Innophos®

Whitepaper

A New Solution For Extending Shelf Life of Bakery Products

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Executive Summary

Commercial bakeries must overcome many challenges in today's business environment. Finding solutions to improve profitability, reduce waste, and address evolving consumer trends are critical for bakeries to stay ahead of the game. Innophos has set out to help meet these challenges with our patent-pending LEVAIR® ESL technology.

This paper covers:

- The environmental and economic impacts of reducing food waste
- Why extending shelf life increases profitability for commercial bakeries
- Keys to extending shelf life in baked goods
- How patent-pending LEVAIR® ESL technology works
- Results from three studies on cupcakes, pound cakes, and mini donuts

Impacts of Reducing Food Waste

Thirty percent of all grain and cereal foods (with a value of ~$10 B) go to waste at the retail and consumer level.[1] Extending product shelf life can play a significant role in helping to reduce food waste.

PROVIDE MORE FOOD TO THE FOOD INSECURE

Over one-third of the food produced is never eaten, wasting the resources used to produce it and creating a multitude of environmental impacts. The uneaten food contains more than enough calories to feed the 35 million estimated food-insecure Americans.

REDUCE GREENHOUSE EMISSIONS

Food waste is one of the biggest contributors to climate change. It is the most common material in landfills and incinerators in the U.S. Food that ends up in landfills generates about 8–10% of the global greenhouse emissions.[2] For example, the methane emitted by rotting food has over 80 times the warming power of CO_2.

CREATE A MORE SUSTAINABLE FOOD SYSTEM

By increasing the efficiency of food production, less agricultural expansion is needed, alleviating land use pressures and potentially, releasing land for reforestation.

INCREASE PROFITS ACROSS THE FOOD VALUE CHAIN

Reducing food waste increases profits by helping to reduce the costs of producing, transporting, storing, and disposing of the wasted food.[3]

Benefits to Extending Shelf Life

For Commercial Bakeries

- Improves manufacturing efficiencies such as optimizing scheduling to allow longer production runs, resulting in fewer line changeovers, thus reducing waste.[4]
- Changes distribution model from delivering to convenience stores or supermarkets to delivering directly to warehouses, allowing for full or half truck deliveries.
- Expands geographical market reach.
- Reduces buybacks of stale products.

For Retailers

- Allows retailers to maintain fuller shelves, reduce out-of-stock items, and pull less product because of "best by" dates.

For Consumers

- Enables consumers to keep baked products longer, waste less, and make fewer trips to the grocery store.[4]

Keys to Extending Shelf Life in Baked Goods

There are two key aspects of extending shelf life in bakery products:

1. Quality achieved through maintaining freshness.
2. Safety achieved through controlling microbial growth.

Maintaining Freshness

The loss of "freshness," which is due to physical and chemical changes during storage, leads to a progressive firming of the crumb, also called "staling." Once stale, consumers no longer consider the product to be "fresh" as the product loses its texture, flavor, and aroma.

Bakery products lose freshness quickly because they are dynamic systems that undergo physical, chemical, and microbiological modifications during storage.

Physical changes cause crumb firming and reflect the occurrence of starch retrogradation. As part of this process, moisture is redistributed between gluten and starch polymers and migrates from the crumb to the crust. The loss of moisture that occurs results in a stiff and dry crumb.

Chemical changes after baking result in rancidity and nutritional loss. Rancidity, resulting from lipid oxidation, triggers the formation of malodor fatty acids and off-flavors. Staling limits the shelf life of the baked products as it impairs their organoleptic properties and quality.[5,6,7]

Nutritional loss occurs when there is degradation of certain ingredients, such as proteins, vitamins, etc.

Controlling Microbial Growth

Microbial growth results in visible mold growth and invisible production of mycotoxins, and is another main factor that limits the shelf life and compromises the safety of bakery products. Water activity (aw), pH, and moisture content are intrinsic factors that influence the spoilage of bakery products. When baked products leave the oven, their surfaces are sterile. Microbial contamination occurring during cooling is a key source of product spoilage.

Mold growth is the main spoilage organism for high and intermediate moisture products where water activity supports its growth. Bacterial spoilage can be a problem in high-moisture bakery products, such as bread. Spores from *Bacillus subtilis* present in the flour can survive the heat treatment during baking and their growth after baking results in the formation of "rope." The characteristics of ropiness in bread products are discoloration, stickiness, and off-flavors.[8]

Shelf life extension is about maintaining freshness and limiting microbial spoilage.

How LEVAIR® ESL Technology Works

Drawing on our 100-year history in providing phosphate-based leavening solutions, Innophos has created LEVAIR® ESL. LEVAIR® ESL is a proprietary, patent-pending combination of phosphates, enzymes, and antioxidants that dramatically extends the shelf life of packaged baked products while reducing preservative levels.

Phosphates play a key role in baking by helping to improve texture, volume, and extend shelf life of baked goods. Phosphates react with baking soda to produce carbon dioxide and help the dough rise and/or provide food for the leavening yeasts.

Phosphates can also work as dough conditioners. They strengthen the gluten network to improve elasticity and increase the degree of starch gelatinization and its ability to bind water, which can limit staling in baked goods.[9]

Finally, phosphates chelate certain minerals involved in lipid oxidation to help prevent rancidity. They act as buffers or acidulants, enhancing the antimicrobial activity of acid-based preservatives.[10,11]

Supporting the multifaceted phosphate functionality in LEVAIR® ESL, its enzymes help preserve texture and its antioxidant content controls rancidity.

Phosphates play a critical, multifaceted role in the functionality of baked goods.

Case Studies

Working with a commercial bakery, Innophos performed three studies to demonstrate the ability of **LEVAIR® ESL** to extend the shelf life of baked products. We conducted both physiochemical and microbiological testing, as well as sensory evaluations, to best assess shelf life extension.

Cupcake Study

Physical Characteristics

We evaluated the efficacy of LEVAIR® ESL to double the shelf life of vanilla and chocolate cupcakes. These cupcakes were baked, frozen, and packaged in clamshells for major big-box stores. Their original shelf life was 9 days after defrosting. We tested the current formulation (control) versus samples containing LEVAIR® ESL with 50% of their standard preservative package. As shown in Figure 1, the moisture content of these cupcakes remained steady up to day 9. After 20 days the control cupcakes had lost 24% of their moisture, while the cupcakes containing LEVAIR® ESL had lost less than 10% of their moisture content. Consistent with less moisture loss, the cupcakes containing LEVAIR® ESL retained more volume and maintained softer texture after 20 days (Figure 2 & Picture 1). Cupcakes containing LEVAIR® ESL were also lower in pH, 6.7 versus 7.2, which helped the preservative package work more effectively.

Figure 1: **Change in moisture content over time in cupcakes**

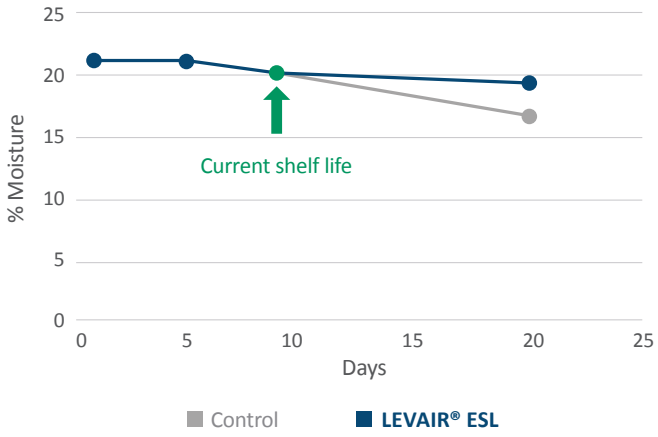
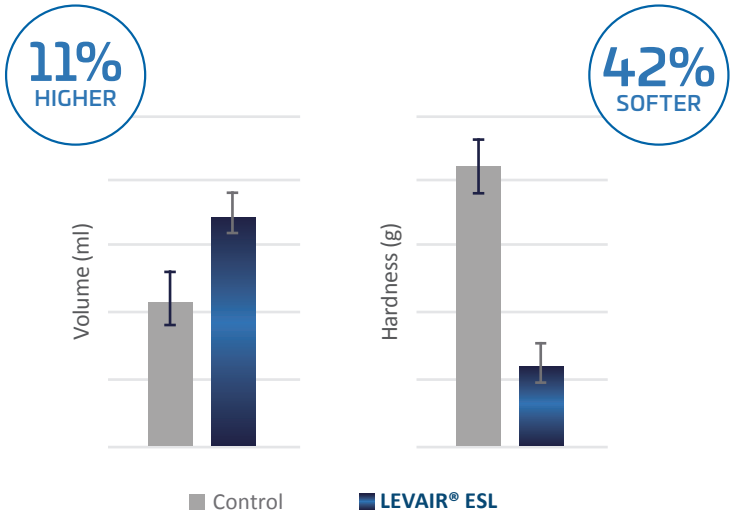


Figure 2: **Cupcake volume and texture 20 days after defrosting**

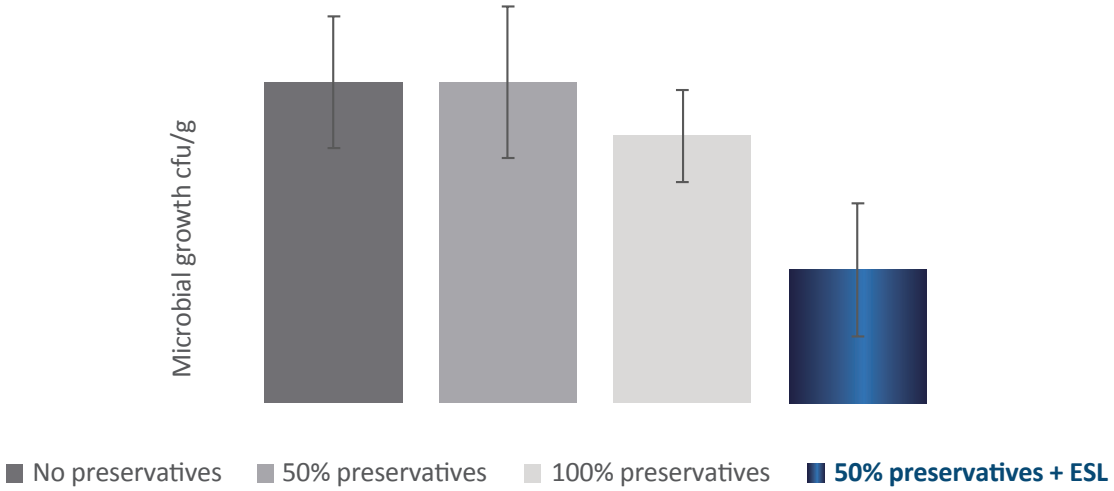


Picture 1: **Cupcakes 20 days after defrosting**

Microbial Challenge Test

We also conducted a microbial challenge test using a mold isolated from the surface of a cupcake obtained from the same bakery. The isolate was identified as *Aspergillus tonophilus*. The cupcakes were inoculated on the surface with the isolate to a final concentration of about 100 spores/g and plated after 14 days of storage at room temperature to measure mold growth. We compared the mold growth on the surface of the cupcakes containing **LEVAIR® ESL** and 50% preservatives to that of control cupcakes containing no preservative, 50% preservative or 100% preservative levels. As shown in Figure 3, we observed no mold inhibition in the control cupcake containing no preservatives or in the control containing 50% preservative. About 17% of the mold was inhibited in the control cupcake containing 100% preservative, and about 60% of the mold was inhibited in the cupcakes containing LEVAIR® ESL and 50% preservative.

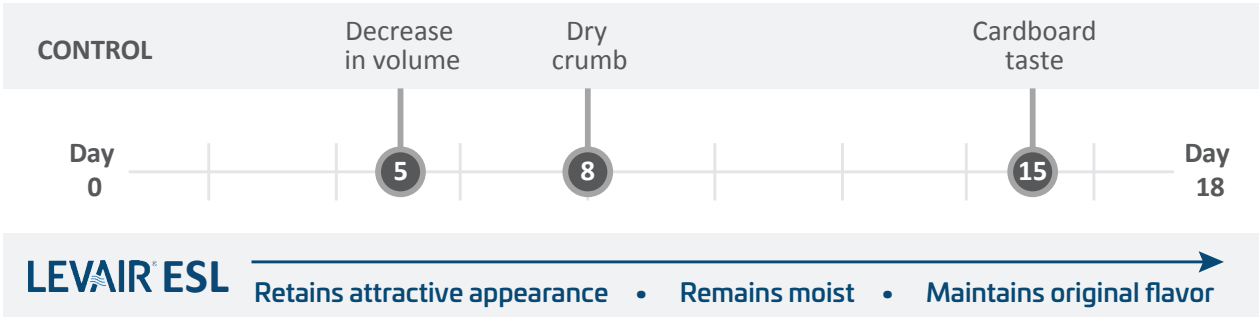
Figure 3: **Microbial challenge tests of cupcakes: mold growth at day 14**



Sensory Evaluation

Two panels, one internal and one independent, conducted sensory evaluations on "blinded" cupcake samples of control product versus products with LEVAIR® ESL. The independent panel findings validated those of the internal panel. Per Figure 4, after 5 days, panelists started noticing a decrease in cupcake volume in the controls, while the cupcakes containing LEVAIR® ESL retained volume through day 18. After 9 days, panelists detected a dry crumb in the controls, correlating with moisture loss, while they described cupcakes containing LEVAIR® ESL as moist through day 18. Finally, after day 17, panelists described a carboard flavor in the control samples, which is typically correlated with the perception of rancidity. The panel detected no off-flavors in the cupcakes containing LEVAIR® ESL.

Figure 4: **Sensory evaluations of cupcakes**



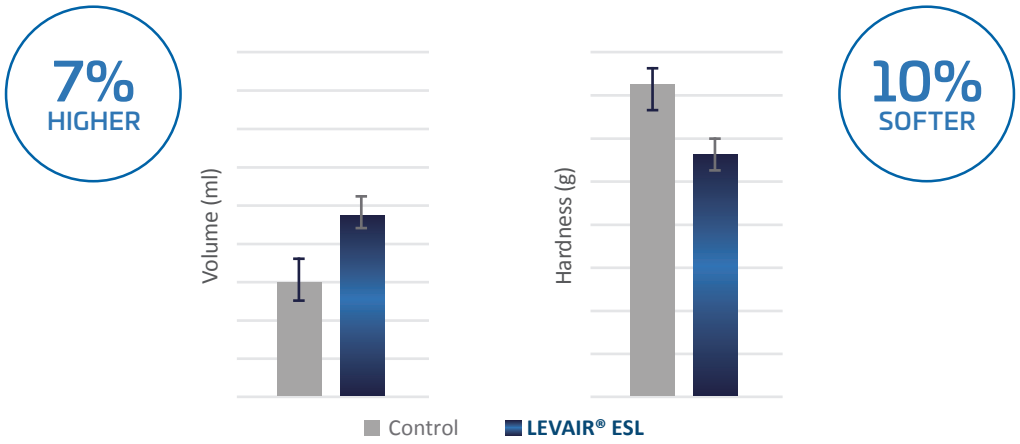
These results supported the shelf life extension of the cupcakes from 9 days to 20 days.

Pound Cake Study

Physical Characteristics

We evaluated the efficacy of **LEVAIR® ESL** to double the shelf life of mini pound cakes. These pound cakes are sold in individually wrapped packages with a shelf life of about 45 days. We evaluated the control formulation versus pound cake samples containing LEVAIR® ESL with 50% of the preservative package. After 90 days of storage at room temperature, the samples containing LEVAIR® ESL retained better volume and maintained softer texture (Figure 5, Picture 2). The mini pound cakes containing LEVAIR® ESL were also lower in pH at 6.6 versus 7.0 of the control. Microbial analysis of the samples after 90 days resulted in no mold growth.

Figure 5: **Mini pound cakes volume and texture after 90 days**



Picture 2: **Mini pound cakes after 90 days**

Sensory Evaluation

The sensory panel perceived a change in texture in the control mini pound cake after 45 days, which the panelists described as “gummy texture.” The samples containing LEVAIR® ESL maintained texture over time. The panel detected a chemical aftertaste and reduced volume in the control samples. In contrast, the panel detected no aftertaste in the samples containing LEVAIR® ESL.

LEVAIR® ESL successfully doubled the shelf life of these mini pound cakes.

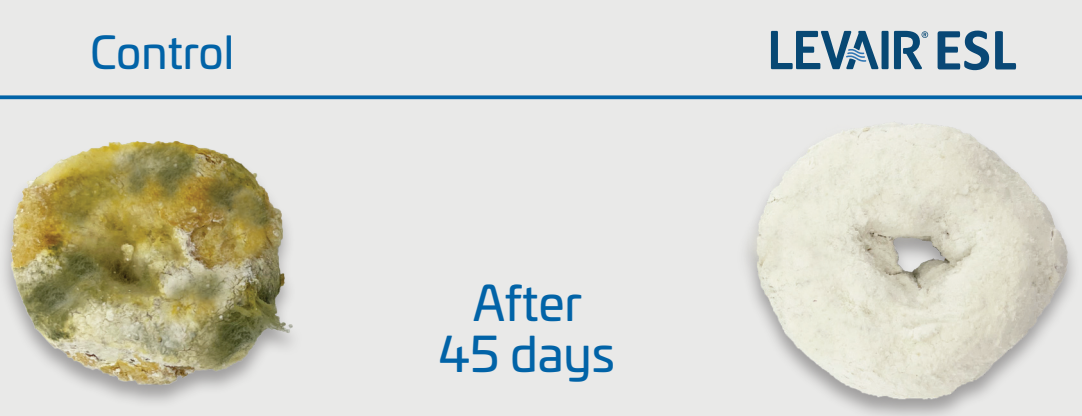
Powdered Mini Donut Study

We evaluated the efficacy of **LEVAIR® ESL** to double the shelf life of powdered mini donuts.

These donuts came packaged in 10 oz bags. Their shelf life was about 21 days. We evaluated the control formulation versus samples containing LEVAIR® ESL. After 45 days, the powdered mini donuts containing LEVAIR® ESL showed no mold growth, better sugar adhesion and softer texture (Picture 3, Figure 5).

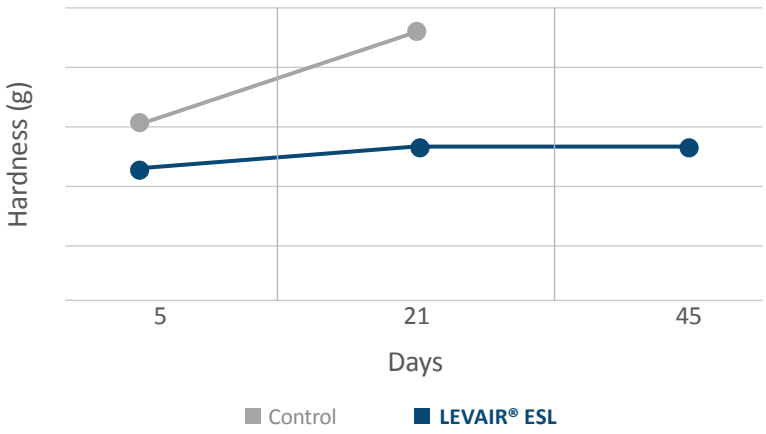
We were unable to test for texture after day 21 as all products showed significant mold growth. The pH of the powdered donuts containing LEVAIR® ESL was 7.5 versus control of 8.2.

Picture 3: **Powdered mini donuts after 45 days**



Based on these results, we extended the shelf life from 21 to 45 days.

Figure 5: **Powdered mini donuts texture over time**



Conclusion

Extending the shelf life of baked products improves the utilization of food and reduces food waste throughout the supply chain. For example, it allows bakeries to enhance manufacturing efficiencies and improve their distribution channels, contributing to their bottom line. It reduces food waste generated by bakeries, retailers, and consumers, lowering the economic and environmental impact of this wasted food and thus helping our planet.

LEVAIR® ESL, a patent-pending, groundbreaking Innophos solution, can double the shelf life of baked products while reducing preservative levels. As shown in three case studies, LEVAIR® ESL is a proven technology in multiple sweet baked applications, and we are currently evaluating the technology in other categories, such as bread.

Reduce food waste, improve your bottom line, and give consumers a better-quality baked product with LEVAIR® ESL.

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