Acidulants in Beverages

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How do you know which acidulants to choose?

- Citric
- Fumaric
- Malic
- Tartaric
- Lactic
- Phosphoric
- Sodium Acid Sulfate
Use qualitative screens to narrow down your selection

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taste and flavour effects

physicochemical properties

acid strength
Improve beverage flavour profile by using acidulants
Review taste and flavour effects to determine the result you want

Olfactory Membrane

Aromatic flavor notes
Flavor modification (blending, enhancement)

Sourness
Astringency
pH effects
Chemical irritation
Review taste and flavour effects to determine the result you want

<table>
<thead>
<tr>
<th>Sourness at pH 3.0, 0.1% w/v</th>
<th>Descriptors</th>
<th>Flavor modifier</th>
<th>Temporal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Citric</td>
<td>bright, refreshing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fumaric</td>
<td>clean, dry</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lactic</td>
<td>smooth, dairy</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Malic</td>
<td>mellow, smooth</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phosphoric</td>
<td>low impact</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SAS</td>
<td>low impact</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tartaric</td>
<td>brusque, dry</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Mark your sample cups, please

C  T  M

A  B
Review taste and flavour effects - demo

Order of tasting:

C - Citric Acid 0.08% w/v

T - Tartaric Acid 0.08% w/v

M - Malic Acid 0.08% w/v
Acids naturally present in fruit can produce true fruit flavour
For example, Malic Acid enhances citrus flavour notes.

<table>
<thead>
<tr>
<th>Fruit, Region (variety)</th>
<th>Malic Acid</th>
<th>Citric Acid</th>
<th>sample size, n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lemon</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Israel</td>
<td>0.26±0.03</td>
<td>5.20±0.33</td>
<td>11</td>
</tr>
<tr>
<td>California (eureka)</td>
<td>0.22</td>
<td>4.19</td>
<td>2</td>
</tr>
<tr>
<td>Mandarin</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>California (dancy)</td>
<td>0.20</td>
<td>1.04</td>
<td>2</td>
</tr>
<tr>
<td>Orange</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Brazil first press</td>
<td>0.20±0.02</td>
<td>0.90±0.05</td>
<td>58</td>
</tr>
<tr>
<td>USA and Cuba</td>
<td>0.16±0.02</td>
<td>0.84±0.13</td>
<td>34</td>
</tr>
<tr>
<td>Spain (navelina)</td>
<td>0.13±0.01</td>
<td>1.17±0.06</td>
<td>63</td>
</tr>
<tr>
<td>Mediterranean</td>
<td>0.12±0.03</td>
<td>1.15±0.10</td>
<td>15</td>
</tr>
</tbody>
</table>

Malic and Citric Acid Levels in Citrus Fruit Juices (% w/v ± std. error)
Malic Acid enhances orange flavour

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Use level (%w/v)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>to 100</td>
</tr>
<tr>
<td>Sucrose</td>
<td>12.50</td>
</tr>
<tr>
<td><strong>Acidulant</strong></td>
<td><strong>0.30</strong></td>
</tr>
<tr>
<td>Orange flavour &amp; color</td>
<td>0.07</td>
</tr>
<tr>
<td>Sodium Citrate</td>
<td>0.04</td>
</tr>
<tr>
<td>Sodium Benzoate</td>
<td>0.03</td>
</tr>
</tbody>
</table>

Formula A - 100% Citric
Formula B - 95/5 Citric/Malic
Preferred by 10/14 panelists

from "Improving the flavor of fruit products with acidulants" at www.bartek.ca
Malic Acid blends together discordant flavour notes

Unblended

Blended
Evaluate different levels of Malic Acid with the dropper bottle

- 1 drop in 200 ml. = 17.5 ppm.
- 3 drops in 200 ml. = 52.5 ppm.
Higher rated beverages contain Malic Acid (www.bevNET.com)
Narrow the selection further with physicochemical properties

- **Phosphoric** (Volatile Liquid)
- **Acetic** (Volatile Liquid)
- **Corrosive**

- **Fumaric** (Non-hygroscopic solid, low solubility)
- **Citric** (Hygroscopic solid, high solubility)
- **Malic**
- **SAS**
- **Tartaric** (Irritant)
- **Lactic** (Liquid)
Log P values predict antimicrobial activity and sourness persistence

<table>
<thead>
<tr>
<th>Organic Acid</th>
<th>Log(octanol/water partition coefficient)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fumaric</td>
<td>0.28</td>
</tr>
<tr>
<td>Acetic</td>
<td>-0.31</td>
</tr>
<tr>
<td>Lactic</td>
<td>-0.62</td>
</tr>
<tr>
<td>Malic</td>
<td>-1.26</td>
</tr>
<tr>
<td>Citric</td>
<td>-1.72</td>
</tr>
<tr>
<td>Tartaric</td>
<td>-2.02</td>
</tr>
</tbody>
</table>
Acid strength determines level required to achieve target pH

Acid level required to lower pH of 0.005N NaOH to a specific value (% w/v)

pH

LA, 80%
MA
CA
TA
FA
SAS, 93%
PA, 85%

LA: Lactic Acid
MA: Malic Acid
CA: Citric Acid
TA: Tartaric Acid
FA: Fumaric Acid
SAS: Sodium Acid Sulfate
PA: Phosphoric Acid
High sourness results from a low pH with weak acids.

Estimated Sourness (units from ratio scales of H. Moskowitz (1971))

- Lactic
- Malic
- Citric
- Fumaric
- Tartaric
- Phosphoric (based on limited data)

$I = 0.005$
Calcium-fortified beverages are prone to calcium salt precipitation
Use acid blends in fruit flavoured beverages

<table>
<thead>
<tr>
<th>NUT</th>
<th>APM</th>
<th>APM/ACE-K</th>
<th>SUC</th>
<th>SUC/ACE-K</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>C</td>
<td>C</td>
<td>C</td>
<td>C</td>
</tr>
<tr>
<td>CFP</td>
<td>CM</td>
<td>CM</td>
<td>CM</td>
<td>CM</td>
</tr>
<tr>
<td>CL</td>
<td>CMT</td>
<td>M</td>
<td>M</td>
<td>CPM</td>
</tr>
<tr>
<td>CM</td>
<td>M</td>
<td>TM</td>
<td>M</td>
<td>M</td>
</tr>
<tr>
<td>CMT</td>
<td>MC</td>
<td></td>
<td>PCM</td>
<td></td>
</tr>
</tbody>
</table>

C = Citric and/or Citrate  
F = Fumaric  
L = Lactic  
M = Malic  
P = Phosphoric and/or Phosphate  
T = Tartaric
Take advantage of the sourness additive effect with acid blends

Estimated Sourness at pH 3.2, 0.2% total Acid, $I = 0.005$

16% increase in sourness from 100/0 to 90/10
Take advantage of the sourness additive effect with acid blends

<table>
<thead>
<tr>
<th>Sample</th>
<th>Formulation</th>
<th>pH</th>
<th>Estimated Sourness</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>0.16% Citric Acid</td>
<td>3.03</td>
<td>5.5</td>
</tr>
<tr>
<td></td>
<td>0.04% Sodium Citrate</td>
<td></td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>0.10% Citric Acid</td>
<td>3.22</td>
<td>5.8</td>
</tr>
<tr>
<td></td>
<td>0.03% Malic Acid</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.04% Sodium Citrate</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
**Target pH determines buffer salt level of use**

<table>
<thead>
<tr>
<th>Buffer salt</th>
<th>Level Required to Achieve pH 3.35 (% w/v)*</th>
<th>Sodium Level (% w/v)</th>
<th>Est. Total Buffer Capacity (Equiv/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calcium Fumarate trihydrate</td>
<td>0.22</td>
<td>----</td>
<td>0.0167</td>
</tr>
<tr>
<td>Sodium Lactate</td>
<td>0.14</td>
<td>0.029</td>
<td>0.0143</td>
</tr>
<tr>
<td>Trisodium Citrate dihydrate</td>
<td>0.12</td>
<td>0.028</td>
<td>0.0113</td>
</tr>
<tr>
<td>Trisodium Phosphate</td>
<td>0.07</td>
<td>0.029</td>
<td>0.0095</td>
</tr>
</tbody>
</table>

*Each buffer salt was added to a mixed solution of Citric Acid (0.16% w/v) and Malic Acid (0.05% w/v)

Increase sourness at a constant pH by raising level of buffer pair

Estimated Sourness (Bartek models)

Concentration of Buffer Pair (% w/v)

pH 3.5

- NaLactate/Malic
- NaLactate/Lactic
- NaCitrate/Malic
- NaCitrate/Citric
Save time by using Bartek’s web site:  www.bartek.ca
Peach/Mango Fruit Smoothie: Citric/Lactic

water, sugar, white grape juice from concentrate, peach puree from concentrate, skim milk, mango puree, pectin, natural flavors, citric acid, cream, lactic acid, rosemary extract, salt

bevNET rating: very good
Banana Colada Fruit Smoothie: Lactic/Citric

filtered water, crystalline fructose, skim milk, banana puree, apple juice concentrate, natural flavor, sugar, tricalcium phosphate, cream, lactic acid, pectin, citric acid, ascorbic acid, niacin, calcium pantothenate, vitamin e acetate, sucralose, pyridoxine hydrochloride, vitamin a palimate, cyanacobalamin

bevNET rating: excellent
Carbonated Energy Drink: Citric/Lactic/Cider Vinegar

carbonated water, sugar, kombucha concentrate, citric acid, lactic acid, cider vinegar, guarana extract, vitamin blend (vitamin c, niacin, pantothenic acid, vitamin b6, folic acid), malt extract, ginseng extract, flavors

bevNET rating: very good
Non-carbonated Energy Drink: Citric/Malic

water, high fructose corn syrup, glucose, natural and artificial flavors, taurine, citric acid, malic acid, d-glucuronolactone, ascorbic acid, inositol, choline, caffeine, niacin (B-3), pantothenic acid (b-5), FD&C yellow #5 and #6, pyridoxine (b6), cyanocobalamin (B-12)

bevNET rating: very good
Carbonated grape soft drink: Citric/Tartaric

carbonated water, high fructose corn syrup, pure washington honey, gum acacia, maltodextrine, citric acid, sodium benzoate (for freshness), tartaric acid and natural and artificial flavors

bevNET rating: excellent
Carbonated cola/tea drink: Citric/Malic/Tartaric
carbonated water, sugar, invert sugar, natural flavors, green tea powder, citric acid, malic acid, tartaric acid, vanilla extract, kola nut extract, sodium benzoate and potassium sorbate
bevNET rating: excellent
Still white tea drink: Malic

water, cane juice, white tea blend, **malic acid**, ginseng, natural flavor

bevNET rating: excellent
Zero calorie sports drink: Citric/Malic

water, citric acid, natural punch flavor with other natural flavors, malic acid, salt, monopotassium phosphate, sodium citrate and sucralose

bevNET rating: excellent
Sugar free ginger ale: 
Citric/Malic 
carbonated water, natural and artificial flavors, citric acid, malic acid, sucralose, sodium benzoate and potassium sorbate, sodium citrate, caramel color 

bevNET rating: perfect
Low calorie carbonated black raspberry soft drink: Malic
carbonated spring water, natural flavors, marion blackberry juice concentrate, malic acid, sucralose, potassium benzoate to ensure freshness, ascorbic acid (vitamin c), vitamin e acetate

bevNET rating: excellent
Zero calorie flavoured water: Citric/Malic

spring water, citric acid, natural flavor, malic acid, sodium benzoate and potassium sorbate, sucralose

bevNET rating: excellent
Low calorie flavoured water: Citric/Malic

mineral water, fructose, carbon dioxide, citric acid, malic acid, acesulfame potassium, aspartame, sodium citrate, potassium sorbate, flavor

bevNET rating: excellent
Enhanced water (women’s health)  
Citric/Malic

water, calcium lactate, cranberry juice concentrate, natural flavors, citric acid, magnesium lactate, malic acid, sucralose, potassium sorbate, acesulfame-k, soy isoflavones, vegetable juice (for color), red 40, liposomes (water, lecithin, vitamin d), pyridoxine, hydrochloride, folic acid, vitamin b12

bevNET rating: excellent
Zero calorie white tea drink: Malic/Citric

filtered water, natural pomegranate passionfruit flavor with other natural flavors, white tea solids, malic acid, white tea extract, ascorbic acid, acesulfame potassium, citric acid, sucralose, niacin (B3), calcium pantothenate, vitamin E acetate, pyridoxine hydrochloride (B6), folic acid, cyanocobalamin

bevNET rating: excellent
Low calorie vanilla berry hibiscus drink: Malic/Citric

filtered water, organic evaporated cane juice, apple and pineapple juices from concentrate, natural flavors, hibiscus extract, vegetable juice for color, malic acid, citric acid

bevNET rating: perfect
Improve beverage flavour profile by using acidulants