Balancing The Sweet & Sour:

Acidulant Selection for Beverages

Choosing the right beverage acidulant is vital in order to achieve a desired flavour profile, acidity and mineral dilution. Increasingly, secondary acidulants are also finding a role in masking the aftertaste of high intensity sweeteners

By Daniel R. Sortwell

THERE are seven beverage acidulants in commercial use. These are Citric, Fumaric, Lactic, Malic, Phosphoric, and Tartaric Acids, and recently introduced, Sodium Acid Sulphate. As shown in Figure 1, it is possible to narrow down the selection of acidulants for a particular beverage formulation from seven to two or three acidulants by considering various factors.

Taste and flavour effects

The most important of the factors considered is the acidulant's impact on taste and flavour. Acidulants have unique taste and flavour effects, as shown in Figure 2. The relative sourness of the acidulants at pH 3.0 is depicted by the sourness bar chart. As shown in this bar chart, Phosphoric Acid and Sodium Acid Sulphate are much less sour than the other acidulants at pH 3.0. For this reason, they are used to lower pH with a minimal increase in sourness. Phosphate and Citrate buffer salts are less sour than Lactate buffer salts and would be selected when buffer salts with minimal sourness are required.

The taste and flavour impacts of the acidulants are listed in the "Descriptors" column. Citric Acid has a bright and refreshing sourness that dissipates quickly, as seen in its temporal curve. It is the primary acidulant in most beverages for this reason. Tartaric and Fumaric Acids are more astringent than the other acidulants and work well in beverages such as cranberry and tamarind where astringency is expected. Lactic Acid provides a cream flavour note that is useful in dairy-and-fruit beverages such

Figure 1. Factors in Acidulant Selection

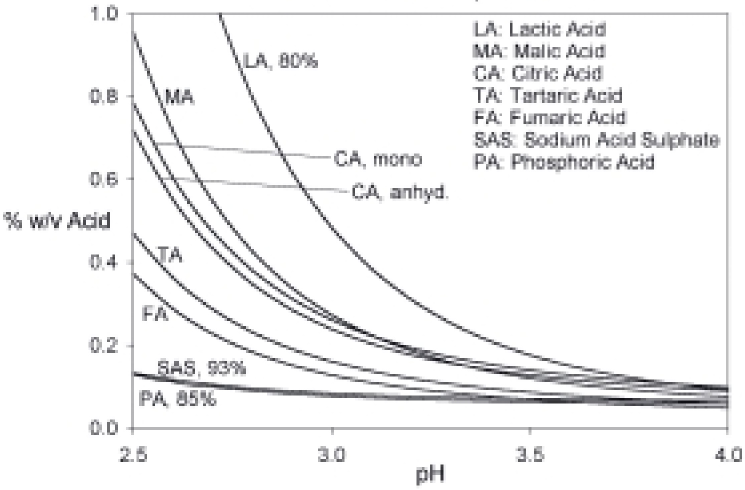
7 beverage acidulants
⇩
Taste and flavor effects
⇩
Handling and storage
⇩
Beverage requirements
⇩
Regulatory limits
⇩
2-3 beverage acidulants

Figure 2. Taste and Flavour Effects of Beverage Acidulants

	Sourness at pH 3.0, 0.1% w/v*	Descriptors	Flavour modifier	Temporal
Citric		bright, refreshing	□	
Fumaric		clean, dry	□□□	
Lactic		smooth, dairy	□□	
Malic		mellow, smooth	□□□□	
Phosphoric		low impact	□	
SAS		low impact	□□	
Tartaric		brusque, dry	□	

*Estimated using Bartek sourness models. See the Self Teaching Guide for Food Acidulants.

Figure 3. Acid Strength* of Beverage Acidulants
*% w/v acid required to lower the pH
of 0.005N NaOH to a specific value



as licuados or smoothies.

Malic Acid has a more persistent sourness than Citric Acid and therefore complements persistent sweeteners such as aspartame and sucralose. Malic Acid is a much stronger flavour modifier than the other acidulants. It enhances fruit flavours and also acts as a flavour blender, even at less than 100 ppm. The use of Malic Acid in new beverages, and especially beverages with health benefits, has increased as a result.

Malic Acid's fruit flavour enhancement property is well known to beverage technologists. Recent studies indicate that this a cognitive effect rather than a physico-chemical effect. Additional support for that

Figure 4: Acidulants Used in Beverages

	NUT	APM	APM/ACE-K	SUC	SUC/ACE-K
Cola	P PC PL	P PC PL	PC		PC
Root Beer, Ginger Ale Cream Soda	C	C CM		CM	
Tea with Fruit	C CP M	C CM M MC	CM CP	MC	
Tea	C MC PC				
Fruit	C CFP CL CM CMT CP F FC L M MC MPC	C CM CMT M MC	C CM M TM	C CM M	C CM CPM M PCM

LEGEND

C = Citric and/or Citrate
F = Fumaric
L = Lactic
M = Malic
P = Phosphoric and/or Phosphate
T = Tartaric

NUT = Non-nutritive sweetener
APM = Aspartame
APM/ACE-K = Aspartame/Acesulfame-K
SUC = Sucralose
SUC/ACE-K = Sucralose/Acesulfame-K

conclusion comes from the fact that Malic Acid is present in all fruits. For example, Malic Acid is naturally present in orange juice at levels of 0.1-0.2% w/v.

Malic Acid blends together discordant flavour notes, creating a smoother, more rounded flavour profile. This is especially useful in beverages that contain strongly flavoured botanical extracts or high intensity sweeteners with objectionable aftertastes. Sodium Acid Sulphate has also been reported to help mask some sweetener aftertastes. For this reason, it is shown with a persistent temporal curve in Figure 2.

Handling and Storage

All beverage acidulants except Fumaric Acid are highly soluble in water. Fumaric Acid has a low solubility and dissolves slowly. High shear mixing stations of the type used to dissolve aspartame are used to increase Fumaric Acid's dissolution rate.

Phosphoric Acid is a corrosive liquid. Additional safety precautions are necessary when handling Phosphoric Acid.

All of the solid beverage acidulants except Fumaric Acid are hygroscopic. Fumaric Acid is non-hygroscopic.

What would you like in your drink?

Are you making a new or existing beverage? If the beverage being formulated has many years of exposure to consumers in the marketplace, then a radical change in the acidulant(s) is not recommended. A major change in the flavour profile would result, since acidulants have different flavour effects.

Is there a specific cost requirement? This may affect the selection of acidulants, although acidulants are not normally a significant factor in the total ingredient cost of a beverage.

> Malic Acid is more often used in combination with high intensity sweeteners than with nutritive sweeteners. It has a more persistent sourness than Citric Acid and therefore complements persistent sweeteners such as aspartame and sucralose, even when used as a secondary acidulant.

Is this a Calcium fortified beverage? If so, Tartaric Acid or grape juice concentrate should be avoided, since Calcium Tartrate would precipitate. If a tea concentrate is used as the basis for a Calcium fortified tea beverage, Calcium Oxalate would precipitate. In this case, tea distillates or extracts can be used.

Is there a specific pH requirement? If the required pH is less than 3.5, the use of weak acids such as Lactic Acid as the primary acidulant would result in a very sour beverage. The weaker the acid, the higher the level of acid required to lower the pH of a beverage system to a given value. This is shown in Figure 3, which compares the acid strength of the beverage acidulants.

Regulatory limits

There are very few regulatory limits on the use of beverage acidulants. In the European Union (EU), Fumaric Acid may be used in beverage dry mixes at a level not to exceed 0.1% w/v of the reconstituted beverage but not in wet beverages. Phosphoric Acid may be used in wet beverages in the EU but not above 0.07% w/v. Regulations concerning the use of acidulants in wine vary by region.

Acidulants currently used in beverages

Acidulants and acidulant combinations currently used in beverages are shown in Figure 4. The beverages used as the basis for this diagram include carbonated soft drinks, still beverages, dry beverage mixes, enhanced waters, energy drinks, and alcoholic drinks. This diagram also shows the order of the acidulants. For example, CM indicates that Citric Acid is the primary acidulant and that Malic Acid is the secondary acidulant. Figure 4 reveals three patterns:

1. In all beverage types except cola, Citric Acid is most often the primary acidulant. Phosphoric Acid is the primary acid in cola beverages.
2. In all beverage types except cola, Malic Acid is most often the secondary acidulant. The CM combination (Citric Acid as the primary acidulant and Malic Acid as the secondary acidulant) is the most widely used acidulant combination.
3. Malic Acid is more often used in combination with the high intensity sweeteners shown than with nutritive sweeteners. As mentioned earlier, Malic Acid has a more persistent sourness than Citric Acid and therefore complements persistent sweeteners such as aspartame and sucralose, even when used as a secondary acidulant.

Acidulant combinations versus single acidulants

The use of acidulant combinations in processed beverages has become more widespread as beverage technologists have recognised their benefits. The increased use of high intensity sweeteners in beverages has resulted in wider usage of secondary acidulants that complement these sweeteners. The combination of Citric Acid as the primary acidulant with Malic Acid as the secondary acidulant has emerged as the preferred acidulant combination in many applications.

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