		99	103	66	
Horseradish:									
Unprocessed:									
Solids.....		2				28			

RESULTS AND DISCUSSION

Fermentation

Dilled Cucumbers

At the end of a 3-week fermentation period, the cucumbers showed white spots, an indication of incomplete curing. However, after the fermented cucumbers were stored in sealed glass jars, whether processed or unprocessed, the white spots were not present. Cucumbers fermented for 5 weeks had no white spots before processing.

In table 2 are shown comparisons of pH, acid, and salt content of brine of cucumbers fermented at room temperature (72° to 90° F.) and at controlled temperature (72° to 75° F.). Cucumbers fermented at room temperature accumulated acid more rapidly, indicating faster fermentation, than did those fermented at controlled temperature. The peak of brine acidity was reached after 3 weeks of fermentation at controlled temperature and after 2 weeks at room temperature. Salt content and pH did not seem to be influenced greatly by temperature of fermentation.

Peroxidase activity was present to a maximum degree at the completion of fermentation, but little or no peroxidase activity was detected in the

processed pickles, even after several months of storage.

Bacteriological plates showed counts, predominantly of yeasts, up to 400 per ml. in unprocessed dilled cucumbers and none in processed dills. No changes in pH were detected during 3 months of storage of processed pickles that would afford conditions for microbial growth of food-poisoning organisms.

Sauerkraut

The acid content of both brine and solids in sauerkraut, calculated as lactic acid, ranged from about 0.9 percent to 1 percent during the first 5 weeks of fermentation (table 3). In the interval between 5 and 6 weeks, the acid content increased to about 1.4 percent for both brine and solids. The U.S. standards for commercial sauerkraut specify an acid content of not less than 1 percent; therefore, the fermentation was considered complete at this time. The pH and salt values decreased slightly as the fermentation progressed. Peroxidase activity was quite strong in the raw cabbage, but had decreased considerably at the end of the fermentation period.

TABLE 2.—Changes in acid and salt content and pH of brine of dilled cucumbers, fermented at controlled and room temperatures

Fermentation period (days)	Acid ¹		pH		Salt	
	Controlled ²	Room ³	Controlled ²	Room ³	Controlled ²	Room ³
	Percent	Percent			Percent	Percent
0-----	0.32	0.26	3.02	3.23	5.25	5.00
3-----	.18	.26	3.65	4.15	3.30	2.95
6-----	.36	.57	3.39	3.51	2.90	2.90
8-----	.64	.78	3.21	3.50	2.80	2.85
10-----	.59	.84	3.25	3.17	2.80	2.80
13-----	.73	.87	3.29	3.12	2.90	2.95
15-----	.75	.89	2.91	3.13	2.90	2.90
17-----	.75	.89	3.19	3.12	2.95	2.95
20-----	.82	.87	3.17	3.18	2.90	2.95
21-----	.84	.84	3.32	3.28	2.90	2.95

¹ Calculated as lactic acid.

² Controlled temperature range, 72° to 75° F.

³ Room temperature range, 72° to 90° F.

TABLE 3.—Changes in acid and salt content and pH of sauerkraut during fermentation

Fermentation period (days)	Acid ¹		pH		Salt	
	Brine	Solids	Brine	Solids	Brine	Solids
	Percent	Percent			Percent	Percent
0	0.07		5.54		3.2	
6	.95		3.92		2.3	
11	.95		3.85			
13	.97	0.88	3.82	3.89	2.2	2.0
18	.99		3.83			
20	.91	1.00	3.85	3.87		
21					2.0	1.9
27	1.00	.93	3.89	3.91	2.1	1.2
29	1.10	1.00	3.74	3.88	2.0	1.2
32	.98	1.07	3.73	3.76		
35	1.16					
37	1.23					
40	1.41	1.39	3.63	3.68	2.0	1.2
42	1.43	1.43	3.63	3.63		

¹ Calculated as lactic acid.

Heat Penetration and Lethality Values

In table 4 are given lethality values for the processed pickled products. Total equivalent minutes at 160° F. were calculated according to the method of Esselen and others (8), assuming a Z value of 18, where Z is the slope of the thermal destruction time curve of the spoilage organism. Temperatures were recorded during both heating and cooling periods, and percentages of equivalent minutes at 160° F. during each of these periods were calculated.

Etchells and Jones (9) have specified bringing the temperature of the product to 165° F. and holding at that temperature for 15 minutes before cooling quickly to 100° F. Esselen (6) has indicated that a holding time equivalent in lethality to 36 minutes at 160° F. in a pasteurization tank is necessary to provide a heat treatment adequate to prevent spoilage and objectionable enzyme activity. Pasteurization times for quart jars of whole fresh-pack pickles under these conditions were reported to be 40 minutes at 180° F., 35 minutes at 185° F., and 30 minutes at 195° F.

After processing, the products were allowed to return to room temperature without forced cooling. The temperatures during the cooling period were responsible for a large portion of the calculated lethality values.

The calculated lethality values for the total equivalent minutes at 160° F. for the various pickled products varied greatly. Sweet gherkins processed 5 minutes at 212° F. had a calculated value of 239. Dilled green beans and tomato-apple chutney, also processed 5 minutes at 212° F., had values of 2,127 and 2,002, respectively. Rate of heat penetration into the food was a factor in the differences in calculated lethality values.

As would be expected, high lethality values were also obtained for corn relish processed 15

minutes at 212° F., and for pickled pears processed 20 minutes at 212° F. These values greatly exceed those required for bacteriological safety. However, the heat treatment aids in the thermal destruction of various enzyme systems (7, 13)⁵ that are responsible for loss of flavor and nutritive value of the pickled products.

pH Values

Determinations of pH were made on the pickle solids and brines before storage and after storage for periods up to 9 months (table 5). Townsend and others (19) have reported a pH of 4.6 to be the maximum permissible for products that relied on acidification for inhibition of the growth of *Clostridium botulinum*. Pickle products, when properly prepared, have a pH too low for the production of toxin by *Clostridium botulinum*. However, it is possible for contaminating micro-organisms to grow and utilize the acid as a source of energy, thus lowering the initial acidity so that botulinum spores, if present, could produce toxin. Adequate water-bath processing would destroy these contaminating micro-organisms, and would inactivate enzymes responsible for changes in texture, flavor, and odor during storage.

Binsted and others (4), however, have pointed out that the pH of a pickled product is influenced by acids other than acetic—such as lactic, citric, and malic—and that these acids may have little effect on the keeping quality of pickles. Binsted states also that since the dissociation constant of acetic acid is relatively small, there is often no difference between the pH of pickles with widely varying acetic acid content.

⁵ Labbee, M. D. THE RELATIONSHIP OF PEROXIDASE AND CATALASE ACTIVITY TO THE DEVELOPMENT OF OFF-FLAVOR AND COLOR IN PROCESSED PICKLES. (Thesis, Ph. D., Univ. of Mass., Amherst) 1952.

TABLE 4.—*Lethality values of processed pickled vegetables and fruits*

Product	Jar size	Process time	Total heating time	Total cooling time	Lethality ¹			Replications
					Total equivalent min. at 160° F.	During heating	During cooling	
Fermented products:								
Dilled cucumbers.....	Quart.....	15 after immersion.....	Min. 15	Min. 30	224	44	56	6
Sauerkraut.....	Quart.....	20 at 212° F.....	30	30	1,485	16	84	3
Fresh-pack pickles:								
Dilled cucumbers.....	Quart.....	20 after immersion.....	20	15	494	49	51	6
Crosseut cucumber slices.....	Pint.....	5 at 212° F.....	17	20	986	40	60	3
Sweet gherkin cucumbers.....	Pint.....	5 at 212° F.....	10	25	239	18	82	5
Dilled green beans.....	Pint.....	5 at 212° F.....	15	10	2,127	53	47	3
Relishes:								
Corn.....	Pint.....	15 at 212° F.....	19	25	2,417	55	45	3
Tomato-apple chutney.....	Pint.....	5 at 212° F.....	8	15	2,002	45	55	3
Fruit pickles: Pears.....	Pint.....	20 at 212° F.....	24	20	5,606	64	36	3

¹ Calculations based on assumed Z value of 18.

TABLE 5.—*pH of pickled vegetables and fruits*

Product	pH before processing	pH after storage for—			
		0 days to 1 week	2 to 3 months	6 months	9 months
Fermented products:					
Dilled cucumbers:					
Processed:					
In solids		3.40	3.42	3.42	3.41
In brine		3.24	3.30	3.31	3.28
Unprocessed:					
In solids	3.39		3.40	3.39	3.41
In brine	3.28		3.27	3.29	3.30
Sauerkraut:					
Processed:					
In solids		3.37			
In brine		3.63			
Fresh-pack pickles:					
Dilled cucumbers:					
Processed:					
In solids			3.89	3.88	3.82
In brine	2.40		3.79	3.77	3.73
Crosseut cucumber slices:					
Processed:					
In solids	3.86	3.86	3.90	3.80	3.76
In brine	3.52		3.78	3.67	3.68
Sweet gherkin cucumbers:					
Processed:					
In solids			3.40	3.19	
In brine			3.27	3.07	
Unprocessed:					
In solids	3.52		3.36	3.23	
In brine	3.24		3.18	3.11	
Dilled green beans:					
Processed:					
In solids		3.70	3.73		
In brine		3.55	3.63		
Unprocessed:					
In solids			3.62	3.55	
In brine	2.52	2.89	3.54	3.32	
Relishes:					
Corn:					
Processed:					
In solids	3.95	3.96	3.92	3.93	
Horseradish:					
Unprocessed:					
In solids		3.52			
Pepper-onion:					
Unprocessed:					
In solids		3.64	3.62		
Piccalilli:					
Processed:					
In solids		3.62	3.71	3.69	3.71
Unprocessed:					
In solids	3.72		3.76	3.75	3.77
Tomato-apple chutney:					
Processed:					
In solids		3.77			
Tomato-pear chutney:					
Unprocessed:					
In solids		3.86			
Fruit pickles:					
Peaches:					
Processed:					
In solids			3.56		
In brine			3.40		
Unprocessed:					
In solids	3.84		3.60		
In brine	3.44		3.39		
Pears:					
Processed:					
In solids			3.62		
In brine			3.58		
Unprocessed:					
In solids	3.86		3.70	3.67	3.69
In brine	3.19	3.44	3.58	3.56	3.59

Since pH alone is not a reliable diagnostic factor of keeping quality, determinations were made of both pH and acidity values.

As shown in table 5, the pH values were below 4.6 for all pickled products. Processing had little effect on pH of fermented dilled cucumbers, crosscut cucumber slices, fresh-pack dilled cucumbers, and pickled pears. The brines, likewise, showed little change in pH as the result of processing.

The pH values of fermented dilled cucumbers, crosscut cucumber slices, fresh-pack dilled cucumbers, and pickled pears changed very little with storage. The pH of both the solids and brine of sweet gherkins decreased slightly between 2 to 3 months and 6 months of storage. There was also a slight decrease in the pH of processed dilled green beans with storage periods up to 6 months. Other products investigated changed very little in pH with storage. Processing appeared to have little effect on changes in pH with storage.

Acid Content

The acetic acid in vinegar is essential in preserving and flavoring pickles (15). A 0.7-percent concentration of acid is usually considered sufficient for preservation (15). Except for fresh-pack dilled cucumbers and pickled pears, which were approximately 0.7 percent in acidity, all products investigated had mean values well in excess of that required (table 6). High acid values were obtained for horseradish, 2.8 percent, and pepper-onion relish, about 2.2 percent (table 6). Acid values for piccalilli, corn relish, and dilled green beans were also relatively high.

Determinations made on fermented dilled cucumbers showed that more than 90 percent of the acidity could be accounted for by lactic acid. Consequently, acid values of the fermented products—dill pickles and sauerkraut—were calculated as lactic acid. All other values were expressed as acetic acid.

There were slight decreases in acidity of processed fermented dills after 2 to 3 months of storage (table 6). The acidity of the unprocessed pickles was about the same as that of the processed. The brine of the unprocessed product was slightly higher in acidity than was that of the processed pickles.

Fresh-pack dills showed little change in acidity with storage or processing. There were slight decreases in acidity of crosscut cucumber slices between 2 to 3 months and 6 months of storage. Sweet gherkins were relatively high in acid, about 1.2 percent, and the acidity did not appear to be affected by processing or by storage time. The acid content of the brine was slightly higher than that of the pickle solids. Unprocessed pickled pears changed only slightly in acidity with storage.

Salt Content

Work by Etchells and Jones (9) and by Pederson (15) has demonstrated that use of a low salt brine, about 3 to 5 percent sodium chloride for fermented dills, aided in the rapid formation of a high amount of acid and a low pH, whereas the use of higher salt brines, 10 percent sodium chloride and above, produced a slower rate of acid formation, together with increasing rates of gas evolution and resultant bloater spoilage. Consequently, in the work reported here, a brine of approximately 5 percent sodium chloride was used for the fermented dills. For sauerkraut, the amount of salt used was about 2.4 percent by weight.

There were slight decreases in salt content of fermented and fresh-pack dills with storage (table 7). The unprocessed fermented dills were slightly higher in salt content than were the processed pickles. The salt content of the brine was about the same as that of the pickles. The salt content of unprocessed dilled green beans was somewhat higher than that of the processed. For most of the other products investigated, there were only slight changes in salt content with processing or storage.

Soluble Solids

Sugar is used in nearly all pickles. It is of value, not only for its influence on flavor, but also because of its preservative action. Bell and Etchells (3) have proposed the following formula relating the amount of acid required for preservation of the pickled product to the amount of sugar present:

$$A = \frac{80 - S}{20}, \text{ where } A = \text{percentage of acetic acid in}$$

the product, and S = percentage of sugar. In work reported here, soluble solids were determined by refractometer; it was assumed that the soluble solids were chiefly sugars.

Fermented dill pickles ranged from 7.1 to 8.1 percent soluble solids (table 8). Processing of the pickles had little effect on soluble solids content. Values decreased somewhat with storage in fermented and fresh-pack dills and in dilled green beans. Crosscut cucumber slices, sweet gherkins, pickled peaches, pickled pears, tomato-apple chutney and tomato-pear chutney all had soluble solids values ranging from about 27 to 45 percent. The values did not appear to be influenced greatly by processing or by storage time.

Soluble solids contents of the brines or sirups were similar to those of the solids of the pickled products. Processing or storage time had little effect on amounts present.

Texture

Shear force readings and panel texture scores indicated that processing of fermented dill pickles

TABLE 6.—*Acid content of pickled vegetables and fruits*

Product	Acid content before processing	Acid content after storage for—			
		0 days to 1 week	2 to 3 months	6 months	9 months
Fermented products: ¹					
Dilled cucumbers:					
Processed:	<i>Percent</i>	<i>Percent</i>	<i>Percent</i>	<i>Percent</i>	<i>Percent</i>
In solids.....		0.94	0.88	0.88	0.84
In brine.....		.91	.84	.82	.82
Unprocessed:					
In solids.....	0.90	-----	.89	.91	.90
In brine.....	.81	-----	.88	.88	.89
Sauerkraut:					
Processed:					
In solids.....		1.21	-----	-----	-----
In brine.....		1.21	-----	-----	-----
Unprocessed:					
In solids.....		1.42	-----	-----	-----
In brine.....		1.42	-----	-----	-----
Fresh-pack pickles: ²					
Dilled cucumbers:					
Processed:					
In solids.....	.26	-----	.70	.72	.69
In brine.....	1.72	-----	.68	.69	.69
Crosscut cucumber slices:					
Processed:					
In solids.....	1.00	.85	.97	.87	.91
In brine.....	1.14	.90	1.00	.94	.98
Sweet gherkin cucumbers:					
Processed:					
In solids.....	1.20	.80	1.19	1.22	1.29
In brine.....	1.22	-----	1.25	1.41	1.41
Unprocessed:					
In solids.....	1.20	-----	1.20	1.27	-----
In brine.....	1.22	-----	1.28	1.36	-----
Dilled green beans:					
Processed:					
In solids.....		1.52	1.29	-----	-----
In brine.....	2.60	1.40	1.26	-----	-----
Unprocessed:					
In solids.....		-----	1.36	1.48	-----
In brine.....	2.60	2.26	1.44	-----	-----

See footnotes at end of table.

TABLE 6.—*Acid content of pickled vegetables and fruits*—Continued

Product	Acid content before processing	Acid content after storage for—			
		0 days to 1 week	2 to 3 months	6 months	9 months
Relishes: ²					
Corn:					
Processed:	<i>Percent</i>	<i>Percent</i>	<i>Percent</i>	<i>Percent</i>	<i>Percent</i>
In solids.....	1. 33	1. 30	1. 24	1. 31	-----
Horseradish:					
Unprocessed:					
In solids.....		2. 76	-----	-----	-----
Pepper-onion:					
Unprocessed:					
In solids.....		2. 16	2. 18	-----	-----
Piccalilli:					
Processed:					
In solids.....	1. 44	1. 39	1. 39	1. 37	1. 27
Unprocessed:					
In solids.....	1. 44	-----	1. 42	1. 40	1. 33
Tomato-apple chutney:					
Processed:					
In solids.....		1. 13	-----	-----	-----
Tomato-pear chutney					
Unprocessed:					
In solids.....		. 91	-----	-----	-----
Fruit pickles: ²					
Peaches:					
Processed:					
In solids.....	1. 07	-----	1. 06	-----	-----
In brine.....	1. 37	-----	1. 10	-----	-----
Unprocessed:					
In solids.....	1. 07	-----	1. 12	-----	-----
In brine.....	1. 37	-----	1. 22	-----	-----
Pears:					
Processed:					
In solids.....	. 64	-----	. 76	-----	-----
In brine.....	1. 26	-----	. 84	-----	-----
Unprocessed:					
In solids.....	. 64	-----	. 72	. 71	. 77
In brine.....	1. 26	. 83	. 84	. 84	. 85

¹ Calculated as lactic acid.² Calculated as acetic acid.

TABLE 7.—*Salt content of pickled vegetables and fruits*

Product	Salt content before processing	Salt content after storage for—			
		0 days to 1 week	2 to 3 months	6 months	9 months
Fermented products:					
Dilled cucumbers:					
Processed:	<i>Percent</i>	<i>Percent</i>	<i>Percent</i>	<i>Percent</i>	<i>Percent</i>
In solids.....		3. 20	3. 13	3. 10	2. 97
In brine.....		3. 28	3. 13	3. 10	2. 96
Unprocessed:					
In solids.....	3. 00		3. 25	3. 25	3. 18
In brine.....	3. 08		3. 22	3. 17	3. 21
Sauerkraut:					
Processed:					
In solids.....		1. 13			
In brine.....		1. 85			
Fresh-pack pickles:					
Dilled cucumbers:					
Processed:					
In solids.....	1. 94		3. 16	3. 13	2. 76
In brine.....	6. 51		3. 39	3. 12	2. 96
Crosscut cucumber slices:					
Processed:					
In solids.....	1. 15		1. 05	1. 10	. 90
In brine.....	1. 10	1. 20	1. 22	1. 32	1. 05
Sweet gherkin cucumbers:					
Processed:					
In solids.....			1. 21	. 90	1. 00
In brine.....			1. 32	1. 05	1. 05
Unprocessed:					
In solids.....	1. 20		1. 15	. 93	
In brine.....	1. 30		1. 22	1. 12	
Dilled green beans:					
Processed:					
In solids.....		3. 15	2. 20		
In brine.....	6. 25	3. 80	2. 40		
Unprocessed:					
In solids.....			2. 56	4. 70	
In brine.....		6. 47	2. 78	4. 95	
Relishes:					
Corn:					
Processed:					
In solids.....	. 74	. 74	. 64	. 63	
Horseradish:					
Unprocessed:					
In solids.....		. 22			
Piccalilli:					
Processed:					
In solids.....		3. 60	3. 60	3. 30	3. 60
Unprocessed:					
In solids.....	3. 47		2. 95	3. 05	3. 00
Tomato-apple chutney:					
Processed:					
In solids.....		. 30			
Tomato-pear chutney:					
Unprocessed:					
In solids.....		. 50			

aided in the maintenance of good texture (tables 9 and 10). A high shear force reading indicated a firm texture. However, optimum shear force varied, depending on the product being investigated. In general, the shear force reading corre-

sponding to a panel texture score of 5 would be considered near optimum for that product. After storage periods up to 9 months, the texture of the processed fermented dill pickles was considerably firmer than that of the unprocessed product.

TABLE 8.—*Soluble solids in pickled vegetables and fruits*

Product	Soluble solids before processing	Soluble solids after storage for—			
		0 days to 1 week	2 to 3 months	6 months	9 months
Fermented products:					
Dilled cucumbers:					
Processed:	<i>Percent</i>	<i>Percent</i>	<i>Percent</i>	<i>Percent</i>	<i>Percent</i>
In solids		7.8	7.9	7.7	7.1
In brine		6.4	6.2	6.4	6.2
Unprocessed:					
In solids	7.8		8.1	7.4	7.6
In brine	6.6		6.6	6.2	6.6
Sauerkraut:					
Processed:					
In solids		9.6			
In brine		8.8			
Unprocessed:					
In solids		10.6			
In brine		10.1			
Fresh-pack pickles:					
Dilled cucumbers:					
Processed:					
In solids			11.2	9.3	8.5
In brine	10.8		9.4	7.7	7.1
Crosscut cucumber slices:					
Processed:					
In solids	31.5		32.7	32.1	35.0
In brine	40.0	28.3	30.8	30.8	33.0
Sweet gherkin cucumbers:					
Processed:					
In solids			35.1	37.0	36.2
In brine			32.9	35.5	34.4
Unprocessed:					
In solids	31.0		37.4	34.4	
In brine	40.2		35.4	35.2	
Dilled green beans:					
Processed:					
In solids		13.4	10.1		
In brine		9.4	7.5		
Unprocessed:					
In solids			11.0	11.4	
In brine	9.6	14.3	10.0	10.1	
Relishes:					
Corn:					
Processed:					
In solids	27.7	26.3	24.8	24.3	
Pepper-onion:					
Unprocessed:					
In solids		29.6	29.0		
Piccalilli:					
Processed:					
In solids		25.5	27.6	27.4	26.2
Unprocessed:					
In solids	28.6		27.8	28.9	27.2
Tomato-apple chutney:					
Processed:					
In solids		33.1			
Tomato-pear chutney:					
Unprocessed:					
In solids		38.0			
Fruit pickles:					
Peaches:					
Processed:					
In solids			29.0		
In brine			27.2		
Unprocessed:					
In solids	27.9		32.4		
In brine	42.2		30.5		
Pears:					
Processed:					
In solids			38.5		
In brine			37.5		
Unprocessed:					
In solids	33.7		44.9	43.1	43.8
In brine	58.1	63.6	43.7	41.9	42.5

TABLE 9.—*Shear values of pickled vegetables and fruits*

Product	Shear values before processing	Shear values after storage for—			
		0 days to 1 week	2 to 3 months	6 months	9 months
Fermented products:					
Dilled cucumbers:	<i>Lbs. force</i>	<i>Lbs. force</i>	<i>Lbs. force</i>	<i>Lbs. force</i>	<i>Lbs. force</i>
Processed.....		385	308	350	349
Unprocessed.....	472		382	311	285
Sauerkraut:					
Processed.....		702			
Unprocessed.....	720				
Fresh-pack pickles:					
Dilled cucumbers:					
Processed.....	407		392	409	361
Crosscut cucumber slices:					
Processed.....	435		315	370	350
Sweet gherkin cucumbers:					
Processed.....			376	400	390
Unprocessed.....	394		374	534	
Dilled green beans:					
Processed.....		536	535		
Unprocessed.....			1,360	745	
Relishes:					
Corn:					
Processed.....	228	207	192	195	
Fruit pickles:					
Peaches:					
Processed.....			40		
Unprocessed.....	44		56		
Pears:					
Processed.....			110		
Unprocessed.....	98		134	130	125

TABLE 10.—Panel texture scores of pickled vegetables and fruits

Product	Mean score after storage for— ¹				Range in scores after storage for—			
	0 days to 1 week	2 to 3 months	6 months	9 months	0 days to 1 week	2 to 3 months	6 months	9 months
Fermented products:								
Dilled cucumbers:								
Processed.....	3.8	4.3	4.3	4.0	3.2-4.2	3.9-5.0	4.0-4.8	3.3-4.8
Unprocessed.....	4.3	4.0	3.8	3.8	4.0-4.8	2.8-4.6	3.4-4.5	3.2-4.5
Sauerkraut:								
Processed.....	4.6	-----	-----	-----	4.0-5.0	-----	-----	-----
Unprocessed.....	3.9	-----	-----	-----	3.0-5.0	-----	-----	-----
Fresh-pack pickles:								
Dilled cucumbers:								
Processed.....	-----	4.0	4.0	3.8	-----	3.3-5.0	3.4-4.8	3.5-4.1
Crosscut cucumber slices:								
Processed.....	-----	4.7	4.5	4.8	-----	4.4-5.0	4.3-4.8	-----
Sweet gherkin cucumbers:								
Processed.....	-----	4.4	4.8	4.5	-----	3.3-4.8	-----	4.4-4.8
Unprocessed.....	-----	4.7	4.5	-----	-----	4.5-5.0	4.4-4.8	-----
Dilled green beans:								
Processed.....	3.8	4.5	-----	-----	3.5-3.9	-----	-----	-----
Unprocessed.....	-----	3.1	3.3	-----	-----	2.8-3.3	3.0-3.8	-----
Relishes:								
Corn:								
Processed.....	4.4	4.3	4.3	-----	4.2-4.8	3.8-5.0	3.9-5.0	-----
Horseradish:								
Unprocessed.....	4.5	-----	-----	-----	4.4-4.8	-----	-----	-----
Pepper-onion:								
Unprocessed.....	3.8	3.7	-----	-----	3.7-4.0	3.4-4.5	-----	-----
Piccalilli:								
Processed.....	4.5	4.7	4.4	4.6	4.2-4.7	4.6-4.8	4.2-5.0	4.5-4.6
Unprocessed.....	4.7	4.8	4.4	4.6	4.2-5.0	4.8-5.0	4.2-5.0	4.3-5.0
Tomato-apple chutney:								
Processed.....	4.2	-----	-----	-----	4.0-5.0	-----	-----	-----
Tomato-pear chutney:								
Unprocessed.....	4.8	-----	-----	-----	3.0-5.0	-----	-----	-----
Fruit pickles:								
Peaches:								
Processed.....	-----	3.6	-----	-----	-----	3.2-4.8	-----	-----
Unprocessed.....	-----	4.3	-----	-----	-----	4.1-4.8	-----	-----
Pears:								
Processed.....	-----	4.4	-----	-----	-----	4.4-4.5	-----	-----
Unprocessed.....	-----	4.0	4.0	4.0	-----	3.2-4.8	3.5-4.8	3.8-4.4

¹ A score of 5 denotes very good; 4, good; 3, fair; 2, poor; 1, very poor.

Shear force and panel texture values indicated little texture change in processed fresh-pack dills and crosscut cucumber slices during storage. Sweet gherkins, both processed and unprocessed, maintained their firm texture during storage.

Shear force readings were higher for unprocessed dilled green beans than for the processed products, indicating a firmer, less tender product. Comments of the panel members indicated that the unprocessed dilled green beans were too firm in texture.

Processing appeared to have little effect on the texture of piccalilli. Processed corn relish, processed and unprocessed piccalilli, and unprocessed pepper-onion relish changed very little in texture after storage periods varying from 2 to 9 months.

Color and Appearance

A decrease in color-difference meter a_L/b_L ratio values indicated a loss in green color during the period between 2 to 3 months and 9 months of storage for both processed and unprocessed fermented dill pickles (table 11). The processed pickles maintained their color better than did the unprocessed. This superiority was indicated by both color-difference meter readings (table 11) and panel scores for color and appearance (table 12). Panel scores, unlike color-difference meter readings, did not decrease with length of storage time of the pickles, probably because the olive-green color which develops with storage is accepted as the normal color of fermented dill pickles.

Color-difference meter readings also decreased as the length of storage period increased for both fresh-pack dilled cucumber pickles and crosscut cucumber slices, indicating some loss of green color. Panel scores showed no significant changes that could be associated with length of storage

time. The a_L/b_L ratio values of sweet gherkins were highest for the pickles stored 6 months. Processing had no significant effect on color of these pickles, as shown by color-difference meter readings and panel scores.

TABLE 11.—Color-difference meter values for pickled vegetables and fruits

Product and color reading	Color values before processing	Color values after storage for—			
		0 days to 1 week	2 to 3 months	6 months	9 months
Fermented products: Dilled cucumbers: Processed: a_L/b_L values ¹ ----- Unprocessed: a_L/b_L values----- Fresh-pack pickles: Dilled cucumbers: Processed: a_L/b_L values----- Crosscut cucumber slices: Processed: a_L/b_L values----- Sweet gherkin cucumbers: Processed: a_L/b_L values----- Unprocessed: a_L/b_L values----- Dilled green beans: Processed: a_L/b_L values----- Unprocessed: a_L/b_L values----- Fermented products: Sauerkraut: Processed: L values ² ----- a_L values ³ ----- b_L values ⁴ ----- Relishes: Corn: Processed: L values----- a_L values----- b_L values----- Fruit pickles: Peaches: Processed: L values----- a_L values----- b_L values----- Pears: Processed: L values----- a_L values----- b_L values----- Unprocessed: L values----- a_L values----- b_L values-----	Green vegetables				
	-----	0. 124	0. 244	0. 181	0. 150
	0. 185	-----	. 205	. 157	. 129
	-----	-----	. 179	. 190	. 127
	. 189	-----	. 204	. 163	. 139
	-----	-----	. 321	. 424	. 359
	. 197	-----	. 328	. 370	-----
	-----	. 403	. 144	-----	-----
	-----	-----	. 091	. 057	-----
	Other vegetables and fruits				
	59. 2	49. 2	-----	-----	-----
	. 7	. 5	-----	-----	-----
	19. 1	18. 4	-----	-----	-----
	47. 4	46. 1	44. 8	44. 0	-----
	1. 1	1. 3	. 5	. 1	-----
	26. 6	24. 9	23. 0	21. 1	-----
	48. 0	-----	37. 7	-----	-----
	9. 9	-----	12. 0	-----	-----
	24. 4	-----	21. 0	-----	-----
	36. 6	-----	36. 2	-----	-----
. 5	-----	1. 6	-----	-----	
13. 9	-----	14. 8	-----	-----	
36. 6	-----	29. 3	32. 8	32. 9	
. 5	-----	1. 3	4. 2	3. 3	
13. 9	-----	11. 8	14. 0	14. 6	

¹ Denotes ratio of green to yellow in sample.

² Denotes lightness of sample.

³ Denotes greenness of sample.

⁴ Denotes yellowness of sample.

TABLE 12.—*Panel color scores of pickled vegetables and fruits*

Product	Mean score after storage for— ¹				Range in scores after storage for—			
	0 days to 1 week	2 to 3 months	6 months	9 months	0 days to 1 week	2 to 3 months	6 months	9 months
Fermented products:								
Dilled cucumbers:								
Processed.....	4.4	4.6	4.7	4.3	3.8-5.0	4.3-5.0	4.1-5.0	3.6-5.0
Unprocessed.....	3.7	4.3	4.3	4.2	2.5-4.0	3.7-5.0	3.5-4.8	3.8-5.0
Sauerkraut:								
Processed.....	4.7	-----	-----	-----	4.0-5.0	-----	-----	-----
Unprocessed.....	4.1	-----	-----	-----	3.0-5.0	-----	-----	-----
Fresh-pack pickles:								
Dilled cucumbers:								
Processed.....	-----	3.8	3.9	3.8	-----	2.5-5.0	3.5-5.0	3.2-4.8
Crosscut cucumber slices:								
Processed.....	-----	4.8	4.8	4.8	-----	4.6-5.0	4.8-5.0	-----
Sweet gherkin cucumbers:								
Processed.....	-----	4.4	4.8	4.6	-----	3.6-5.0	4.7-5.0	4.5-4.6
Unprocessed.....	-----	4.6	4.2	-----	-----	4.5-5.0	3.8-4.8	-----
Dilled green beans:								
Processed.....	4.2	4.7	-----	-----	-----	-----	-----	-----
Unprocessed.....	-----	3.8	3.9	-----	-----	3.0-4.0	3.6-4.5	-----
Relishes:								
Corn:								
Processed.....	4.8	4.6	4.6	-----	4.6-5.0	4.2-5.0	4.5-4.8	-----
Horseradish:								
Unprocessed.....	4.7	-----	-----	-----	4.5-4.9	-----	-----	-----
Pepper-onion:								
Unprocessed.....	4.4	4.2	-----	-----	4.3-4.8	3.9-5.0	-----	-----
Piccalilli:								
Processed.....	4.3	4.6	4.7	4.8	4.0-4.5	4.0-4.8	4.5-4.7	4.5-4.8
Unprocessed.....	4.3	4.6	4.5	4.7	4.0-4.5	4.0-4.9	4.2-4.6	4.5-4.9
Tomato-apple chutney:								
Processed.....	4.6	-----	-----	-----	4.0-5.0	-----	-----	-----
Tomato-pear chutney:								
Unprocessed.....	4.8	-----	-----	-----	4.0-5.0	-----	-----	-----
Fruit pickles:								
Peaches:								
Processed.....	-----	3.9	-----	-----	-----	3.2-5.0	-----	-----
Unprocessed.....	-----	3.5	-----	-----	-----	-----	-----	-----
Pears:								
Processed.....	-----	4.6	-----	-----	-----	4.5-4.6	-----	-----
Unprocessed.....	-----	4.1	3.9	3.6	-----	3.2-4.8	3.2-4.7	2.5-4.8

¹ A score of 5 denotes very good; 4, good; 3, fair; 2, poor; 1, very poor.

Color-difference meter readings indicated a loss of green color in dilled green beans with storage. Panel color scores, however, showed no significant deterioration in color of the product with storage. Scores for the unprocessed product were somewhat lower than were those for the processed dilled green beans.

Panel scores indicated only slight deterioration in color of processed corn relish stored for periods up to 9 months. Color-difference meter L and b_L readings also decreased slightly as the length of storage period increased, denoting some darkening and loss of yellow color with storage. Panel color scores for piccalilli indicated that the color of the product was not greatly affected by processing or length of storage time.

Panel scores for appearance of processed pickled pears stored 2 to 3 months averaged 4.6, compared to 4.2 for the unprocessed pears stored for the same length of time. Gardner L scores (table 11) averaged 36.6 for the unprocessed pears before

storage, and 29.3 for the same product after 2 to 3 months' storage, denoting some darkening of the unprocessed pears with storage. The comparable L value for the processed pears after the same storage period was 36.2, about the same as the value obtained on the pears before storage.

Flavor

Panel flavor scores (table 13) for processed fermented dilled cucumbers were slightly higher than for the unprocessed samples. Scores for processed dills were above 4, good flavor, at all storage periods, whereas scores for unprocessed fermented dills were below 4 after storage for 6 months and after 9 months. These results indicate that processing aided in retaining desirable flavor in fermented dilled cucumbers. Flavor scores for sweet gherkins also were slightly higher for processed than for unprocessed pickles.

Panel flavor scores were higher for fresh-pack

dilled cucumbers stored 6 months than for the same product stored 9 months. In contrast, the flavor of crosscut cucumber slices and sweet gherkin cucumbers did not appear to be adversely affected by storage periods up to 9 months.

Panel flavor scores for processed green beans were similar before and after storage for 2 to 3 months. Scores for the unprocessed green beans stored 2 to 3 months were considerably lower than for the processed samples.

Flavor scores for processed corn relish stored 6 months were about the same as those for corn relish before storage. The flavor of piccalilli,

both processed and unprocessed, did not appear to be adversely affected by storage periods up to 9 months.

Panel scores suggested little change in flavor of unprocessed pickled pears in the storage interval between 2 to 3 months and 9 months.

In general, the flavor scores for the processed pickles were higher than were those for the unprocessed pickles. The inactivation by processing of enzymes responsible for development of off-flavor is no doubt a factor in the superior flavor of the processed pickles during storage.

TABLE 13.—*Panel flavor scores of pickled vegetables and fruits*

Product	Mean score after storage for— ¹				Range in scores after storage for—			
	0 days to 1 week	2 to 3 months	6 months	9 months	0 days to 1 week	2 to 3 months	6 months	9 months
Fermented products:								
Dilled cucumbers:								
Processed.....	4.0	4.2	4.5	4.1	3.6-4.8	3.7-5.0	3.8-5.0	3.9-4.5
Unprocessed.....	4.3	4.1	3.9	3.9	4.0-4.8	3.2-4.5	3.2-4.8	3.5-4.8
Sauerkraut:								
Processed.....	4.1				3.0-5.0			
Unprocessed.....	3.5				2.0-5.0			
Fresh-pack pickles:								
Dilled cucumbers:								
Processed.....		3.4	3.7	3.3		2.7-4.8	3.0-4.8	2.5-4.2
Crosscut cucumber slices:								
Processed.....		4.7	4.6	4.9		4.3-5.0	4.4-4.8	4.8-5.0
Sweet gherkin cucumbers:								
Processed.....		4.1	4.4	4.7		3.5-4.8	4.2-4.7	4.6-4.8
Unprocessed.....		4.0	4.3			3.8-4.8	4.0-4.8	
Dilled green beans:								
Processed.....	4.3	4.2			4.1-4.8			
Unprocessed.....		3.8	3.3	3.3		3.8-4.0	2.8-4.2	
Relishes:								
Corn:								
Processed.....	4.1	4.3	4.1		3.7-5.0	3.2-5.0	3.2-4.8	
Horseradish:								
Unprocessed.....	4.2				3.7-4.8			
Pepper-onion:								
Unprocessed.....	4.0	3.7				3.6-4.0		
Piccalilli:								
Processed.....	4.1	4.1	4.3	3.9	4.0-4.1	3.6-4.6	4.0-4.4	3.8-4.0
Unprocessed.....	3.9	4.1	4.2	4.3	3.0-4.3	3.8-4.8	4.0-4.5	4.0-4.9
Tomato-apple chutney:								
Processed.....	4.6				3.5-5.0			
Tomato-pear chutney:								
Unprocessed.....	4.8				4.0-5.0			
Fruit pickles:								
Peaches:								
Processed.....		2.8				1.8-3.8		
Unprocessed.....		3.5				3.1-4.8		
Pears:								
Processed.....		4.5						
Unprocessed.....		4.0	4.0	3.8		3.4-4.1	3.5-4.5	3.0-4.5

¹ A score of 5 denotes very good; 4, good; 3, fair; 2, poor; 1, very poor.

LITERATURE CITED

- (1) BARKER, S. B., and SUMMERSON, W. H.
1941. THE COLORIMETRIC DETERMINATION OF LACTIC ACID IN BIOLOGICAL MATERIAL. Jour. Biol. Chem. 138: 535-554.
- (2) BAUSCH & LOMB OPTICAL CO.
[n.d.] ABBE-3L REFERENCE MANUAL. Cat. 33-45-58. 22 pp. Rochester 2, N.Y.
- (3) BELL, T. A., and ETCHHELLS, J. L.
1952. SUGAR AND ACID TOLERANCE OF SPOILAGE YEASTS FROM SWEET-CUCUMBER PICKLES. Food Technol. 6: 468-472.
- (4) BINSTED, R., DEVEY, J. D., and DAKIN, J. C.
1962. PICKLE SAUCE AND PICKLE MAKING. Ed. 2, 269 pp., London.
- (5) ECKBLAD, I. M.
1957. PICKLE POINTERS. Ext. Bul. 523. Wash. Agr. Col. Agr. Ext. Serv., Pullman, Wash. 16 pp.
- (6) ESSELEN, W. B.
1960. PICKLE RESEARCH AT THE UNIVERSITY OF MASSACHUSETTS. Glass Packer 39 (8): 3-6, 9.
- (7) ——— ANDERSON, E. E., RUDER, L. F., JR., and PFLUG, I. J.
1951. PASTEURIZED FRESH WHOLE PICKLES. I. Pasteurization Studies. Food Technol. 5: 279-284.
- (8) ——— FAGERSON, I. S., PFLUG, I. J., and others.
1952. PASTEURIZED FRESH WHOLE PICKLES. III. Heat Penetration in Fresh Pack Pickles. Glass Packer 31 (3): 175-178, 201.
- (9) ETCHHELLS, J. L., and JONES, I. D.
1944. PROCEDURES FOR PASTEURIZING PICKLE PRODUCTS. Glass Packer 23 (7): 519-523, 546.
- (10) GARDNER LABORATORY.
[n.d.] GARDNER AUTOMATIC COLOR-DIFFERENCE METER. Bul. 156, 9 pp. Bethesda, Md.
- (11) JOSLYN, M. A.
1953. REPORT ON PEROXIDASE IN FROZEN VEGETABLES. Jour. Assoc. Off. Agr. Chem. 36: 161-178.
- (12) KRAMER, A., BURKHARDT, G. J., and ROGERS, H. P.
1951. THE SHEAR-PRESS: A DEVICE FOR MEASURING FOOD QUALITY. Canner 112 (5): 34-36, 40.
- (13) NEBESKY, E. A., ESSELEN, W. B., JR., and FELLERS, C. R.
1951. PEROXIDASE INACTIVATION IN PROCESSED CUCUMBER SLICES. Jour. Milk and Food Technol. 14 (1): 103, 104, 108.
- (14) PATASHNIK, M. A.
1953. A SIMPLIFIED PROCEDURE FOR THERMAL PROCESS EVALUATION. Food Technol. 7: 1-6.
- (15) PEDERSON, C. S.
1950. PICKLE MAKING PRINCIPLES. Farm Res. 16 (3): 4.
- (16) SCHALES, O., and SCHALES, S. S.
1941. A SIMPLE AND ACCURATE METHOD FOR DETERMINATION OF CHLORIDE IN BIOLOGICAL FLUIDS. Jour. Biol. Chem. 140: 879-883.
- (17) SCHONHERZ, Z.
1955. THE DETERMINATION OF SALT IN BRINES, PICKLES, SALTED MEATS AND SEASONINGS BY TITRATION WITH MERCURIC NITRATE SOLUTION. Food Mfr. 30: 460.
- (18) STARK, J. B., GOODBAN, A. E., and OWENS, H. S.
1953. BEET SUGAR LIQUORS, DETERMINATION AND CONCENTRATION OF LACTIC ACID IN PROCESSING LIQUORS. Jour. Agr. and Food Chem. 1 (8): 564-566.
- (19) TOWNSEND, C. T., YEE, L., and MERCER, W. A.
1954. INHIBITION OF THE GROWTH OF *CLOSTRIDIUM BOTULINUM* BY ACIDIFICATION. Food Res. 19 (5): 536-542.
- (20) UNITED STATES DEPARTMENT OF AGRICULTURE
1944. PICKLE AND RELISH RECIPES. Leaflet 269, A.R.S., 16 pp.
- (21) ———
1957. HOME CANNING OF FRUITS AND VEGETABLES. Home and Garden Bul. 8, 45 pp.
- (22) ———
1963. MAKING PICKLES AND RELISHES AT HOME. Home and Garden Bul. 92, 32 pp., illus.