

**LEVAIR®**

Exploring Carbon Footprint
Reduction Through
Extended Shelf Life

Introduction

The demand for sustainable, nutritious products is reshaping the food industry. A recent American Bakers Association survey reveals that sustainability influences purchasing decisions for two-thirds of Americans, particularly among younger consumers¹. While bakeries face mounting pressure to adopt sustainable practices, they must balance these initiatives with productivity and profitability goals. Shelf life extension technology offers a strategic solution, simultaneously addressing environmental concerns and business objectives. By reducing food waste—which accounts for 17% of direct greenhouse gas emissions—and by optimizing supply chain logistics, this technology helps bakeries maintain competitive advantage while meeting growing consumer demand for environmentally responsible products.

Providing credible, transparent data on carbon emissions can help promote acceptance of innovative food ingredients such as LEVAIR® ESL. We conducted a downstream gate-to-grave Life Cycle Assessment (LCA) to quantify how LEVAIR® ESL extends the shelf life of baked goods, thereby reducing the potential carbon footprint of these products. This comprehensive analysis, drawing from published research and interviews with bakery industry experts, compares the environmental impact of products baked with LEVAIR® ESL against conventional shelf life alternatives.

WHAT YOU WILL LEARN:

- LEVAIR® ESL is a unique solution that doubles the shelf life of baked goods (yeast raised and chemical leavened) by **maintaining freshness and limiting microbial spoilage**.
- Our downstream gate-to-grave LCA shows that using LEVAIR® ESL to extend the shelf life of bakery products has the potential to **reduce the carbon footprint** of cupcakes, powdered donuts, mini pound cakes, and bread by **17-18% per serving**.
- Longer shelf life leads to less food waste at retail sites, which means bakeries can **improve their operational efficiency and profitability** through longer production runs and fewer line changeovers.
- Longer shelf life also contributes to **savings in distribution logistics** and less buyback of expired products.

Life Cycle Assessment of Baked Products

A Life Cycle Assessment (LCA) is a holistic method of assessing the environmental impact and resources used throughout the life of a product (ISO 14040, 2006). Few researchers have investigated the environmental profile of bakery products; their studies have found that the most important contributors are ingredient production, transportation, and manufacturing activities ^{6, 7, 9}.

In this study, a downstream gate-to-grave LCA was conducted to estimate the carbon footprint impact of extending the shelf life of a baked product with LEVAIR® ESL (WAP Sustainability Consulting, 2024). The gate-to-grave LCA included baked products manufacturing, finished product transportation, and retail but excluded production of LEVAIR® ESL and other ingredients as well as consumer use following purchase of the baked product. Drawing from published research and interviews with bakery industry experts, this comprehensive analysis compares the environmental impact of products baked with LEVAIR® ESL shelf life extension technology against conventional shelf life alternatives.

LEVAIR® ESL is added as an ingredient to the batter or dough during manufacturing of baked goods; it makes up less than 1% of the total formulation. Once the products leave the bakery, they are transported to food retailers



Figure 1. System Boundary Diagram for Downstream Gate-to-Grave LCA

and stored on shelves at ambient temperature until purchased by consumers. **Figure 1** shows the system boundary diagram for our downstream analysis.

Earlier research has shown that LEVAIR® ESL can typically double the shelf life of baked goods by maintaining freshness and controlling microbial growth¹¹. **Figure 2** shows the shelf life of four common baked products with and without LEVAIR® ESL.

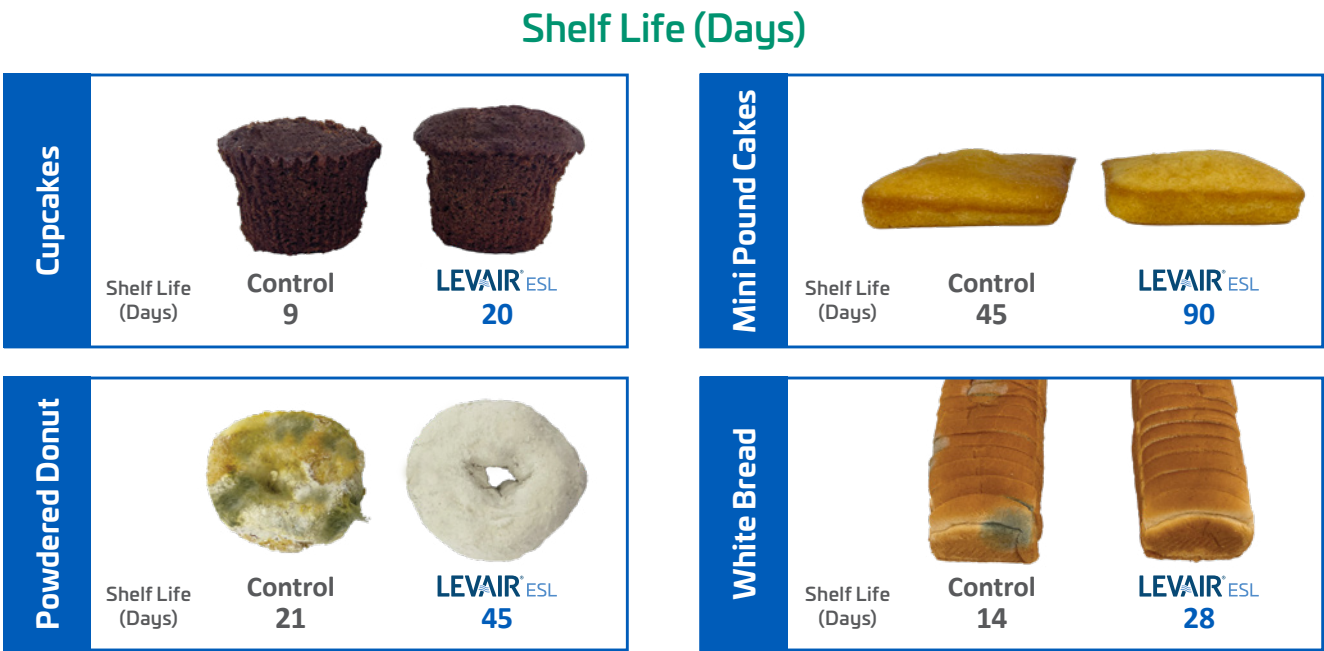


Figure 2. LEVAIR® ESL Doubles Shelf Life of Multiple Baked Products

Extending shelf life provides opportunities for reducing the carbon footprint of multiple baked products across the manufacturing, distribution, and retail stages.

Food waste stems from a variety of reasons, including:

- Ingredients discarded due to spoilage or expiration
- Discarded dough or batter
- Finished products that:
 - Fail to meet quality standards at the bakery
 - Get damaged during transportation or while on retail display
 - Pass their sell-by dates

This analysis assumed that the carbon footprint of all baked goods is the same on a per-kilogram basis, 3.3 kg CO₂e/kg product for the cradle-to-grave system boundary⁹. This number is representative of the various carbon footprints reported in the literature, including the carbon footprint for bread, which ranges from 0.5 to 6.6 kgCO₂e/kg⁸; for cupcakes and cakes, from 2.0 to 4.8 kgCO₂e/kg⁷, for biscuits, from 1.5 to 4.5 kgCO₂e/kg²; and for Pandoro, a type of sponge cake, which is estimated at 3.5 kgCO₂e/kg³.

The following sections describe our assumptions and analyses at each stage of the process.

1. Bakery Manufacturing

This study assumes that the manufacturing process is the same for all baked goods. In reality, however, the manufacturing process varies depending on many factors, including the type of product, the ingredients, how the batter and dough are mixed, formed, and proofed (for yeast-based products), the baking time and temperature, cooling and packaging, and the equipment used at each stage.



Bakeries typically target daily production runs of each item to meet consumer demand for freshly baked products and to minimize excess inventory and stale products on retail shelves. While plants can have the flexibility to run multiple products per line per day, line changeovers can result in downtime, which can be costly in terms of labor and lost output. For example, line changeovers may take hours of manpower spent cleaning, adjusting, and verifying the equipment setup. In addition, changeovers can require longer startup cycles, generate raw materials waste, and result in greater product inconsistency and rejection.

Because LEVAIR® ESL doubles the shelf life of baked goods, it can be used as a strategy to improve manufacturing efficiency and potentially reduce the carbon footprint of these items. Baked goods containing LEVAIR® ESL can be produced with longer production runs and fewer changeovers. That means bakeries will no longer need to bake every product variety every day in order to have fresh products on the grocery shelf.

Interviews with bakery representatives revealed that, on average, about 20% of each batch is wasted when a line is started. For example, when baking a mini cupcake with a 21-day shelf life, this bakery used to conduct about four line changeovers per day; each line change typically took 30 to 45 minutes, during which time the ovens were kept running. Assuming that the first batch of the day and each batch started after a line changeover resulted in 20% waste per batch, the total amount of waste after four line changes was about 10% of the entire day's production. After doubling the shelf life of the mini cupcakes to 42 days, the bakery was able to run the same product on the same line for a whole shift without a line change, not only producing more units per day but also reducing total waste to 2.5% per day, a 7.5% improvement in the product's carbon footprint.

According to bakery industry sources, manufacturing can account for as much as 25-30% of the wholesale cost of a baked product¹⁰. By extending product shelf life with LEVAIR® ESL, bakeries can reduce their cost per unit as well as their environmental impact.

2. Distribution

Decades ago, there used to be a bakery on nearly every corner to ensure consumers could buy fresh bread and other baked goods on a daily basis. Over the years, technology advances have enabled extensive consolidation of the manufacturing process. But shelf life considerations have continued to necessitate frequent line changes (as described above) coupled with meticulous distribution planning to keep freshly baked goods on retail shelves. Moreover, while the cost of manufacturing is high, distribution costs can be even more expensive, making up 40-60% of the retail price of bread¹⁰. Extending shelf life, therefore, allows bakeries to streamline distribution as well, e.g., shifting from daily direct delivery routes to individual stores to consolidating products in warehouses and running fewer and less frequent delivery routes with full or half-full truckloads.

In a case study, Hostess Brands reported that it was able to increase the shelf life of Twinkies® from 25 to 65 days by tweaking the formula of starches, oils and gums in the product. As a result, the cakes could be delivered through a centralized warehouse system, reducing spending on distribution from 36% to 16% of revenue

and allowing for expanded retail reach⁴. Optimizing delivery route logistics can also result in carbon footprint reductions.

Our analysis assumes that all distribution costs directly correlate to fuel purchases and, therefore, greenhouse gas emissions, so any decrease in fuel spending reduces the carbon footprint of the distribution stage. We used the ratio of the percentage change in the baked good shelf life without and with LEVAIR® ESL to the percentage change in the Twinkies® shelf life extension to estimate the decrease in carbon footprint intensity for distribution. Our analysis suggests that extending product shelf life with LEVAIR® ESL would reduce the impact of distribution by 43 - 47% for cupcakes, powdered donuts, mini pound cakes, and bread.



Extending shelf life allows bakeries to streamline distribution.

3. Retail

This study assumes that baked products are stored on retail shelves at ambient temperature until they are purchased by customers or disposed as food waste when they reach the best-by date. At the retail stage, potential impacts on the carbon footprint of baked goods include the waste treatment of discarded unsold products and the sunk costs of manufacturing products that end up in waste treatment.

WRAP, a global environmental action organization, conducted a study which explored the impact of shelf life extension on food waste reduction at retail¹².

According to this study, doubling the available life (on-shelf) of bread could result in a 33% reduction (from 3% to 2%) in retail waste.

We applied this ratio to the specific shelf life extension results achieved using LEVAIR® ESL, in order to calculate the reduction in retail waste for the four baked products.

This analysis points to potential retail carbon footprint reductions ranging from 17-18% per serving.

Downstream Analysis Results

This downstream analysis of baked product manufacturing, distribution, and retail suggests that doubling the shelf life of baked products with LEVAIR® ESL has the potential to reduce their carbon footprint by 17-18% per serving. As shown in **Figure 3**, we calculated an overall per-serving reduction in global warming potential (GWP)⁵ of 18% for cupcakes and powdered donuts, and 17% for mini pound cakes and white bread.

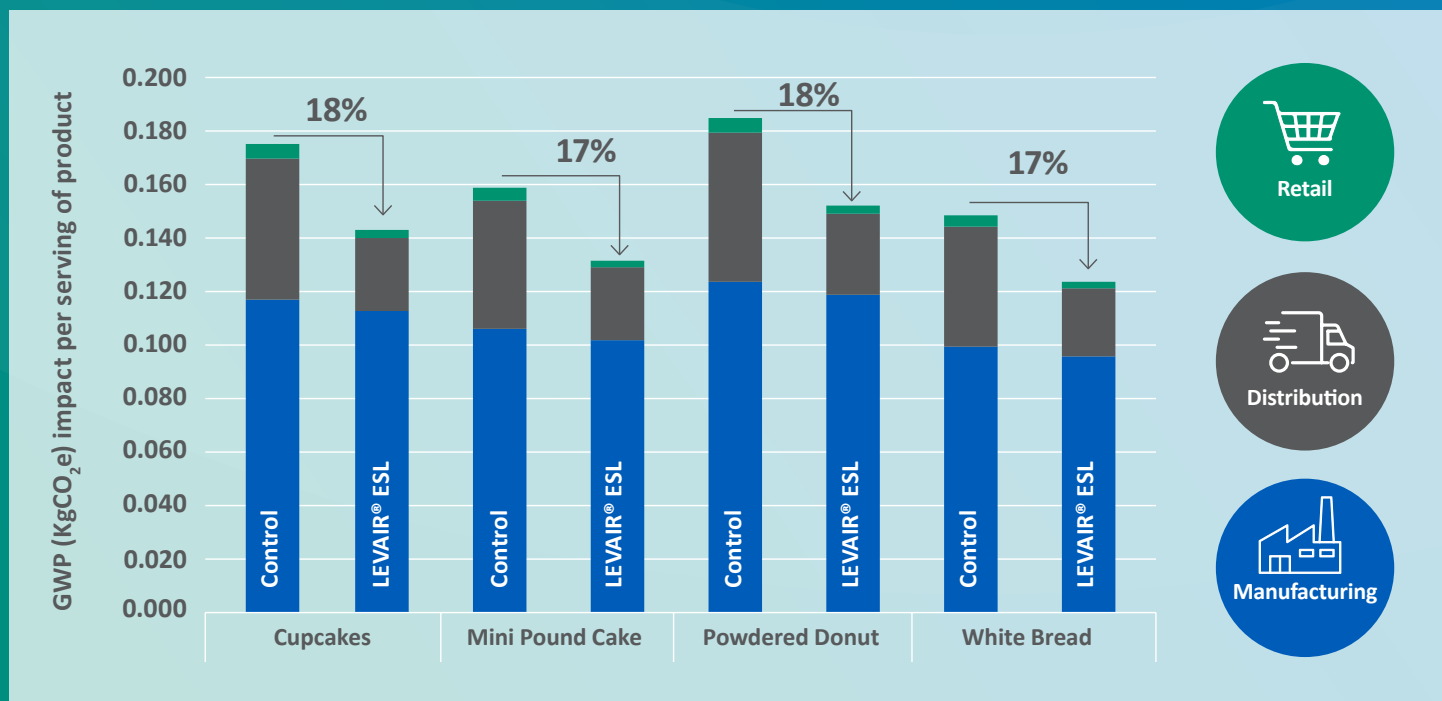


Figure 3. Potential Reduction in Global Warming Potential - Per Serving When Using LEVAIR® ESL

Conclusion

LEVAIR® ESL, a groundbreaking Innophos solution, can double the shelf life of baked products, resulting in reduced carbon footprint per serving and contributing to a more sustainable food chain. Bakery companies stand to benefit from more efficient manufacturing operations and supply chains while generating less food waste. Longer shelf life also represents avoided costs in terms

of reduced raw material requirements, less energy and water consumption, lower packaging and labor costs, lower distribution and fuel costs, and fewer wasted products on retail shelves. This represents a win-win, not only for society but also for the bottom line of the bakery industry across the board.

Extend shelf life, cut costs, and reduce waste with LEVAIR® ESL—an innovative solution that enhances sustainability while optimizing bakery operations.



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