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HEAT PROCESSING CHARACTERISTICS OF FRESH CUCUMBER PICKLE PRODUCTS

I. Heating Rates of Spears

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FRESH CUCUMBER PICKLE SPEARS are fresh cucumbers that have been sliced, packed in jars or cans, spiced, brined or syruped, sealed and pasteurized. It is an attractive pack of good flavor and texture that is well received by the consumer. The total production of fresh cucumber spear pickles has grown to the extent that it represents a significant percentage of the total pickle pack.

This is the report of a detailed study of the heating characteristics of spear type cucumber pickles.

Spears are produced by slicing the cucumbers lengthwise into four, five or six wedges (Fig. 1); the ends may be cut square (Fig. 2). Spears are hand-packed into containers of such height that the spears, when packed vertically, extend to the top of the jar, but leave adequate head space. The spears are place-packed with the cut surface to the outside. The covering liquor for the dill-flavored pack is a

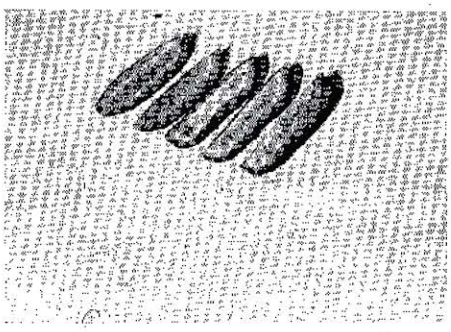

Fig. 1. Cucumber spears made by slicing the cucumber lengthwise into wedges.

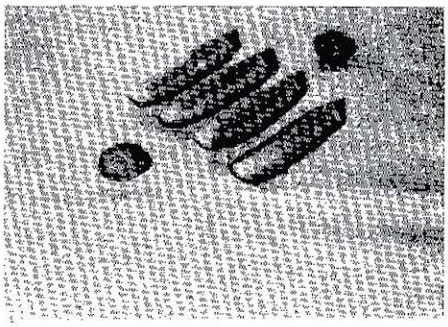

Fig. 2. Cucumber spears with square ends made by slicing end cap before slicing lengthwise.

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salt-acid brine; a sugar-salt-acid syrup is used to make the sweet-spear product. Preservation of fresh spear products is achieved through a heat pasteurization process.

EXPERIMENTAL

The heating characteristics of spears in glass jars and tinplate cans were determined by measuring the temperature at the assumed point of slowest heating with copper-constantan thermocouples sealed in a 1/4-inch O.D. Bakelite rod (similar to the thermocouples described by Townsend *et al.*[1]). The rod was inserted into the container through an Ecklund[2] stuffing box.

In Fig. 3 are illustrated the thermocouple rod unit, stuffing box parts, and a jar of spears with the thermocouple in place. The temperatures were measured and recorded by a multiple-point temperature-recording potentiometer. The heating rate data were plotted according to the method of Ball and Olson[3] and the heating rate, f_h,

[1] Townsend, C. T., J. M. Reed, J. McConnell, M. J. Powers, W. B. Esselen, I. I. Sommers, J. J. Dwyer, and C. O. Ball. (1949) "Comparative heat penetration studies on jars and cans." *Food Technology*, 3:213-226.

[2] Ecklund, O. F. (1949). "Apparatus for the measurement of the rate of heat penetration in canned foods." *Food Technology 3*, 231-233.

[3] Ball, C. O. and F. C. W. Olson. (1957). *"Sterilization in Food Technology."* McGraw-Hill Pub. Co., N. Y.

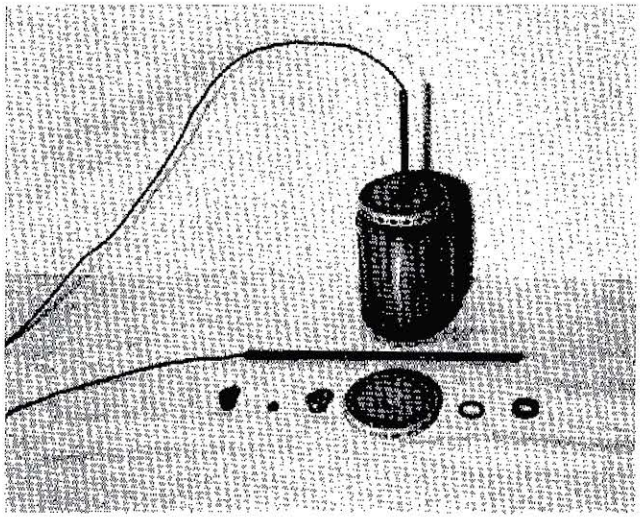

Fig. 3. Apparatus for measuring rate of heating of jars of spears. In the foreground are parts of the Ecklund stuffing box and a lid prepared to receive the stuffing box. The thermocouple is shown in the center of the picture; a jar of spears with thermocouple inserted through stuffing box is shown in the rear of the picture.

and lag factor, j, determined. All tests were replicated and the results of each experiment analyzed statistically. The physical description of the containers used and the location of the thermocouple in inches above the container bottom are given in Table 1.

TABLE 1—Container dimensions

Name	Normal fill (oz.) (a)	Outside diameter (in.)	Height to top of finish (in.)	Jar weight (oz.)	Thermocouple distance from bottom of jar (in.)
Vegetable jar (No. 303)..	16	3.00	4.75	7.1	0.90
Tinplate can (No. 2).....	20.5	3.44	4.56	....	0.88
Vegetable jar (No. 2½)..	28	4.00	5.00	12.2	0.90

(a) Overflow capacity about ½ oz. more.

Tests were carried out both in the laboratory and in the field. For field tests the laboratory equipment, including the water bath, temperature controller, and temperature recording potentiometer, was moved into the plant of a commercial manufacturer.

Laboratory packs were made using the following procedure: The cucumbers were washed for 5 minutes in a tumbling-action washer, then blanched for 5 minutes at 140° F. The spears were cut by hand and place-packed after cutting. The syrup or brine was preheated to 135-140° F. and poured over the spears; 1 ml. of spice oil mixture[4] was added and the jars were sealed and pasteurized.

The pickles were pasteurized in an automatically controlled water bath maintained at approximately 180° F. for all tests except one when a temperature of 195° F. was used. The point-to-point variation in this bath was determined to be less than 1.25° F., and the standard deviation of the temperature variation at any one point was about 0.25° F.

The laboratory packed jars were filled with a known weight of product. This weight is expressed as a fill ratio, the ratio of the weight of the cucumbers to the nominal fluid ounce capacity of the container; for example, 12-oz. of cucumbers in a 16-oz. jar is described as a fill ratio of 0.75. In the field studies the production-line-packed, LP, product was used for the heating rate studies. The objective in deter-

[4] Courtesy W. J. Stange Co.

mining the heating characteristics of the line-packed products was to compare those data with corresponding data from laboratory packs.

For the laboratory packs a 1.4 percent acid and 5.0 percent salt brine was used to cover the dill spears and a syrup containing 51.0 percent sucrose, 2.8 percent acid, and 4.0 percent salt was used for the sweet pickle spears. The brine or syrup used by the pickle manufacturer was used for the production line packs studied in the field.

RESULTS

The results of tests carried out to determine the effect of the fill ratio on the heating characteristics of spears are presented in Table 2. The 1955 data show a significant difference between the extreme fill ratios, whereas in the 1956 data the difference is not significant; however, there appears to be the same trend toward larger f_h values with lower fill ratios. The lag factors, j, are different in both years. In general, these results show that increasing the fill ratio of a syrup packed product results in a significant decrease in sterilizing value for a given processing time and temperature.

The results of tests comparing skin-in with skin-out are presented in Table 3. In the first test, the cut surface of the cucumber was placed next to the surface of the glass container as is done commercially,

TABLE 2—Effect of fill ratio on the heating characteristics of sweet cucumber spears in 16-oz. jars

Fill ratio	No. jars in test	Lag factor (j)				Heating rate (f_h) min.			
		Ave.	Min.	Max.	Std. dev.	Ave.	Min.	Max.	Std. dev.
1955									
0.69.....	8	1.65	1.18	2.08		38.3	33.1	43.4	
0.75.....	11	1.69	1.43	2.10	0.31	36.0	27.4	41.0	4.78
0.82.....	12	2.00	1.47	2.62		32.0	22.1	45.0	
1956									
0.62.....	9	1.33	1.10	1.51		43.3	36.8	55.2	
0.70.....	12	1.36	1.07	1.72	0.20	40.0	34.8	47.6	4.14
0.75.....	6	1.63	1.27	2.04		41.0	37.2	43.0	
0.84.....	7	1.97	1.48	2.52		38.6	33.2	41.2	

TABLE 3—Effect of cut-surface position on heating characteristics of sweet fresh cucumber spears (fill ratio 0.75; 16-oz. jar; 1957)

	No. jars in test	Fill ratio	Lag factor (j)				Heating rate (f_h) min.			
			Ave.	Min.	Max.	Std. dev.	Ave.	Min.	Max.	Std. dev.
Cut surface next to glass.....	8	0.75	1.64	1.46	1.79	0.12	36.2	33.5	39.3	2.09
Skin surface next to glass.....	8	0.75	1.71	1.59	1.91		40.9	38.2	43.4	

whereas in the second test the skin side of the cucumber wedge was placed next to the glass. The results show that there is a difference, significant at the 1 percent level, in the heating rate. The jars with the cut surface out (skin-in) heated faster than those with the skin out.

Table 4 presents the results of tests to determine the effect of holding filled, syruped, closed containers for 30 minutes before heating. In the first test, the product was syruped and sealed and then allowed to stand for 30 minutes at room temperature before processing. This test was compared with a second test in which the jars were processed immediately after packing. An analysis of variance indicated no significant difference in either the f_h or j value due to the 30-minute hold. There appears to be a trend toward faster heating with increased holding time.

TABLE 4—Effect of time between sealing and heating on heating characteristics of sweet fresh cucumber spears (line pack; 16-oz. jars; 1957)

	No. jars in test	Fill ratio	Lag factor (j)				Heating rate (f_h) min.			
			Ave.	Min.	Max.	Std. dev.	Ave.	Min.	Max.	Std. dev.
Spears held for 30 min. before heating.....	8	LP	1.35	1.15	1.63	0.35	38.5	32.8	45.6	3.85
Spears heated immediately.....	12	LP	1.65	1.25	2.19		39.6	30.8	49.2	

The effect of heating medium temperature on the heating characteristics of line-packed 16-oz. jars of spears in syrup is shown in Table 5. Heating was significantly faster, smaller f_h, in the 195°F bath, than in the 180°F water bath. There was no significant change in the lag factor, j.

Tests were carried out to determine the effect of container type and size and covering liquor on the heating characteristics of the spear products. These data are presented in Table 6. The mean heat-

TABLE 5—Effect of heating medium temperature on the heating characteristics of fresh sweet cucumber spears (line pack, 16-oz. vegetable jars, thermocouple at center of jar)

Water bath temperature °F.	Number jars in test	Lag factor (j)				Heating rate (f_h) min.			
		Ave.	Min.	Max.	Std. dev.	Ave.	Min.	Max.	Std. dev.
180	30	1.58	1.18	2.18	0.44	46.1	35.2	55.1	4.3
195	10	1.28	1.28	1.89		36.2	29.2	41.9	

ing rate, f_h, of 28-oz. syrup packed jars, is greater than the heating rate of 16-oz. syrup packed jars by more than 26 percent. The lag factor, j, also increases. Increasing the jar size from 16 to 28-oz. increased the heating rate of spears in brine by only 17 percent, while the lag factor remained almost constant. If the brine packed product is compared with a syrup packed product in the same size container, the syrup packed product shows an increase in lag factor of about 40 percent and an increase in heating rate of about 100 percent. This effect of the syrup requires that fresh sweet products be given a longer pasteurization process than fresh brine products.

DISCUSSION

A comparison of the heating characteristics of line-packed jars of sweet spears in 1960 (Table 5) with results of other years (Table 6) suggests that some factor in manufacture has changed in 1960 to cause the jars to heat more slowly, larger f_h. The results in Table 2 suggest that this change in heating rate could be due to a decrease in fill ratio. Differences in the location of the thermocouple in the jars, at the geometric center for data in Table 5 compared to 0.90-in. above bottom for other data, should have little or no effect on the heating rate since this product approaches conduction heating. Comparison of the data for a heating medium temperature of 195° F. (Table 5) vs. a heating medium temperature of 180° F. should bring realization that the heating rate is not constant but is influenced by external conditions. It is anticipated that the heating rate will vary with the nature of the heating medium in addition to the variation due to heating medium temperature.

The results of these studies on the heating rate of cucumber spear products are summarized in Table 7. The average values obtained from the data have been statistically projected by adding 3.09

TABLE 6—Effect of container and covering liquid on the heating characteristics of fresh cucumber spears

	No. jars in test	Year	Fill ratio	Lag factor (j)				Heating rate (f_h) min.			
				Ave.	Min.	Max.	Std. dev.	Ave.	Min.	Max.	Std. dev.
16-oz. jars; syrup pack	12	1956	0.75	1.52	1.27	2.05	0.21	40.8	21.3	46.0	6.48
	8	1957	0.75	1.64	1.46	1.79	0.12	36.2	33.5	39.3	2.09
	8	1958	0.72	1.84	1.52	2.26	0.23	40.7	34.5	46.0	3.40
	12	1957	LP	1.65	1.25	2.19	0.34	39.6	30.8	49.2	3.85
	40	1958	LP	1.52	1.25	2.09	0.18	41.9	36.2	48.4	3.74
No. 2 can, syrup pack	6	1957	0.65	1.61	1.40	1.93	0.19	41.3	35.2	48.8	4.37
28-oz. jar, syrup pack	12	1956	0.72	1.67	1.34	1.97	0.20	51.6	40.8	63.3	7.32
16-oz. jar, brine pack	21	1956	0.75	1.21	1.06	1.48	0.11	21.0	17.7	25.6	1.89
28-oz. jar, brine pack	12	1956	0.72	1.17	1.02	1.35	0.08	24.7	23.0	27.2	1.33
	6	1956	0.72	1.04	0.97	1.15	0.06	22.0	20.6	23.4	0.88
	19	1958	LP	1.20	1.00	1.75	0.22	24.2	20.4	29.8	2.65
	30	1960	LP	1.13	0.94	1.36	0.12	22.9	17.0	25.8	2.38

TABLE 7—Summary of cucumber spear heating characteristics

Type of pack and container size	Heating rate (f_h) min.		Lag factor (j)	
	Average	1/1000(a)	Average	1/1000(a)
Syrup—16-oz. jar	40.1	53.3	1.57	2.23
Brine 16-oz. jar	21.0	26.8	1.21	1.55
Syrup—28-oz. jar	51.6	74.2	1.67	2.29
Brine—28-oz. jar	24.0	30.5	1.16	1.68
Syrup—No. 2 can	41.3	54.8	1.61	2.19

(a) The heating rate or lag factor is expected to exceed this value in only one jar out of 1,000.

times the corresponding standard deviation to give a heating rate and lag factor of that jar per thousand that will have the largest heating rate, f_h, and that jar that will have the largest lag factor, j. These or similar projected values should be used in designing the pasteurization process.

SUMMARY

Rates of heating, f_h, and lag factor, j, determined under both laboratory and commercial conditions, are presented for spears in brine and syrup in 16-oz. and 28-oz. glass containers and No. 2 metal cans. The data indicate that:

1. Syrup packs heat more slowly than brine packs, more slowly than would be predicted by considering the jar size or covering liquor effects alone.

2. Holding spears for 30 min. after packing and sealing does not significantly change the rate of heating.

3. Packs in which the cut surface faces out heat faster than packs with the skin side facing out.

4. The heating medium temperature affects the heating rate of spears in syrup.

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