THE INVERSION OF CANE SUGAR IN SOME OF THE SYRUPS OF THE UNITED STATES PHARMACOPOEIA

BY

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A study of the inversion of cane sugar in some of the syrups of the United States Pharmacopoeia was reported by F. W. Haussman in the American Journal of Pharmacy. (1) The results given by Mr. Haussman were not altogether what would be expected, and it is only to be questioned why work of this nature has not been undertaken sooner. The inversion of cane sugar in aqueous solutions by various chemical substances has long been known and thorough study has been made in various directions.(2)

Dr. Kahlenberg in a review of Mr. Haussman's work suggests the carrying of the work still further with several modifications. The work reported on was done primarily to note the amount of inversion during the warm weather of the summer. No comparative rate was noted, as to whether inversion was less than in the summer or absent altogether. It was thought advisable to embody this modification in this series of work.

Three samples of a syrup prepared at one time were exposed under different conditions as to temperature. One sample was kept in a refrigerator (lowest 7.9 ; highest 12.0, mean average 9.95 .) A second sample was exposed to the room

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1. Am. Journal of Pharmacy, 70,p. 585.
2. Pharmaceutical review, 17, p. 11.

temperature (lowest 15.5 ; highest 23.7, mean average 19.6). The third sample was kept in a thermostat at a temperature higher than the highest summer temperature (lowest 32.0; highest 35.0 ; mean average 33.5). All samples were kept in well filled glass stoppered bottles. The samples in the refrigerator and thermostat in the dark, and the samples in the room were exposed to very weak diffused sunlight.

The second modification in carrying on the work, was in the use of a polariscope graduated to read sugar percentages direct(saccharometer)- Schmidt and Haensch- instead of determining the amount of inverted sugar by means of Fehling's Solution. Only those syrups which were clear and colorless or nearly so could be examined in this manner, but the number of readings upon each syrup was very greatly increased over that by the Fehling's Solution method. Readings were taken in a 50 mm. tube because of the high rotation in longer tubes. The direct readings are given as dilutions could not be made to correct concentration errors.

The series of experiments has demonstrated nothing new in the line of sugar inversion; but does show that nearly all of the medicated syrups undergo inversion more or less complete

in a comparatively short space of time; and that the ordinary precaution "keep in a cool place" does not prevent, and only ineffectually retards the change to a slight degree. None of the syrups by being tightly stoppered and kept well filled, fermented. Under those conditions it would not seem at all necessary to keep syrups(those included in the following experiments) in the cold.

In all the syrups containing neither acids nor salts, practically no inversion occured. As those are used primarily as diluents or vehicles not much importance is attached to them. In all syrups containing acids or salts inversion more or less did take place. Time has been too short to prepare syrups containing glucose, for comparative study of each separate syrup.

Experimental Part.

Simple Syrup.

Simple syrup was prepared by the second method given in the United States Pharmacopoeia for observation as to inversion and also for the preparation of other syrups. No change was observed in the syrup.

Table I.

Date.	4/6	4/8	4/11	4/13	4/15	4/20	4/22	4/27	4/29	5/6	5/16
Th.	83.8	83.	84.3	84.3	84.	84.	84.	84.	84.	82	80
R. T.	83.8	83.5	84.	83.9	84.	84.	84.	84.	84.	84.	82.
Ref.	83.8	83.5	83.5	83.5	83.5	83.5	83.5	83.5	83.5	83.	83.

Syrup of Acacia.

Syrup of acacia did not change to any appreciable extent during the three months during which the observations were extended. The last few readings indicated a slight amount of inversion in the thermostat sample.

Table II.

Date.	4/13	4/15	4/18	4/20	4/22	4/27	4/29	5/6	5/16	5/27
Th.	53.	53.3	53.	53.	53.	53.	48.	44.	40.	40.
R. T.	53.	53.	53.	53.	53.	53.	53.	53.	53.	53.
Ref.	53.	53.	53.	53.	53.	53.	53.	53.	53.	53.

Syrup of Orange Flowers.

Syrup of orange flowers is practically the same as simple syrup. The samples employed were prepared by the second process of the United States Pharmacopoeia. Slight decrease in cane sugar percentage was observed after long standing in the thermostat.

Table III.

Date.	4/8	4/11	4/13	4/15	4/20	4/22	4/27	4/29	5/6	5/16	5/27
Th.	67.7	67.2	67.	67.	67.	67.	67.	66.8	66.	66	65.
R. T.	67.	67.	67.	67.	67.	67.	62.	67.	57.	55.	57.
Ref.	67.7	67.7	67.7	67.7	67.	67.	67.	66.	67.	65.	65.

Syrup of Althaea.

Syrup of althaea showed practically no change at all as to inversion, a slight deepening of color was observed together with a slight precipitate.

Table IV.

Date.	4/15	4/18	4/20	4/22	4/27	4/29	5/6	5/18	5/27
Th.	64.	64.	64.	64.	64.	64.	64.	64.	63
R. T.	64.	64.	64.	64.	64.	64.	64.	64.	64.
Ref.	64.	64.	64.	64.	64.	64.	64.	64.	64.

Syrup of Orange.

Syrup of orange showed no change during a period of two months. Some trouble was experienced in readily obtaining a clear preparation.

Table V.

Date.	4/22	4/25	4/27	4/29	5/6	5/16	5/27
Th.	—	—	61.	60.7	60.	60.	59.
R. T.	62.	62.	62.	61.	60.	60.	60.
Ref.	—	—	61.	60.5	60	60.	60.

Syrup of Tolu.

Syrup of tolu was easier to prepare than the preceding syrup, but did not show any inversion at all.

Table VI.

Date.	4/11	4/13	4/15	4/18	4/20	4/22	4/27	4/29	5/6	5/16	5/27
Th.	—	69.5	71.	71.	71.	71.	70.	70.	70.	70.	70.
R. T.	72.3	70.5	71.	70.5	71.	71.5	71.5	71.5	70.5	70.	70.
Ref.	—	72.	72.	71.	71.	71.5	71.5	71.5	70.5	70.	70.

Syrup of Lime.

Syrup of Lime was prepared to observe the change in a syrup having an alkaline reaction. No change was observed, as would naturally be expected, there being no inverting agent.

Table VII.

Date.	4/25	4/27	4/29	5/1	5/6	5/16	5/27
Th.	—	27.	27.	27.	27.	27.	27.
R. T.	27.	26.5	27.	27.	27.	27.	27.
Ref.	—	27.	27.	27.	27.	27.	27.

Syrup of Citric Acid.

Syrup of Citric acid furnishes the first example of a syrup containing an acid and consequently shows inversion. The inversion is rapid in the sample exposed to the thermostat temperature and less in that at the room temperature, and barely started in the refrigerator. The sample in the thermostat also became turbid, the material increased and gradually settled as a flocculent precipitate.

Table VIII.

Date.	4/6	4/8	4/11	4/13	4/15	4/18	4/20	4/25	4/27	4/29	5/1	5/6
Th.	—	63.8	53.1	50.2	46.	42.	34.8	26.	24.	21	8	—
R. T.	69.6	66.	65.	66.	66.	66.3	66.	66.	66.	65.	60	60.
Ref.	67.4	67.4	67.4	68.	67.2	68.	68.	68.	68.	68.	63.	63.

Syrup of Hydriodic Acid.

Syrup of Hydriodic acid furnished an example of rapid and almost complete inversion, irrespective of where the syrup was kept. Cold retarded the syrup but a very short space of time. A slight brownish color developed in all samples, but was not due to free iodine, as all tests for its presence resulted negatively.

Table IX.

Date.	4/11	4/13	4/15	4/16	4/20	4/22	4/25	4/27	4/29	5/6	5/16	5/27	5/29
Th.	—	20	20	20	20	16.8	17.	17.	15.	15.	15.	16.	16.
R. T.	23	16	12.	13.5	18.	20.	19.	22.	22.	22.	22.	22.	24.
Ref.	13	14.	9.8	12	7.	14.	13.	13.	16.	18	23.	23.	23.

Syrup of Ferruus Iodide.

Syrup of Ferrousiodide showed inversion to some extent, but owing to an accident to the first sample prepared, the period of observation is considerably shorter than in the case of the other samples. It is long enough however to show that inversion does take place in the sample kept in the refrigerator. The sample kept in the cold changed but through one percent mark. Inversion here is evidently due to dissociation of Ferrous Iodide. No free iodine was detected.

Black figures indicate Dextro-ratation.
Red figures indicate Levo-rotation.

Table X.

Date.	4/27	4/28	4/29	5/4	5/16	5/27
Th.	—	49.	45.	40.	22.	19.
R. T.	49.	49.	49.	49.	47.	45.
Ref.	—	49.	49.	49.	48.	48.

Syrup of the Phosphates, Iron, Quinine and Strychnine.

This complex syrup began to invert, and in less than two weeks inversion was nearly complete in all samples. Not much change in color was observed, but the darkening had begun to some extent.

Table XI.

Date.	4/8	4/10	4/13	4/15	4/18	4/21	4/22	4/25	4/27	4/29	5/6	5/16	5/27
Th.	—	21.	24.	24.	24.	24.	24.	24.	24.	24.	24.	24.	26.
R. T.	39.8	29.	19.	10.	4.	2.8	8.	14.	14.	18.	19.	20.	24.
Ref.	—	37.	35.	31.7	27.	25.	19	15.	15.	14.6	14.5	20.	22.

Syrup of Squills.

Syrup of Squills showed rapid inversion at the thermostat temperature, but very slow at the room and refrigerator temperature.

Table XII.

Date.	4/8	4/11	4/13	4/15	4/18	4/20	4/22	4/27	4/29	5/6	5/16	5/27
Th.	—	54.3	51.	50.	38.2	36.2	33.	24.	20.	10.	—	—
R. T.	70	68.6	68.5	68.3	68.2	68.	68.	68.	67.3	65.	64.	61.
Ref.	—	70	67.6	70.	70.	69.3	69.3	69.3	69.2	68.	64.	65.

Syrup of Calcium Lactophosphate.

Syrup of Calcium Lactophosphate containing both lactic and phosphoric acids, inverted rapidly in the thermostat, and less so under the other two conditions but more rapidly than the preceding syrup.

Table XIII.

Date.	4/8	4/15	4/18	4/20	4/22	4/25	4/27	4/29	5/6	5/16
Th.	—	6.	13.	16.	20.	21.	20.	22.	20.	20.
R. T.	61.	56.	53.	50.	45.	42.	39.	30.	24.	18.
Ref.	—	59.	58.5	55.	55.	55.	55.	50.	45.	43.

Syrup of Hypophosphites.

Syrup of hypophosphites having a large amount of salts of, and some free hypophosphorus acid present does not invert rapidly under any of the three conditions.

Table XIV.

Date.	4/30	4/2	4/25	4/27	5/4	5/6	3/16	3/27
Th.	—	43.	43.	43.	43.	40.	40.	39.
R. T.	44.3	43.	43.	44.	44.	43.5	43.	42.
Ref.	—	43.	43.	44.	44.	44.	42.	43.

Syrup of Hypophosphites of Iron.

This syrup does not invert much more than the syrup of hypophosphites from which it is prepared. There is hardly any inversion under any of the three conditions.

Table XV.

Date.	4/8	4/11	4/13	4/15	4/18	4/20	4/22	4/27	4/29	3/6	3/16	3/27
Th.	—	43	43	42.2	42.	42.	44.	44.	44.	44.	42.5	42.
R. T.	53.	48.	46.	46.	46.	46.	46.	46.	46.	46.	45.	43.
Ref.	—	45.	46.6	46.	45.8	46.	46.	46.	46.	46.	46.	46.

The following compilation indicates the syrups official in the different revisions of the United States Pharmacopoeia.

Syrupus:	'30.	'40.	'50.	'60.	'70.	'80.	'90.
Syrupus Acaciae	X	X	X	X	X	X	X
Syrupus Aceta	X	—	X	X	X	X	X
Syrupus Allii	X	X	X	X	X	X	X
Syrupus Aurantii Cortecio	X	X	X	X	X	—	—
Syrupus Colchici	X	—	—	—	—	—	—
Syrupus Limonis	X	—	X	X	X	X	—
Syrupus Rhei	X	X	X	X	X	X	X
Syrupus Rhei Aromaticus	X	X	X	X	X	X	X
Syrupus Rhei et Sennae	X	—	—	—	—	—	—
Syrupus Sarsaparilla	X	—	—	—	—	—	—
Syrupus Scillae	X	X	X	X	X	X	X
Syrupus Senegae	X	X	X	X	X	X	X
Syrupus Zingiberis	X	X	X	X	X	X	X
Syrupus Acidi Citrici	—	X	X	X	X	X	X
Syrupus Amygdalae	—	X	X	X	X	X	X
Syrupus Ipecacuanhae	—	X	X	X	X	X	X
Syrupus Krameriae	—	X	—	X	X	X	X

	'30.	'40.	'50.	'60.	'70.	'80.	'90.
Syrupus Pruni Virginianae.	—	—	x	x	x	x	x
Syrupus Sarsap. Comp.	—	x	x	x	x	—	—
Syrupus Scillae Comp.	—	x	x	x	x	x	x
Syrupus Sennae	—	x	x	—	—	x	x

Table XVII.

Date.	Th	R.T.	Ref.
Mar. 29.	32.5	15.7	7.9
" 30.	33	15.7	8.1
" 31.	33.	16.9	8.5
Apl. 1.	32.3	—	8.9
" 3.	—	17	—
" 4.	33.	15.5	9.8
" 5.	33.	16.5	9.5
" 6.	33.	16.7	9.5
" 7.	32.5	16.7	9.3
" 8.	32.4	16.2	8.7
" 10.	32.3	17.5	8.5
" 11	33.	18.2	10.2
" 12	33.	17.9	10.2

apl. 13.	33.3°	18.3	10.
" 14.	33.8	18.9	10.
" 15.	33.7	17.9	10.2
" 17.	33.7	17.9	10.
" 18.	33.5°	18.2	9.3
" 19.	33.	18.	9.9
" 20.	34.	18.5°	10.2
" 21.	32.1	19.8	13.5°
" 22.	32.	18.5	10.6°
" 24.	33.	20.3	9.9
" 26.	32.5°	20.	9.2
" 27.	33.2	18.5°	11.3
" 28.	34.2	21.	9.8
" 29.	32.	20.4	10.6
May 1.	33.	21.	9.7
" 2.	33.5°	19.	10.2
" 3.	34.1	20.9	10.7
" 4.	33.6	20.1	9.9

May 5.	34.2	19.3	10.4
" 6.	34.	18.4	9.6.
" 8.	34.2	18.	9.2
" 9.	34.	18.5	9.5
" 10.	34.1	18.9	9.9
" 12.	35	18.1	8.5
" 13.	34.7	20.	9.
" 15.	34.2	19.2	8.9
" 16.	33.9	19.6	9.1
" 17.	33.7	18.3	9.1
" 18	34.3	18.1	10.
" 20.	33.5	17.	9.5
" 22.	33.8	18.5	9.8
" 23	33.6	19.	9.9
" 24	34.	17.	7.6
" 25	34.	—	7.7
" 26.	33.5	18.4	10.
" 27.	32.8	20.4	9.4

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