

Technology Section

Pakistan J. Sci. Ind. Res., Vol. 14, Nos. 4-5, August-October 1971

UTILIZATION OF CORN-SUGAR IN CANNED VEGETABLES

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(Received September 1, 1970; revised November 24, 1970)

The effects of corn sugar (Cerelose brand) on the colour properties, texture qualities and flavour acceptability of five different canned vegetables were studied. Canned vegetables were processed with brine solutions containing various proportions of sucrose and Cerelose at two different levels of sugar solids (2.5 and 5.0%). Measurements of drained weight, texture and colour were made after the equilibration of the canned vegetables at 40°F and 90°F for various periods. The drained weights and shear press readings of certain vegetables were increased when corn sugar was used in the brine. Hunter colour values L (lightness), aL (redness) and bL (yellowness) of all the vegetables were affected when sucrose was replaced by dextrose in the brine. Dextrose caused slight to moderate effects when used at 25% replacement of sucrose and greater effects when used in quantities up to 100% replacement. The flavour of the canned vegetables was affected but little by the presence of dextrose in the brine.

Corn sugars are used extensively in canned fruits and fruit products. However, a relatively small amount of corn sugars are used in processing canned vegetables. Relatively little is known about the effects of corn sugar solids on the qualities of canned vegetables.

During the past few years new types and kinds of corn sugars are available. In view of this, a study was undertaken regarding the use of corn sugar (Cerelose brand) dextrose for processing canned vegetables. The object was to study the effects of corn sugar on the colour properties, texture qualities and flavour acceptability of canned vegetables.

Review of Literature.—Fellers *et al.*¹ reported the satisfactory use of dextrose in canned peas, beets and tomatoes. Canned sweet corn containing added dextrose became dark in colour and had a poor flavour. Dextrose was used advantageously in sweet pickles.

Elckelberg^{2,3} indicated that up to 50% replacement of sucrose by dextrose in canned peas and canned beets was acceptable. The use of Cerelose brand dextrose, reported by Fabian and Pivnic,⁴ as replacement of sucrose up to a certain percentage, did not affect consumer's acceptability of pickles.

Lopez *et al.*⁵ indicated that the addition of dextrose contributed to the normal flavour of sauerkraut.

Twigg⁶ reported on the use of two different corn syrups and dextrose as a partial replacement of sucrose in canned peas. A small difference in

sweetness of peas packed with corn syrup and with sucrose was noted.

Experimental

Processing Vegetables.—Five different vegetables—peas, sliced beets, lima beans, cut yellow wax beans and whole kernel corn were processed with two different series of sugar solutions consisting of proportions of sucrose/dextrose. The vegetables were processed in the commercial lines at different canneries in Wisconsin, U.S.A.

The corn sugar used for processing vegetables was Cerelose brand dextrose. Carefully weighed lots of canned vegetables were processed for determination of drained weights.

Sweeteners.—The compositions of the solutions used as brines and added to the canned vegetables prior to processing are shown in Table 1.

For vegetables other than corn, two types of sugar brines were prepared, containing sweeteners at the rate of 2.5 and 5.0% sugar solids. For whole kernel corn, sweeteners were used containing 5.4 and 7.0% solids respectively. Salt was added at the rate of 2.0% in the brine solution for peas, beets, lima beans, 1.0% in the brine for wax beans and was omitted for whole kernel corn. Measured amount of brines were added to the cans by a 'Flotron' dispenser prior to the addition of the vegetables.

Measurements.—The drained weights of the canned vegetables were measured according to the Almanac.⁷ The texture of the canned vege-

tables was measured by a L.E.E-Kramer shear press following the method of Kramer.⁹ The soluble solids content of the brine solutions used for processing vegetables were measured by a hand refractometer.

The colour of the canned vegetables, after different periods of storage at 40°F and 90°F was measured by a Hunter Colour and Colour Difference Meter Model D25 (Hunter⁸). The colorimeter values of the canned vegetables were also measured after they had been given steam table treatment for periods of 0, 1, 2, 4 hr at 180°F. The colorimeter was first standardized against a Hunterlab white colour plate No. 025-1300 and then standardized against respective Hunterlab colour plates.

The pH values of sugar solutions from the canned vegetables subjected to steam table treatment were measured.

The flavour of the canned vegetables was evaluated by a taste testing panel and rated by a hedonic scale with 9 to 1 points (Peryam).¹⁰ Five samples of the products including one control sample containing sucrose only, were presented to the judges (15 for each set) in a predetermined random order. Each judge evaluated the rating of the samples on a printed card. The evaluations were translated to numerical scores for analysis of variance.

If the F score for a group was significant, the mean preference scores of the samples were then analysed by a T-test, to determine which of the sample means were significantly different. The 0.05 level of significance was used.

Results and Discussion

The effects of dextrose on the physical stability of sugar solutions are illustrated in Table 2. The total solids of sugar solutions were decreased when dextrose was used in the 5.0% solids level. The pH values of 2.5% sugar solutions containing dextrose as replacement of sucrose were less when measured after heat treatment of the solution.

The drained weights and texture of the canned vegetables containing sucrose and dextrose in the brine were shown in Table 3. The drained weights of canned beets (2.5% solids level) and the shear press reading of wax beans were increased when dextrose was used.

Tables 4 and 5 show the soluble solids contents of the canned vegetables after storage at 40°F and 90°F. The results were relatively consistent for each treatment and were dependent apparently on the concentrations of sweetener in the brine, and characteristics of vegetables.

The Hunter Colour Meter values of canned vegetables are shown in Tables 6-10. The L (lightness) values of the vegetables except beets generally decreased when dextrose was used at 5.0% sweetener replacement of sucrose. The aL (redness) values of all the vegetables except wax beans were greater when dextrose was used in the brines at 75-100% replacement of sucrose, and the bL (yellowness) values generally were less.

TABLE 1.—COMPOSITION OF BRINE SOLUTIONS USED IN CANNED VEGETABLES.

Code	Proportions (solids basis)	Sucrose lb/88 lb	Dextrose lb/88 lb
1	100/0	2.20	
2	75/25	1.65	0.55
3	50/50	1.10	1.10
4	25/75	0.55	1.65
5	0/100	0.00	2.20
6	100/0	4.40	
7	75/25	3.30	1.10
8	50/50	2.20	2.20
9	25/75	1.10	3.30
10	0/100	0.00	4.40

^a Each solution used for peas, beets, lima beans, contained 2% sodium chloride; the solution used for wax beans contained 1% sodium chloride, the solution used for whole kernel corn contained no sodium chloride.

TABLE 2.—PHYSICAL PROPERTIES OF SUGAR SOLUTIONS.

Sugar solution	Proportions (solids basis)	Total solids (%)	Refractometer ^{ab} reading		pH ^{ab}		Transmittance ^{abc} (%)	
Sucrose	100/0	2.50	2.5	2.3	5.60	5.40	100.0	97.0
Sucrose/dextrose	75/25	2.50	2.0	2.0	5.45	4.65	98.0	97.0
	50/50	2.45	2.0	1.9	5.45	4.75	98.0	97.0
	25/75	2.50	1.9	1.9	5.40	4.65	98.0	97.0
	0/100	2.40	1.8	1.8	5.45	4.60	97.5	96.5
Sucrose	100/0	5.00	4.6	4.6	5.65	5.00	98.0	96.0
Sucrose/dextrose	75/25	4.95	4.4	4.4	5.65	4.55	98.5	96.0
	50/50	4.90	4.2	4.2	5.65	4.55	98.0	96.0
	25/75	4.80	4.1	4.1	5.60	4.50	97.0	96.0
	0/100	4.80	4.0	4.0	5.65	4.55	97.5	95.5

^{ab} Measurements made before^a and after^b heating the solutions. ^c Measurements made by Beckman spectrometer 20, at 525 m μ .

TABLE 3.—EFFECTS OF USE OF VARIOUS PROPORTIONS OF SUCROSE/DEXTROSE IN BRINE SOLUTIONS ON THE DRAINED WEIGHT AND TEXTURE OF CANNED VEGETABLES.

Sugar solution	Proportions (solids basis)	Beets		Lima beans		Wax beans		Whole kernel corn ^a
		DraINED weight(G) (average)	Shear press ^b (units) (average)	DraINED weight (G) (average)	Shear Press ^c (units) (average)	DraINED weight (G) (average)	Shear press ^d (units) (average)	DraINED weight(G) (average)
<i>2.5% Sugar solids</i>								
Sucrose (reference)	100/0	271.2	18.6	203.1	29.0	127.5	18.4	310.2
Sucrose/dextrose	75/25	274.0	20.8	206.2	29.8	128.4	19.6	309.6
	50/50	274.3	19.2	207.3	29.6	127.4	19.9	309.6
	25/75	274.3	19.8			127.8	19.8	308.8
	0/100	274.5	19.0			128.3	19.2	309.3
<i>5.0% Sugar solids</i>								
Sucrose (reference)	100/0	273.4	20.2			128.8	20.2	309.6
Sucrose/dextrose	75/25	271.1	21.0	195.3	31.0	129.3	23.0	311.4
	50/50	269.2	20.3	196.6	32.0	129.7	21.6	311.4
	25/75	272.9	20.6	198.1	29.8	127.7	21.4	310.2
	0/100	274.4	20.2	197.7	31.0	128.8	21.0	309.2

^a Sugar added at the rate of 5.4% and 7.0% sugar solids respectively; ^b Shear press setting: 3000 lb ring, 50/300 high scale, 35 second speed; ^{c,d} Shear press setting: 3000 lb ring, 50/300 low scale, 35 second speed.

TABLE 4.—SOLUBLE SOLIDS CONTENT IN BRINE OF CANNED VEGETABLES AFTER EQUILIBRATION AT 40°F FOR THREE MONTHS.

Sugar solution	Proportions (solids basis)	Refractometer reading as % sucrose ^a				
		Peas	Beets	Lima beans	Wax beans	Whole kernel ^b corn
<i>2.5% Sugar solids</i>						
Sucrose (reference)	100/0	7.8	8.6	8.0	5.2	10.4
Sucrose/dextrose	75/25	8.3	9.0	9.0	5.1	9.1
	50/50	8.3	8.8	8.7	5.0	9.9
	25/75	8.2	8.8	5.0	5.0	9.2
	0/100	8.2	8.4	8.7	5.0	9.5
<i>5.0% Sugar solids</i>						
Sucrose (reference)	100/0	9.4	8.2	10.0	6.5	8.7
Sucrose/dextrose	75/25	8.5	9.2	9.6	6.1	9.5
	50/50	8.6	9.0	9.5	6.0	9.6
	25/75	8.7	9.0	9.4	6.0	9.9
	0/100	8.8	9.0	9.4	6.0	8.4

^a Samples were composites of brine from 4-6 cans; ^b Sugar added at the rate of 5.4% and 7.0% sugar solids respectively.

TABLE 5.—SOLUBLE SOLIDS CONTENT IN BRINE OF CANNED VEGETABLES PREVIOUSLY STORED TWO MONTHS AT 90°F.

Sugar solution	Proportions (solids basis)	Refractometer reading as % sucrose ^a				
		Peas	Beets	Lima beans	Wax beans	Whole kernel corn
<i>2.5% Sugar solids</i>						
Sucrose (reference)	100/0	8.0	8.9	8.4	5.5	10.2
Sucrose/dextrose	75/25	8.6	8.7	9.0	5.1	10.6
	50/50	8.7	8.4	9.2	5.2	9.7
	25/75	8.2	8.5	8.7	5.1	8.8
	0/100	8.2	8.8	9.2	5.1	9.4
<i>5.0% Sugar solids</i>						
Sucrose (reference)	100/0	8.5	8.5	10.4	6.2	9.6
Sucrose/dextrose	75/25	8.6	9.6	10.0	6.3	10.0
	50/50	8.9	9.8	10.6	6.3	9.9
	25/75	8.9	9.6	10.0	6.1	10.6
	0/100	9.0	9.7	9.6	6.1	10.2

^a Samples were composites of brine from 4-6 cans.

TABLE 6.—HUNTER COLOUR VALUES^{ab} OF CANNED PEAS MEASURED AFTER STORAGE AT 40°F, AND 90°F, FOR DIFFERENT INTERVALS.

Sugar solution	Proportions (solids basis)	(0 months)			(40°F(3 months))			90°F (2 months)			90°F (7 months)		
		L	aL	bL	L	aL	bL	L	aL	bL	L	aL	bL
<i>2.5% Sugar solids</i>													
Sucrose (reference)	100/0	44.0	-3.2	19.0	43.3	-3.1	18.5	42.4	-2.4	18.6	42.5	-2.6	18.5
Sucrose/dextrose	75/25	41.6	-2.7	18.3	42.7	-3.0	18.3	42.1	-2.2	18.2	42.6	-2.4	18.7
	50/50	42.3	-2.5	18.3	41.6	-2.4	17.9	42.3	-2.1	18.2	42.0	-1.7	18.1
	25/75	41.6	-2.2	18.1	41.2	-2.4	17.9	41.5	-1.9	17.8	40.5	-1.3	17.5
	0/100	41.9	-2.4	17.9	40.4	-2.1	17.4	39.4	-1.4	16.9	41.2	-1.0	17.7
<i>5.0% Sugar solids</i>													
Sucrose (reference)	100/0	41.7	-2.6	18.2	41.8	-2.8	18.0	42.9	-2.5	18.4	43.6	-2.0	18.8
Sucrose/dextrose	75/25	42.6	-2.3	18.5	41.2	-2.6	17.8	42.1	-2.0	18.5	43.3	-2.0	18.8
	50/50	41.4	-1.8	18.1	40.8	-2.2	17.6	41.1	-1.5	18.2	42.0	-1.2	18.6
	25/75	39.9	-0.8	17.7	39.8	-1.3	17.3	39.5	-0.9	17.5	40.6	-0.3	18.2
	0/100	39.4	-0.4	17.7	39.3	-0.9	17.3	0.5	-0.5	17.7	39.3	-0.1	17.9

^a Values represent measurements on composites of 4-6 cans of vegetables; ^b Hunter colour reference standard No. 025 1303.

TABLE 7.—HUNTER COLOUR VALUES^{ab} OF CANNED BEETS MEASURED AFTER STORAGE AT 40°F and 90°F FOR DIFFERENT INTERVALS.

Sugar solution	Proportions (solids basis)	(0 months)			40°F(3 months)			90°F (2 months)			90°F (7 months)		
		L	aL	bL	L	aL	bL	L	aL	bL	L	aL	bL
<i>2.5% Sugar solids</i>													
Sucrose (reference)	100/0	14.4	13.4	1.7	17.4	19.4	5.1	16.9	13.9	1.9	15.4	14.1	2.8
Sucrose/dextrose	75/25	15.2	12.6	1.1	17.6	22.8	5.2	16.8	19.0	3.6	17.0	19.6	3.9
	50/50	14.7	14.8	1.6	17.8	23.5	5.4	17.6	16.6	2.5	16.0	18.2	3.4
	25/75	15.5	12.1	1.1	19.1	20.4	4.8	16.5	18.8	3.2	17.5	18.3	3.6
	0/100	15.2	14.1	1.8	18.6	24.5	5.9	15.7	15.0	1.8	19.1	17.7	3.4
<i>5.0% Sugar solids</i>													
Sucrose (reference)	100/0	16.0	14.9	2.5	17.8	23.4	5.3	14.4	15.0	2.1	16.8	19.2	3.5
Sucrose/dextrose	75/25	16.7	14.5	1.7	20.9	19.6	5.0	14.4	15.2	2.1	17.3	17.1	2.9
	50/50	16.7	12.0	1.1	17.4	22.5	5.2	14.9	15.1	1.6	16.7	18.4	3.1
	25/75	14.7	14.3	1.3	18.7	25.2	5.5	16.7	15.6	2.9	16.8	19.0	2.6
	0/100	15.6	13.3	1.1	17.8	25.5	5.4	15.3	14.7	1.2	17.3	18.2	2.0

^a Values represent measurements on composites of 4-6 cans of vegetables; ^b Hunter colour reference standard No. 025-1302.

TABLE 8.—HUNTER COLOUR VALUES ^{ab} OF CANNED LIMA BEANS MEASURED AFTER STORAGE AT 40°F, AND 90°F FOR DIFFERENT INTERVALS.

Sugar solution	×	Proportions (solids basis)	(0 months)			40°F (3 months)			90°F (2 months)			90°F (7 months)		
			L	aL	bL	L	aL	bL	L	aL	bL	L	aL	bL
2.5% Sugar solids														
Sucrose (reference)		100/0	49.5	-2.9	17.1	49.6	-2.7	18.0	48.8	-1.7	17.9	49.2	-1.5	18.6
Sucrose/dextrose		75/25	50.6	-2.5	18.2	51.6	-2.9	18.4	48.5	-1.4	18.2	50.3	-1.3	17.9
		50/50	50.0	-2.1	18.4	50.7	-2.5	18.6	49.3	-1.3	18.6	49.7	-0.9	17.8
		25/75	49.9	-1.9	18.2	50.3	-2.2	18.2	48.8	-0.5	18.7	48.6	-0.7	18.0
		0/100	49.6	-1.7	18.0	48.6	-2.1	18.4	47.5	0.0	18.3	46.5	-0.8	18.3
5.0% Sugar solids														
Sucrose (reference)		100/0	49.8	-3.1	18.1	49.1	-0.6	18.2	49.6	-1.8	18.6	49.6	-1.3	17.9
Sucrose/dextrose		75/25	50.4	-2.2	18.7	49.0	-0.8	18.5	49.3	-0.3	18.7	48.7	-0.1	18.0
		50/50	49.0	-1.0	18.3	49.1	-0.9	18.4	48.4	-0.3	18.6	46.9	1.0	17.9
		25/75	48.0	0.2	18.0	49.7	-1.7	18.3	46.3	1.5	17.9	47.1	2.0	17.6
		0/100	47.5	0.3	17.6	49.5	-1.9	18.3	49.6	1.9	17.8	44.3	3.0	17.3

^a Values represent measurements on composites of 4-6 cans of vegetables; ^b Hunter colour reference standard No. 025-1303.

TABLE 9.—HUNTER COLOUR VALUES ^{ab} OF CANNED WAX BEANS AFTER STORAGE AT 40°F AND 90°F, FOR DIFFERENT INTERVALS.

Sugar solution	Proportions (solids basis)	(0 months)			40°F (3 months)			90°F (2 months)			90°F (7 months)			
		L	aL	bL	L	aL	bL	L	aL	bL	L	aL	bL	
2.5% Sugar solids														
Sucrose (reference)		100/0	53.9	0.1	25.0	53.5	0.5	24.2	52.6	-0.2	23.6	56.6	1.0	25.4
Sucrose/dextrose		75/25	50.2	0.6	23.7	53.5	1.5	24.5	53.0	0.3	24.2	55.3	1.3	25.3
		50/50	52.0	-0.5	24.4	54.8	1.3	25.3	53.9	1.0	25.0	55.4	2.0	25.5
		25/75	51.6	-0.1	23.8	53.0	1.6	24.3	52.6	1.0	25.1	56.2	1.6	24.9
		0/100	51.7	0.1	23.9	55.0	1.4	25.2	52.9	1.4	24.6	54.3	2.2	25.3
5.0% Sugar solids														
Sucrose (reference)		100/0	52.1	0.4	24.4	55.5	1.1	26.6	53.2	1.4	25.2	53.4	1.4	24.4
Sucrose/dextrose		75/25	52.5	0.1	24.1	55.1	1.2	25.9	53.8	0.8	24.7	54.2	1.7	24.7
		50/50	53.2	-0.5	24.5	54.3	1.9	26.0	52.2	0.5	24.2	53.0	1.8	24.0
		25/75	52.3	0.0	24.4	52.8	2.1	24.6	52.0	1.3	23.9	53.9	1.8	24.5
		0/100	51.9	0.4	24.3	53.0	2.4	24.4	51.8	1.1	24.3	53.6	1.2	24.7

^a Values represent measurements on composites of 4-6 cans of vegetables. ^b Hunter colour reference standard No. 025-1304.

TABLE 10.—HUNTER COLOUR VALUES ^{ab} OF CANNED WHOLE KERNEL-CORN AFTER STORAGE AT 40°F AND 90°F AT DIFFERENT INTERVALS.

Sugar solution	Proportions (solids basis)	(0 months)			40°F (3 months)			90°F (2 months)			90°F (7 months)			
		L	aL	bL	L	aL	bL	L	aL	bL	L	aL	bL	
5.4% Sugar solids														
Sucrose (reference)		100/0	59.8	3.8	27.3	61.0	3.7	28.2	56.9	5.5	26.7	51.7	6.7	24.5
Sucrose/cerelose		75/25	56.9	4.5	26.3	57.1	4.5	27.3	55.3	5.8	23.7	56.2	7.4	25.7
		50/50	57.9	4.3	26.0	56.8	4.8	26.9	55.2	6.7	24.5	53.9	6.7	25.5
		25/75	56.3	5.0	25.5	55.5	5.3	27.1	55.4	6.9	25.0	51.7	6.5	24.1
		0/100	55.7	4.8	24.8	55.3	5.1	26.4	53.9	6.6	24.0	50.5	7.2	24.2
7.0% Sugar solids														
Sucrose (reference)		100/0	60.1	3.8	27.5	59.8	3.5	26.9	58.0	5.3	25.3	54.5	6.1	25.5
Sucrose/cerelose		75/25	57.0	3.9	24.9	56.8	4.2	26.2	56.4	5.5	25.6	52.3	6.0	24.2
		50/50	56.4	4.4	24.7	56.3	4.2	25.5	53.5	6.3	24.7	52.2	6.7	23.1
		25/75	55.5	4.8	24.8	54.7	4.1	25.3	53.5	6.2	24.0	50.5	7.0	24.6
		0/100	53.8	5.7	24.5	53.5	4.9	24.5	53.3	5.9	24.4	51.1	5.9	24.4

^a Values represent measurements on composites of 4-6 cans of vegetables; ^b Hunter colour reference standard No. 025-1304.

TABLE II.—EVALUATION OF FLAVOUR OF CANNED VEGETABLES CONTAINING VARYING PROPORTIONS OF SUCROSE AND CORN SUGAR IN THE BRINE.

Peas					Beets					Lima beans							
(a)	5	4	3	2	1	(a)	2	3	1	5	4	(a)	1	4	5	2	3
(b)	5.40	6.13	6.33	6.40	6.67	(b)	5.53	5.67	5.80	5.50	5.93	(b)	4.33	5.00	5.33	5.47	5.67
(a)	10	9	7	8	6	(a)	6	7	10	8	9	(a)	9	10	7	6	8
(b)	4.13	5.07	5.93	6.07	6.07	(b)	4.20	5.07	5.33	5.40	5.74	(b)	4.20	4.60	4.87	5.33	5.73
Wax beans					Whole kernel corn												
(a)	5	1	3	2	4	(a)	4	1	5	3	2						
(b)	5.33	5.47	5.47	5.60	5.60	(b)	5.20	5.73	5.80	5.87	6.20						
(a)	9	8	6	7	10	(a)	10	9	7	8	6						
(b)	4.87	4.93	5.20	5.53	5.53	(b)	5.00	5.07	5.07	6.00	6.00						

^a Indicates sample code numbers as outlined in Table 1. ^b Indicates mean preference score for each sample in each group arranged in increasing order of preference (larger number indicates greater preference). ^c Values underlined by the same line are not significantly different from each other. Values not so underlined are significantly different at the .05 level.

Hunter colour values of all the canned vegetables subjected to steam table treatment were affected significantly by the presence of dextrose in the brine. The effects were greater when replacements of sucrose were greater. The flavour of canned vegetables was affected but little by the presence of dextrose in the brine (Table II).

The quality of vegetables packed with brines containing up to 50% replacement of sucrose with corn sugar was approximately equivalent to those packed with brines containing only sucrose.

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