BARTEK

Technical Bulletin

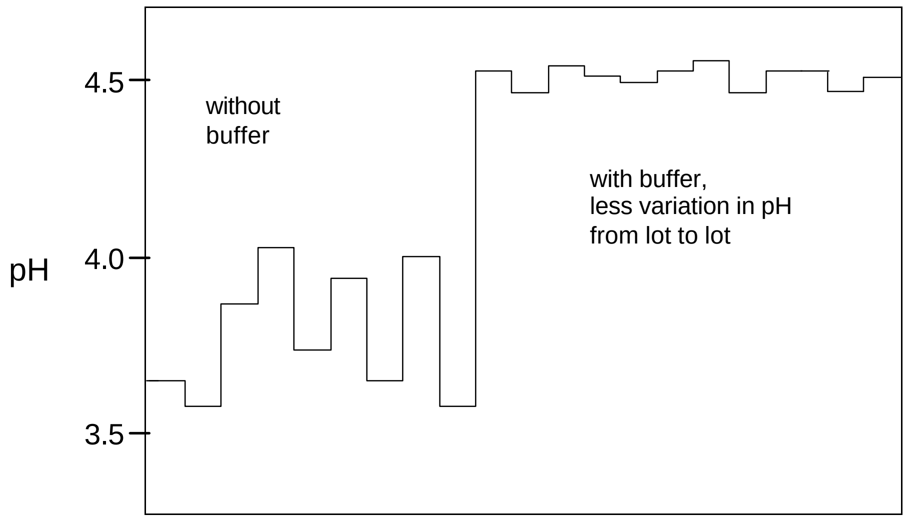
Buffer Salt/Malic Acid Combinations

I. Introduction

A buffer is a partially neutralised acid that resists changes in pH. Typical buffer salts used in food and beverage applications include Sodium Citrate and Sodium Lactate.

Different combinations of acids and buffer salts can be used as buffers, for example, Malic Acid with Sodium Lactate.

Buffers reduce the variation in the pH of an end-product, as shown in the graph to the right. pH variation is detrimental to consistent quality.



Why use buffers? Buffers are used specifically to:

- Reduce flavour variation from two pH effects:
    - changes in intensity of flavour chemicals with pH
    - changes in sourness, sweet/sour balance
- Decrease variation in shade of natural pigments
- Control gelling in pectin-based products
- Reduce variation in texture from lot to lot.

The **Buffer Salt/Malic Acid weight ratios** in this bulletin are used to determine the weight ratio of buffer salt to Malic Acid required to achieve a specific pH, or conversely, to determine the pH of a specific weight ratio of a buffer salt and Malic Acid. This information can be used to:

- accelerate the development of beverages and confectionery products, since product formulations which yield the desired pH can be developed faster.
- compare alternate buffer salts in terms of the amount required to achieve a specific pH.

For more information: Bartek Ingredients Inc. • 421 Seaman St. • Stoney Creek, Ontario L8E 3J4 • Canada
Tel: (905) 662-3292 • (905) 662-1127 • Order desk: 1-800-263-4165 • Fax: (905) 662-8849
www.bartek.on.ca • sales@bartek.on.ca

II. Explanation of Table, page 3

To achieve a specific pH, first find the desired pH in the top or bottom row and then find the ratios which correspond to it by moving vertically. For example, to achieve a pH of 4.0 with citrates, either 1.04 kg of Potassium Citrate could be used with 1.0 kg of Malic Acid, or 0.94 kg of Sodium Citrate could be used with 1.0 kg of Malic Acid.

III. Examples

CANDY APPLICATION. Compare Sodium Acetate, Sodium Citrate, and Sodium Lactate in terms of the amount needed to achieve a pH of 4.5 with 1% Malic Acid (for a candy product).

As shown in the table, 1.16% Sodium Acetate, 1.51% Sodium Citrate, and 4.51% Sodium Lactate are required to achieve a pH of 4.5 with 1% Malic Acid. The potassium salts require slightly more than the sodium salts due to their higher molecular weights.

BEVERAGE APPLICATION. Compare Potassium Citrate, Potassium Lactate, and Tripotassium Phosphate in terms of the amount required to achieve a pH of 3.7 with 0.1% Malic Acid (for a beverage).

0.076% Potassium Citrate, 0.105% Potassium Lactate, and 0.053% Tripotassium Phosphate are required to achieve a pH of 3.7 with 0.1% Malic Acid. The values from the table are multiplied by 0.1 in this case.

BEVERAGE APPLICATION. A noncarbonated beverage which contains Malic Acid, Sodium Benzoate, and Potassium Sorbate and has a pH of 3.3 will be aseptically processed in the future in order to eliminate the two preservatives. Potassium Citrate will be used as a buffer salt to replace the two preservatives. If the beverage contains 0.15% Malic Acid, what level of Potassium Citrate would be used to achieve the same pH?

The weight ratio of Potassium Citrate to Malic Acid at pH 3.3 is 0.39. Therefore, 0.39 x 0.15%, or 0.059% Potassium Citrate would be used as a starting point. If this is too sour, the levels of Malic Acid and Potassium Citrate can be reduced while maintaining the same weight ratio between them. In this way, the pH will remain at 3.3.

Weight Ratios of Buffer Salt/Malic Acid Combinations at Various pHs at 25°C.

↓Buffer Salt↓ pH→	2.9	3.0	3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.8	3.9	4.0	4.1	4.2	4.3	4.4	4.5	4.6	4.7	4.8	4.9	5.0	5.1	5.2	5.3	5.4	5.5	5.6	5.7	5.8	5.9
Calcium Acetate, anhyd., $C_4H_6CaO_4$, mol wt 158.17	0.08	0.15	0.25	0.36	0.46	0.56	0.66	0.75	0.85	0.95	1.06	1.19	1.33	1.50	1.70	1.94	2.23	2.57	2.99	3.49	4.09	4.82	5.70	6.77	8.06	9.63	11.5	13.8	16.6	20.0	24.2
Sodium Acetate, anhyd., $C_2H_3NaO_2$, mol wt 82.03	0.04	0.08	0.13	0.18	0.24	0.29	0.34	0.39	0.44	0.49	0.55	0.61	0.69	0.78	0.88	1.01	1.16	1.34	1.55	1.81	2.12	2.50	2.96	3.51	4.18	4.99	5.98	7.18	8.63	10.4	12.5
Zinc Acetate, dihydrate, $C_4H_6O_4Zn{\cdot}2H_2O$, mol wt 219.50	0.11	0.21	0.35	0.49	0.64	0.78	0.91	1.04	1.17	1.32	1.47	1.64	1.85	2.08	2.36	2.70	3.10	3.57	4.15	4.84	5.68	6.69	7.91	9.39	11.2	13.4	16.0	19.2	23.1	27.8	33.5
Potassium Benzoate, $C_7H_5KO_2$, mol wt 160.22	0.09	0.16	0.26	0.37	0.49	0.62	0.74	0.87	1.01	1.17	1.35	1.58	1.85	2.18	2.59	3.10	3.73	4.52	5.49	6.70	8.18	10.0	12.2	14.9	18.1	21.9	26.5	31.8	37.9	44.9	52.9
Sodium Benzoate, $C_7H_5NaO_2$, mol wt 144.11	0.08	0.15	0.24	0.34	0.44	0.55	0.67	0.78	0.91	1.05	1.22	1.42	1.66	1.96	2.33	2.79	3.36	4.06	4.94	6.02	7.36	8.99	11.0	13.4	16.3	19.7	23.8	28.6	34.1	40.4	47.6
Potassium Citrate, hydrate, $C_6H_5K_3O_7{\cdot}H_2O$, mol wt 324.41	0.07	0.13	0.21	0.29	0.39	0.48	0.58	0.67	0.76	0.85	0.94	1.04	1.14	1.25	1.37	1.51	1.66	1.83	2.02	2.24	2.48	2.74	3.04	3.37	3.73	4.13	4.56	5.04	5.55	6.11	6.71
Sodium Citrate, dihydrate, $C_6H_5Na_3O_7{\cdot}2H_2O$, mol wt 294.10	0.07	0.12	0.19	0.27	0.35	0.44	0.52	0.60	0.69	0.77	0.85	0.94	1.03	1.13	1.25	1.37	1.51	1.66	1.83	2.03	2.24	2.49	2.75	3.05	3.38	3.74	4.14	4.57	5.03	5.54	6.08
Calcium Lactate, anhyd., $C_6H_{10}CaO_6$, mol wt 218.22	0.11	0.23	0.39	0.58	0.79	1.01	1.24	1.50	1.80	2.15	2.58	3.11	3.78	4.63	5.71	7.07	8.77	10.9	13.5	16.7	20.6	25.2	30.5	36.6	43.4	50.8	58.6	66.6	74.6	82.2	89.1
Potassium Lactate, anhyd., $C_3H_5KO_3$, mol wt 128.18	0.07	0.14	0.23	0.34	0.46	0.59	0.73	0.88	1.05	1.26	1.51	1.83	2.22	2.72	3.35	4.15	5.15	6.40	7.95	9.83	12.1	14.8	17.9	21.5	25.5	29.8	34.4	39.1	43.8	48.3	52.3
Sodium Lactate, anhyd., $C_3H_5NaO_3$, mol wt 112.07	0.06	0.12	0.20	0.30	0.41	0.52	0.64	0.77	0.92	1.10	1.32	1.60	1.94	2.38	2.93	3.63	4.51	5.60	6.95	8.60	10.6	12.9	15.7	18.8	22.3	26.1	30.1	34.2	38.3	42.2	45.8
Tripotassium Phosphate, K_3PO_4, mol wt 212.27	0.06	0.11	0.17	0.23	0.30	0.36	0.42	0.48	0.53	0.58	0.63	0.68	0.72	0.77	0.81	0.86	0.91	0.96	1.01	1.06	1.11	1.16	1.21	1.26	1.31	1.36	1.41	1.45	1.49	1.52	1.55
Trisodium Phosphate, Na_3PO_4, mol wt 163.94	0.05	0.08	0.13	0.18	0.23	0.28	0.33	0.37	0.41	0.45	0.49	0.52	0.56	0.59	0.63	0.67	0.70	0.74	0.78	0.82	0.86	0.90	0.94	0.98	1.01	1.05	1.09	1.12	1.15	1.18	1.20
Potassium Sorbate, $C_6H_7KO_2$, mol wt 150.22	0.07	0.15	0.24	0.34	0.44	0.53	0.62	0.71	0.80	0.90	1.01	1.13	1.26	1.43	1.62	1.85	2.12	2.45	2.84	3.31	3.89	4.58	5.41	6.43	7.66	9.15	11.0	13.1	15.8	19.0	23.0
↑Buffer Salt↑ pH→	**2.9**	**3.0**	**3.1**	**3.2**	**3.3**	**3.4**	**3.5**	**3.6**	**3.7**	**3.8**	**3.9**	**4.0**	**4.1**	**4.2**	**4.3**	**4.4**	**4.5**	**4.6**	**4.7**	**4.8**	**4.9**	**5.0**	**5.1**	**5.2**	**5.3**	**5.4**	**5.5**	**5.6**	**5.7**	**5.8**	**5.9**

III. Examples (cont.)

COUGH LOZENGE APPLICATION. How much Zinc Acetate could be included in a cough lozenge which contains 1% Malic Acid without raising the pH of the lozenge above 3.3?

As shown in the table, at a pH of 3.3, the weight ratio of Zinc Acetate to Malic Acid is 0.64. Therefore, as much as 0.64% Zinc Acetate could be included in the formulation without raising the pH of the lozenge above 3.3.

IV. Background

Empirical equations that predict the pH of buffer salt/Malic Acid combinations were developed by measuring the pH of 0.09% w/w aqueous solutions that contained different ratios of buffer salts and Malic Acid. The weight ratio values shown in the table were generated using these empirical equations.

The pHs and weight ratios shown in the table should be considered only as starting points in product formulations. Actual pHs and weight ratios will vary depending on the ionic strength of the medium and what other acids, bases, and buffering ingredients are present.

Additional information is found in: Beynon, R.J. & Easterby, J.S. 1996. Buffer Solutions, The Basics. IRL Press at Oxford University Press, NY.