Extended Shelf Life (ESL) Solutions Through Microencapsulation

Today's baking industry requires quick and effective solutions to prolong the shelf life and stability of bakery products. Prolonging shelf-life considers not only microbial stability during storing, but it's also of great importance to keep the characteristic organoleptic properties such as texture, flavor, and aroma throughout extended periods of time; this will aid in reducing food waste/loss and creating a fidelity bond with consumers and bakery brands.

For baked goods, practical preservation is crucial for extending shelf life and maintaining quality. Currently, shelf life is extended using a combination of ingredients such as sorbates, propionates, and organic acids. Their use can significantly improve product shelf life; however, inadequate concentrations can have undesired effects on the overall final product quality.

These undesired effects can be overcome through the use of microencapsulation. The use of encapsulated preservation-focused ingredients enables bakers to extend the shelf life of their products while mitigating the undesired effects of highly reactive ingredients during baking.

What is Microencapsulation?

Microencapsulation (encaps) is a process that involves the entrapment of liquids or solids (powders) in a system, typically using a lipid to create a wall to delay their availability and, therefore, their function. This technology can be used in baked goods to deliver preservatives, flavors, and vitamins, among other active ingredients, without affecting finished product attributes or processability.

How is it activated?

There are three main mechanisms that drive the release of lipid-encapsulated active ingredients:

Temperature

Causes the encapsulated coating to melt, allowing the active to disperse. A prime example of this mechanism is the increased temperature during baking.

Moisture

As the encapsulate is exposed to prolonged moisture, water migrates inside, causing the active to leach out. An example of this is the moisture found in doughs or batters.

Shear

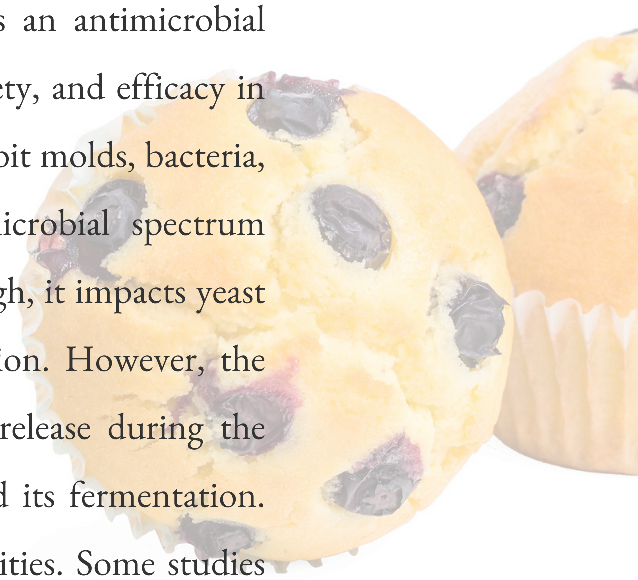
Some encaps are sensitive to shear forces produced by mechanical means such as mixing and extruding. When applied, these forces break the coating, leading to the release of the active ingredient. Encaps can be designed to withstand various shear conditions, allowing for controlled release of the required active ingredient.

A correct understanding of these release mechanisms —temperature, moisture, and shear —can help bakers utilize encapsulated ingredients to enhance product quality by ensuring that the active ingredients are released at optimal times for maximum impact.

Types of Ingredients

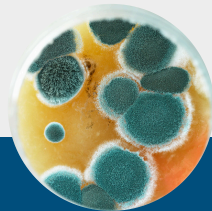
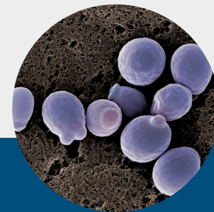
A wide range of ingredients can be encapsulated to improve the overall quality of baked goods. However, only those ingredients associated with extending the shelf life and preservation of baked goods will be discussed.

Sorbic Acid

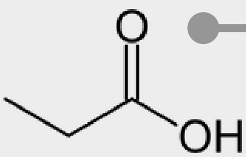


Is an organic compound used in the baking industry as an antimicrobial ingredient. It is favored for its organoleptic neutrality, safety, and efficacy in baked goods. It has a broad antimicrobial spectrum to inhibit molds, bacteria, fungi, and yeasts (see image below). This wide antimicrobial spectrum includes bakers’ yeasts, and when used directly on the dough, it impacts yeast activity, reducing dough volume by inhibiting fermentation. However, the usage of encapsulated sorbic acid eliminates this by its release during the baking process, long after the baker's yeast has completed its fermentation. This allows it to maximize its microbial-inhibiting capabilities. Some studies have shown that the use of encapsulated sorbic acid, in combination with raw calcium propionate, can increase the shelf life of flatbread by up to 60 days.

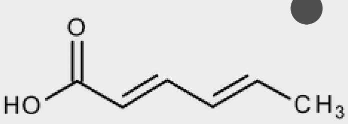
Synergy Broadens the Spectrum


PROPIONIC



SORBIC



MOLD	YEAST	BACTERIA
		Bacillus spp. (e.g. "Rope") *Proteus vulgaris* *Lactobacillus plantarum* *Sarcina lutea*
Penicillium Aspergillus Mucor Fusarium Geotrichum	*Saccharomyces cerevisiae* Candida	*Escherichia coli* *Staphylococcus aureus* *Salmonella spp.* *Listeria monocytogenes*
Rhizopus Alternaria Botrytis Cephalosporium Helminthosporium Pullullaria Sporotrichum Trichoderma	Brettanomyces Byssochlamys Cryptococcus Debaryomyces Hansenula Pichia Rhodotorula Torulaspora Zygosaccharomyces	*Pseudomonas putrefaciens* *Vibrio parahaemolyticus*

Organic Acids

Acids such as Citric, Malic, Fumaric, and Lactic are often used to reduce the pH in baked goods to add an acidic or sour taste or as an acidulant to reduce the pH of baked goods, enhancing the effectiveness of preservatives (see graph below). However, adding these acids can have a negative effect on the dough's handling characteristics, damaging gluten and creating a sticky and hard-to-handle dough. They can also interfere with chemical leavening systems, affecting the texture and organoleptic characteristics of the finished product.

Citric Acid

Is an organic compound found in citric fruits and is commonly used as an acidulant or to add an acidic or sour taste to food and baked products.

Malic Acid

Is an organic compound usually found in apples, plums, and cherries, similar to citric acid it is used as an acidulant to effectively reduce the pH of baked goods.

Fumaric Acid

Is an organic compound widely found in nature, it can be used as a clean-label acidulant for the pH regulation of baked goods.

Lactic Acid

Is an organic compound naturally found in milk and used in the baking industry as an acidulant for pH regulation. It provides that sweet, sourdough taste to artisan-style breads.

How does it function?

Microencapsulation offers a wide range of benefits on baked goods when used instead of raw sorbic acid, and traditional acidulants. The most relevant are: Encapsulation offers a wide range of benefits for baked goods when used in place of raw sorbic acid and traditional acidulants. The most relevant are:

Mitigates sorbic acid effect on yeast

Sorbic acid can impair yeast activity, leading to reduced fermentation rate and dense bread. Encapsulation solves this issue by separating the sorbic acid from the rest of the mixture until after the yeast has completed its function, allowing for both ingredients to be effective.

Allows for optimum pH to be achieved for preservation without affecting dough handling or flavor

The optimal pH for bread is ~5.3, at this pH, the flavor of the bread is highly acceptable to consumers (no sour dough like flavors) while also allowing the preservation system to be effective at acceptable dose levels. When bread is allowed to ferment fully, this pH level is typically reached; however, in industrial baking, this is often not the case, and pH levels of 5.6-5.7 are commonly observed. At these higher pH levels, preservatives such as sorbic acid and calcium propionate have much lower efficacy (see the impact of preservatives is pH dependent image), requiring significantly higher doses to be added to be effective. Encapsulated acids can be used to lower the pH of the dough to the optimal 5.3 pH, enabling preservatives to have a highly impactful effect without affecting dough handling or finished product attributes.

Synergistic relationship for preservation between Sorbic and Propionic acid

When used in combination and at the optimal pH, calcium propionate and encapsulated sorbic acid not only provide broad coverage against yeast, mold, and bacterial spoilage, but they also exhibit a synergistic effect, allowing for lower usage levels while maintaining continued functionality (see Figure 1). This can provide a cost in use benefit and improve organoleptic characteristics by addressing potential off-flavors and aromas created by high usage levels.

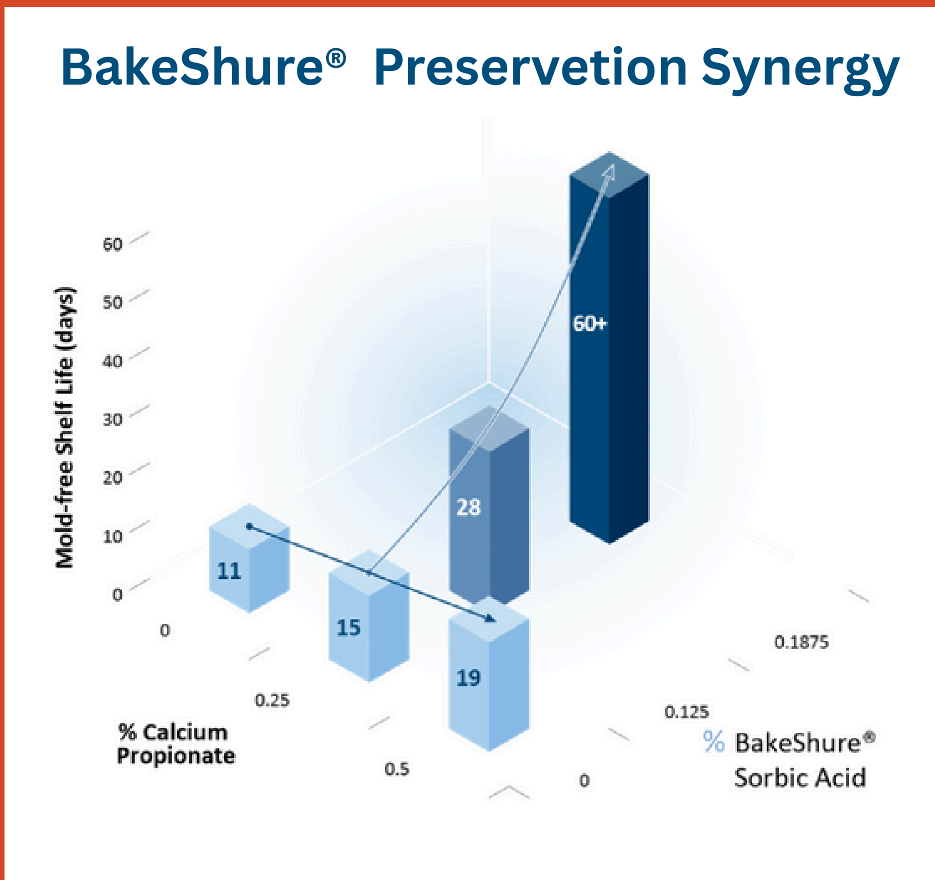


Figure 1. Comparasion of mold-free shelf life with BakeShure©

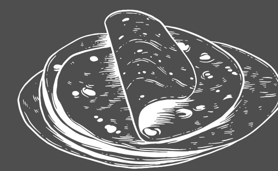
Mitigates Effects of organic acids on gluten and chemical leavening systems

The use of organic acids in baked goods is often essential to deliver optimal pH as acidulants or to impart a sour flavor for organoleptic purposes. Adding raw acid can have a negative effect on the gluten (protein found in flour) in bakery items, causing stickiness and leading to challenges in handling and processability. Raw acids can also affect the chemical leavening often used in bakery products, specifically the reaction between sodium bicarbonate and a leavening acid such as SALP or SAPP, for example. However, by encapsulating the acid, they can be readily used as an acidulant or a flavoring agent without affecting the gluten or leavening systems. This is demonstrated in tortillas, where fumaric (or sometimes malic) acid is commonly used as an acidulant to adjust the pH.

In tortillas, a raw acid will have an impact associated with the extensibility of the dough under different pH conditions. Typically, neutral pH dough yields more extensible gluten, allowing the dough to retain its desired stretch-formed properties in tortillas. Meanwhile, the more acidic dough tends to be less extensible and is less likely to keep its deformed shape.

The use of raw acidulants helps extend the product's shelf life; however, due to their dissolution before baking, they may cause shrinkage in the product. Fumaric acid is an excellent alternative due to its lower solubility in comparison with other food-grade acids, but it still produces a certain level of shrinkage. Encapsulated fumaric acid, however, significantly lowers shrinkage of the product while providing the acidic conditions to preserve product shelf life and aid in the preservative action of sorbic acid.

Balchem's BakeShure® FT in Tortillas



IIn a study conducted by Balchem, tortillas were treated with a bromocresol purple dye, where the blue area indicates a neutral pH and the yellow area shows an acidic dispersion. BakeShure® FT uniformly distributes throughout the tortilla, resulting in an even pH drop, improving overall shelf life. As seen in Figure 2.

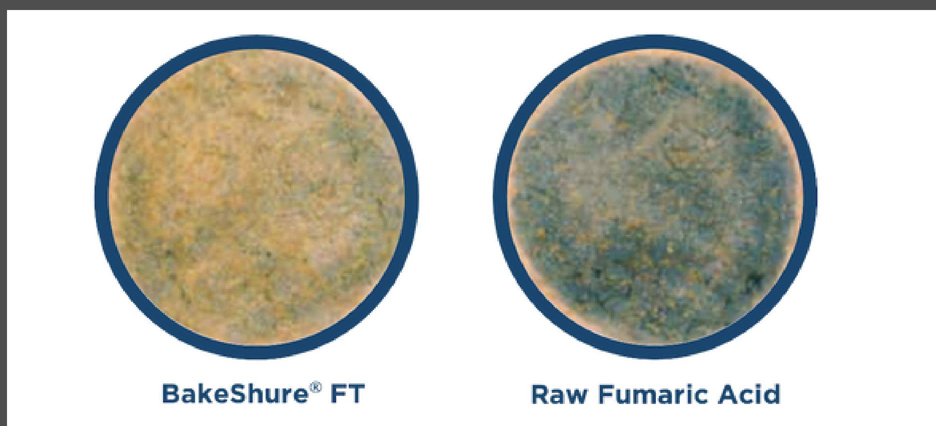


Figure 2. Comparasion of distribution of preservative in tortillas

They also measured the dough and the final product pH using raw acid and encapsulated acid (BakeShure® FT) without any acid added. It was shown that the dough's pH was lower with the use of the raw acid, which may have caused issues during shaping due to decreased extensibility (See Figure 3). Both encapsulated and no-added acid dough had similar pH levels, which may produce a more extensible dough, as seen by the higher total diameter values of tortillas made with no-added acid and Balchem's BakeShure® FT. However, while the no-added acid tortillas had a larger diameter than those with added raw acid, they presented a higher pH than both raw acid and encapsulated acid tortillas, meaning that the no-added acid tortillas are more susceptible to microbial contamination. While the encapsulated acid (BakeShure® FT) tortillas presented both a higher total diameter and a lower final pH value once baked, resulting in a product with the potential for a longer shelf life and better overall product quality.

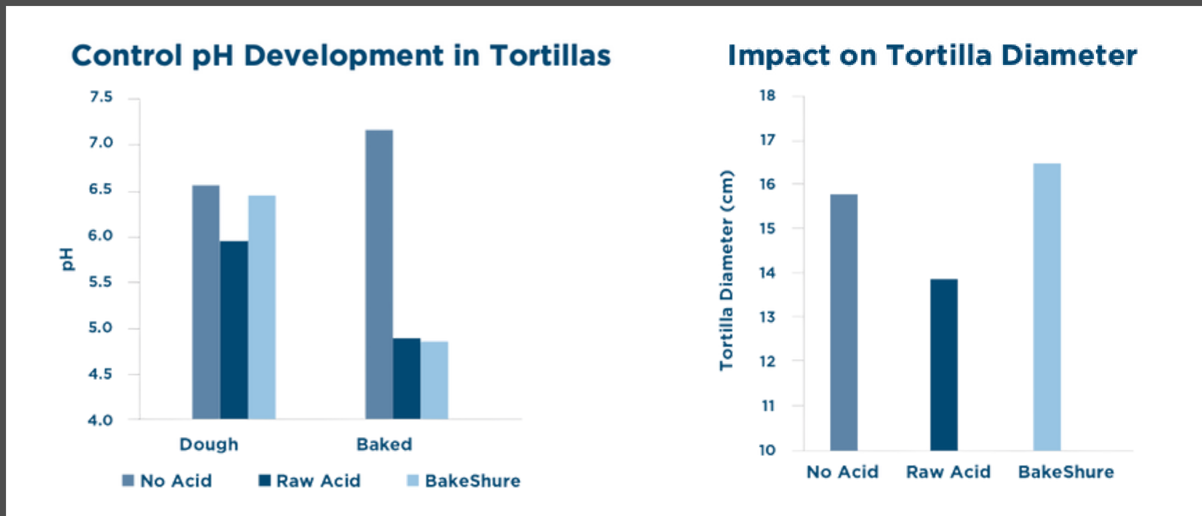


Figure 3. (a) Control pH Development in Tortillas , (b) Impact on Tortilla Diameter

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