[CONTRIBUTION FROM THE FRUIT PRODUCTS LABORATORY, UNIVERSITY OF CALIFORNIA]

THE EFFECT OF SEVERAL FACTORS ON THE SOLUBILITY OF TARTRATES

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During investigations on the removal of tartrates from certain grape products, it became necessary to determine the solubility of tartrates under certain conditions. Potassium bi-tartrate and neutral calcium tartrate were the salts particularly concerned.

A review of the literature indicates that considerable data already exist on tartrate solubilities, although much of the data desired in our studies could not be found in published form.

The change of solubility with temperature has been determined for the range from 0 to 100°[1] for both salts. Solubilities in the presence of certain ions and in certain acids have been determined to some extent. The published data indicate that ions common to the salt concerned usually depress the solubility, and that neutral ions have little effect on the solubility.

No information could be found on the effect of neutral potassium tartrate on the solubility of potassium bi-tartrate. In this case the added salt has two ions in common with the salt studied. It would be expected that the solubility of the potassium bi-tartrate would be decreased to an appreciable extent by the presence of neutral potassium tartrate. The results tabulated below and shown in Fig. 1 indicate this to be the case to a very marked degree, especially at the lower concentrations of the neutral tartrate.

TABLE I

SOLUBILITY OF $KHC_4H_4O_6$ IN THE PRESENCE OF $K_2C_4H_4O_6$ AT 20°

Mole of $KHC_4H_4O_6$/liter	Mole of $K_2C_4H_4O_6$/liter	Mole of $KHC_4H_4O_6$/liter	Mole of $K_2C_4H_4O_6$/liter
0.0284	0	0.00667	0.00443
.0218	0.000443	.00540	.00714
.0176	.000886	.00360	.0143
.0124	.00177	.00280	.0214
.0096	.00266	.00264	.0286
.00805	.00354	.00260	.0357

The fact that very small concentrations of neutral tartrate greatly affect the solubility of the bi-tartrate may explain the formation of large deposits of cream of tartar in juice from mature grapes, and in grape juice after standing for some time, since under these conditions the acidity is decreased, forming the neutral tartrate which depresses the solubility of the remaining bi-tartrate.

[1] Seidell, "Solubilities of Inorganic and Organic Compounds," Vol. I, pp. 221, 564.

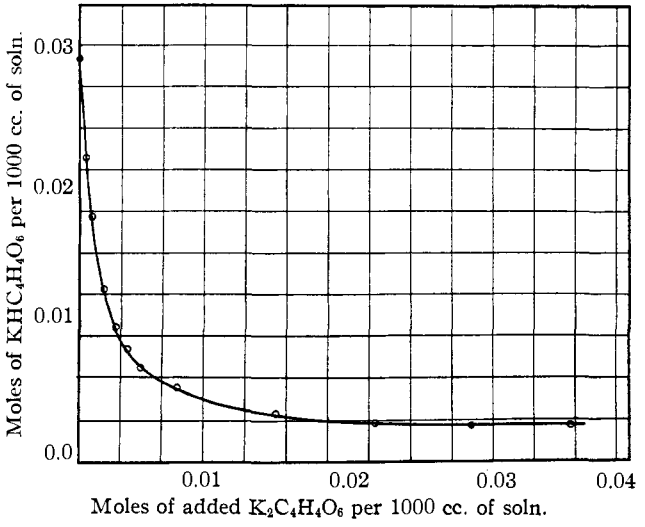

Fig. 1.—The effect of $K_2C_4H_4O_6$ on the solubility of $KHC_4H_4O_6$ in water at 20°.

Tartaric acid was found to have some effect on the solubility of potassium bi-tartrate in concentrations up to about 0.01 mole per liter. This is shown in Table II and Fig. 2.

TABLE II

SOLUBILITY OF $KHC_4H_4O_6$ IN TARTARIC ACID SOLUTIONS AT 20°

Mole of $KHC_4H_4O_6$/liter	Mole of $H_2C_4H_4O_6$/liter
0.0284	0
.0268	0.0030
.0260	.0055
.0240	.0105
.0238	.0335
.0238	.0485

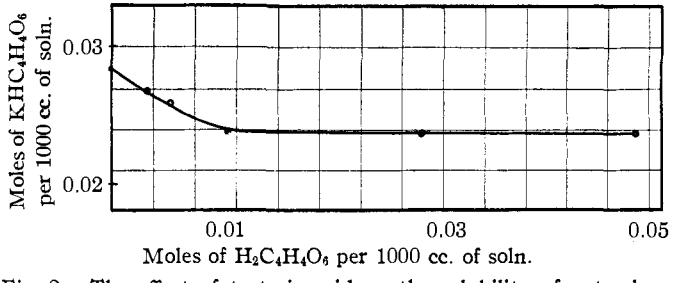

Fig. 2.—The effect of tartaric acid on the solubility of potassium bi-tartrate in water at 20°.

From the data of Table II considered in comparison with Table I, it would seem that the effect of tartaric acid is due chiefly to the ions produced, rather than to the tartaric acid molecule itself.

The solubility of potassium bi-tartrate was also determined in invert sugar solutions. The results appear in Table III and in the solid curve of Fig. 3.

TABLE III

SOLUBILITY OF $KHC_4H_4O_6$ IN INVERT SUGAR SOLUTIONS AT 20°

Soly. of $KHC_4H_4O_6$ in mole per liter	Soly. of $KHC_4H_4O_6$ in mole per 1000 g. soln.	Percentage invert sugar by weight
0.0284	0.0284	0
.0276	.0260	15
.0264	.0232	30
.0240	.0198	45
.020	.0155	60
.0124	.0087	80

TABLE IV

SOLUBILITY OF CALCIUM TARTRATE IN TARTARIC ACID SOLUTIONS

Mole of $H_2C_4H_4O_6$ per liter	Mole of $CaC_4H_4O_6$ per liter at 20°	Mole of $CaC_4H_4O_6$ per liter at 18° (Paul, 1915)[a]
0	0.00253	0.00244
0.0067	0.00399	.00350
.0134	....	.00445
.0268	.00677	.00581
.0402	....	.00678
.0469	.00810	....
.0536	....	.00758
.0670	.00910	.00848

[a] Ref. 1, pp. 221, 222.

The dotted line in the curve indicates the theoretical solubility curve, if the solvent action were due solely to the water present. Thus it can be

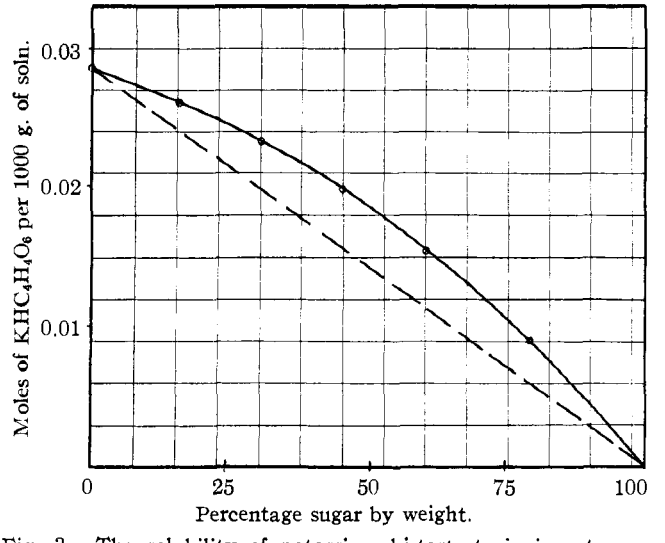

Fig. 3.—The solubility of potassium bi-tartrate in invert sugar solutions at 20°.

seen that the presence of the sugar has a slight solvent action on the potassium bi-tartrate.

For calcium tartrate the solubility in hydrochloric and tartaric acids[2] has been determined for 18°. The solubility in tartaric acid solutions was

[2] Ref. 1, pp. 221, 222.

determined for 20° and the results are given in Table IV and in Fig. 4. The two curves seem to agree quite well.

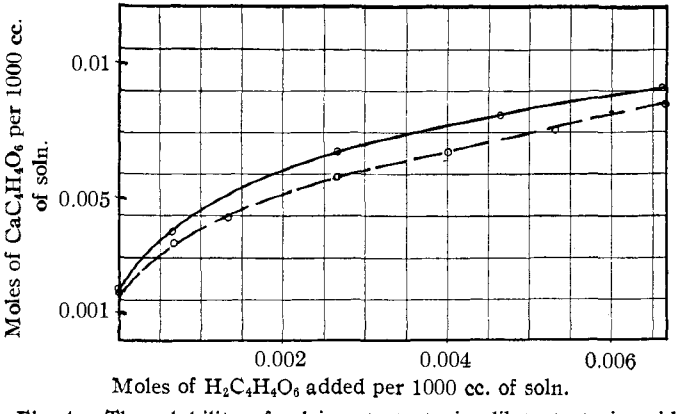

Fig. 4.—The solubility of calcium tartrate in dilute tartaric acid solutions: solid line is solubility at 20°; dotted line is solubility at 18° (Ref. *a*, Table IV).

Method of Analysis.—In all cases the salt of which the solubility was to be determined was added to the solution in excess. The mixture was stirred for at least an hour with a mechanical stirrer, and allowed to settle for several hours at 20° before filtering and analyzing. No precaution was taken to exclude the presence of carbon dioxide from the air, but since the solutions were all acid it was believed that carbon dioxide would have little effect. All of the data for the potassium bi-tartrate were obtained by titration with $N/10$ sodium hydroxide. For the calcium tartrate solubilities, ash determinations were made on the solutions.

Summary

The solubilities of potassium bi-tartrate in the presence of some of the substances with which it is associated in grape juice were determined. Some of these, especially the neutral tartrate, have a rather striking effect on the solubility of the bi-tartrate and this fact may help to explain the rather peculiar behavior of cream of tartar in grape juice.

Some solubility data on calcium tartrate were obtained which seem to agree well with previously published data.

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