Innophos®

Whitepaper

LEVAIR®

Solutions for High-Protein Baking

Healthy Baking

Today's consumers are seeking healthier and more premium alternatives in sweet baked products.[1] A key focus in healthy baking is adding functional ingredients, such as protein and fiber. Protein and fiber-fortified products provide increased nutritional value and promote satiety, and for these reasons are viewed as guilt-free indulgences.

Producing high-protein sweet baked goods involves more than simply adding more protein. Commercial bakers and processors face many challenges in maintaining the texture, volume, consistency, and machinability of these products. Innophos has a long history of providing innovative solutions to the bakery industry and can help formulators optimize their high-protein baked goods.

Key Messages:

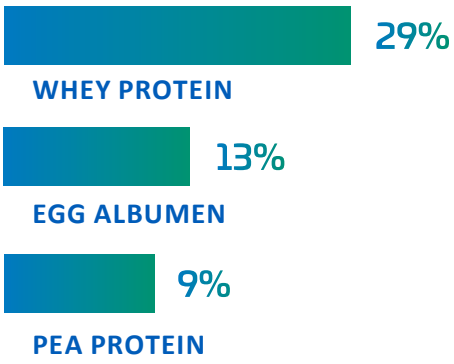
- Launches of wholesome sweet baked treats packed with protein are growing steadily
- Volume, texture, and machinability are key challenges when introducing additional protein in baking
- Phosphates can play a key role in addressing the challenges of high-protein baking
- At Innophos, we have launched a new product, LEVAIR® Fortify to optimize high-protein baked products

High-Protein Trend in Sweet Baked Goods

The claim “High Source of Protein” on a product label is one of the most influential purchasing factors for consumers. Sweet baked goods and baking mixes with high protein and high fiber claims have grown at +14% CAGR between 2017-2021. Positive cues like “High Source of Protein” are thriving because they help reduce guilt about consuming otherwise indulgent sweet baked goods. In the baked goods category, high protein claims are often paired with high fiber benefits to further entice consumers.[2]

Top Protein Ingredients in Sweet Baked Goods

Bakers have many choices for proteins to use in their recipes. The most commonly used proteins[3] are:



Additional plant-based protein entrants into sweet baked goods include almond, chickpea, fava, and brown rice, among others.[3] As formulators incorporate new products with different sources of protein into their recipes, they will need to develop specific solutions to address the texture, volume, and machinability challenges created by each protein.

Challenges of Protein Fortification

Proteins have many roles in baking. They act as dough conditioners, structuring agents, and moisture controllers.[4] The core challenge when introducing more protein into a formulation is hydration, as the amount of protein within a formulation greatly impacts water absorption. When bakers increase the amount of protein in a product, the hydration challenges are compounded: the higher the protein concentration, the greater the water absorption. The added protein absorbs water, leading to insufficient hydration of the batter, resulting in a dry, crumbly texture of the finished product. To counteract the effect of the added protein, bakers can add water. However, if they add too much water the batter becomes runny, resulting in machinability issues and texture challenges in the finished product.

The Role of Gluten

Most grain-based flours contain native proteins including insoluble glutens, which are unique in their ability to form viscoelastic systems. Gluten consists of gliadins which are associated with extensibility and viscosity, and glutenin, associated with strength and elasticity.[5] When hydrating the flour, the gluten proteins absorb water and partially unfold. Hydrogen bonding, hydrophobic interactions, and sulfhydryl-disulfide interchange reactions contribute to the development of the unique viscoelastic properties of the dough and batter.

The Hydration Challenge

When fortifying a product, the added proteins will compete with the native flour proteins for the available water. If there is insufficient water to hydrate the gluten, the formation of the gluten network is impaired. The dehydrated gluten will have a secondary structure that is more compact, impacting the extensibility and elasticity of the dough or batter.[6] Adding protein has a profound effect on batter consistency, creating challenges in machinability, as well as finished product volume and texture.

Solving Texture and Volume Challenges

Phosphates are widely used in sweet baked products as a leavening agent. The phosphate-based leavening acids react with a base (e.g., sodium bicarbonate) to produce carbon dioxide, water, and a neutral salt. Once the batter is heated during baking, the carbon dioxide and air incorporated during mixing expand and the water becomes steam, all of which leads to an increase in product volume. The amount of carbon dioxide released at the appropriate step in the manufacturing process is key to achieving the desired volume and texture in the baked product.

Phosphates also play a key role in dough conditioning, as they interact with the proteins in the formulation and influence their functional properties. Phosphates impact the solubility properties of proteins by changing pH, increasing ionic strength, chelating minerals, and thus altering the net charge of the proteins. Phosphates bind protein and water through electrostatic interactions and influence their hydration and gelation state, controlling moisture migration and improving machinability and structure development during baking.

Innophos has 100 years of history providing phosphate-based solutions to the bakery industry. At Innophos, we have leveraged our knowledge in chemical leavening and phosphate-protein interaction to develop LEVAIR® Fortify to help bakers overcome the challenges of texture, volume, and consistency of protein-fortified products.

LEVAIR®

Optimizing Texture and Volume in Protein-Fortified Muffins

To demonstrate the benefits of LEVAIR® Fortify, we developed two muffin recipes with 8g protein per serving, replacing 4% of the flour with either:

- **whey protein** (BakePLUS from Amco, 81% min. protein)

or

- **pea protein** powder (80% min. protein).

Our control muffin formulation, which provides 5g protein per serving, is described in Table 1 and includes a commercial dual-acting baking powder.

Table 1: **Control muffin formulation**

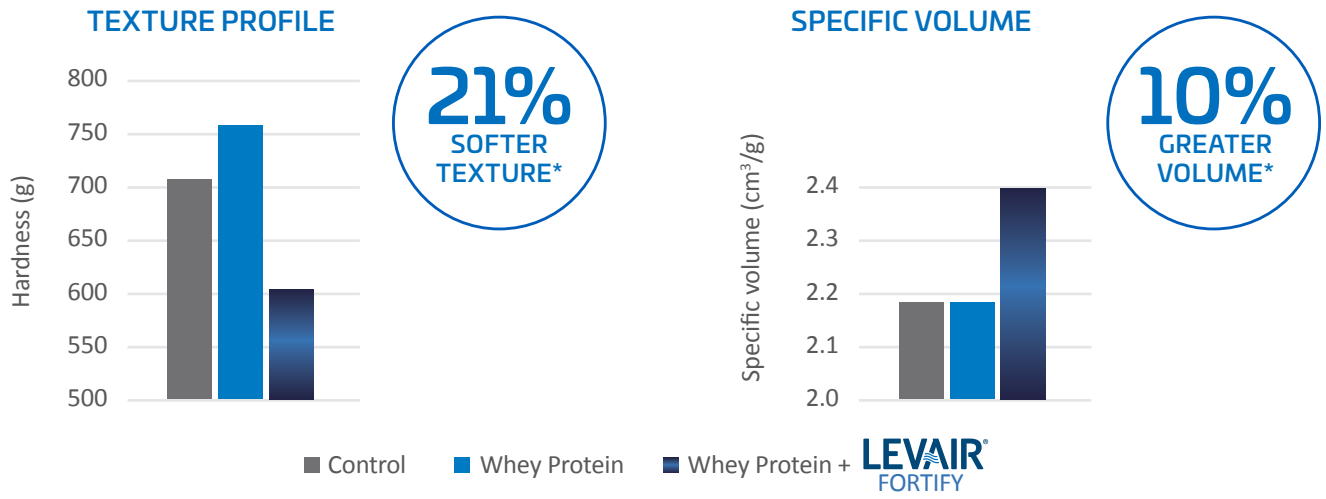
INGREDIENTS	%
Cake Flour	29.1
Granulated Sugar	18.7
Water	31.2
Potassium Sorbate	0.2
Instant Waxy Corn Starch	0.8
Non-Fat Dry Milk	2.1
Salt	0.4
Baking Powder	2.1
Xanthan Gum	0.1
Dried Whole Eggs	2.2
B&V Vanilla Flavor	0.6
Emulsifier	0.8
Soybean Oil	11.7
TOTAL	100.0

Whey Protein Muffins

Whey proteins, a byproduct of the cheese industry, are the most popular proteins used in the baked good industry. Whey proteins are amphiphilic, have good emulsifying, foaming, gelling, and water binding properties. They impart a clean flavor and color, and provide a substrate for browning Maillard reaction.[7] However, the incorporation of whey protein concentrates can affect the rheological properties of dough.[8]

As shown in Graph 1, to improve the texture, we replaced the cake flour and commercial baking powder with whey protein and LEVAIR® Fortify (1%) and sodium bicarbonate (0.6%). LEVAIR® Fortify helped produce a softer texture while also increasing specific volume vs. the control.

Graph 1: **Hardness and specific volume of muffins fortified with whey protein**



*Whey protein muffin plus LEVAIR® Fortify vs. whey protein muffin with commercial dual-acting baking powder

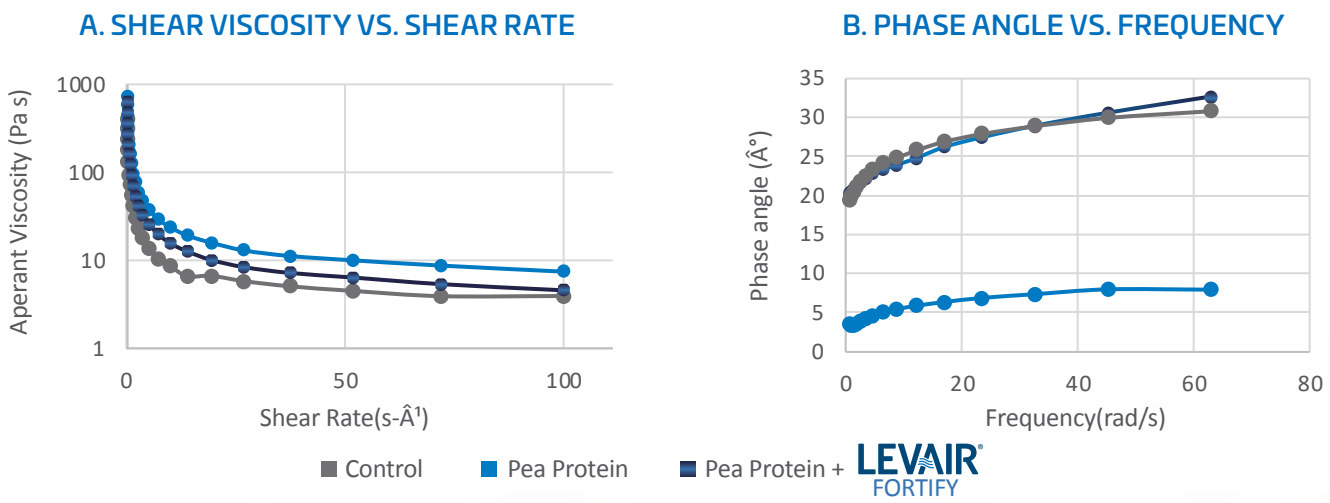
Pea Protein Muffins

Pea protein is commonly used when formulators are seeking a plant-based solution. Pea protein has a well-balanced amino acid profile and intrinsic functional benefits including solubility, emulsifying, and foaming properties. In gluten-based cake formulations that we performed, the addition of pea protein impacted the cake density and increased the viscosity of the batter, limiting the incorporation of air. The viscosity increase is due to larger particle diameter and water-holding capacity, compared to the wheat flour.[9] Proteins that bind a lot of water can lead to stiffer dough and thus negatively affect the volume of the baked product.

Improved Machinability with LEVAIR® Fortify

Replacing the cake flour with pea protein had a considerable effect on the rheological properties of the batter. As shown in Graph 2.A, the batter viscosity decreased with increasing shear rate, showing a shear thinning behavior. The addition of pea protein increased the viscosity of the batter. When the commercial baking powder was replaced with LEVAIR® Fortify (1%) and sodium bicarbonate (0.6%), the batter viscosity was reduced, bringing it closer to the control. This suggests that the LEVAIR® Fortify influenced the water-holding capacity of the proteins. The phase angle vs. frequency chart (2.B) shows that the added pea protein increased the elastic behavior of the batter (phase angle closer to 0). The addition of LEVAIR® Fortify reversed the trend, performing similarly to the control. These findings support improved machinability of the product containing higher proteins in the presence of LEVAIR® Fortify.

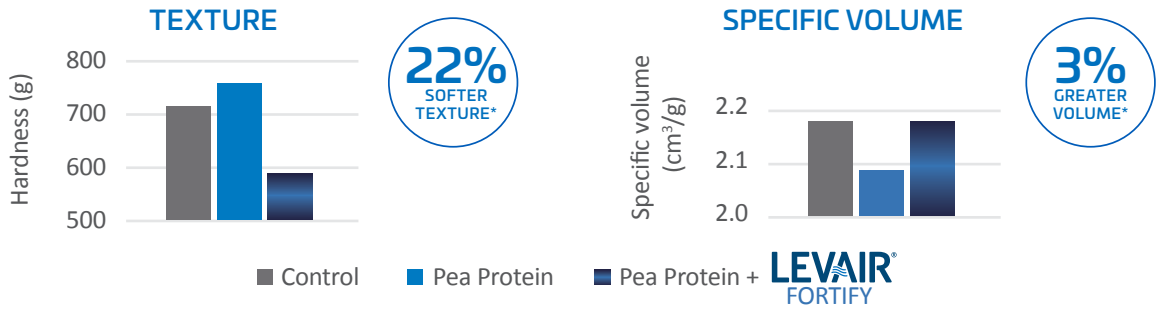
Graph 2: **Viscoelastic behavior of the batters fortified with pea protein**



Achieving Softer Texture and Higher Volume

The addition of pea protein resulted in harder muffins with less specific volume than the control (Graph 3). After the addition of LEVAIR® Fortify, as described above, a significant improvement in texture as well as an uptick in volume was achieved.

Graph 3: **Hardness and specific volume of muffins fortified with pea protein**



*Pea protein muffin plus LEVAIR® Fortify vs. pea protein muffin with commercial dual-acting baking powder

These studies show that the addition of **LEVAIR® Fortify had a beneficial impact on the product texture and specific volume, and also improved the machinability of the muffins** batter fortified with different proteins.

Conclusion

Bakers face unique challenges when formulating high-protein products, based on the protein source and the amount of protein desired. Each protein source exhibits different functional properties that influence the interactions between the components of the flour. The right blend of phosphates helps optimize the texture and volume of protein, and improves machinability. With a deep expertise in phosphate-protein interactions and bakery applications, Innophos has developed LEVAIR® Fortify, a unique solution to help create the highest quality fortified protein products.

Contact us before you start your next protein-fortified baking project.

www.innophos.com

1. Innova Trends Survey 2021.

2. Innova Market Insights (2020). *High In/Source of Protein Bakery.*

3. Innova Market Insights (2022). Ingredients in *High In/Source of Protein Bakery Claims Launches in Sweet Baked Goods Category*.

4. Fenema, O., Srinivasan, D., & Parkin, K. (5th edition, 2017). *Introduction to Food Chemistry.* CRC press.

5. Shewry, P., Halford, N., Belton, P., & Tatham, A. (2002). The structure and Properties of Gluten: An Elastic Protein from Wheat Grain. *Philos. Trans. R. Soc. Lond., B, Biol. Science 357*, 133.

6. Zhou, Y., Dhital, S., Zhao, C., Ye, F., Chen, J., & Zhao, G. (2020). Dietary fiber-gluten Protein Interaction in Wheat Flour Dough: Analysis, Consequences and Proposed Mechanisms. *Food Hydrocolloids.*

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9. Assad Bustillos, M., Jonchere, C., Reguerre, A., & Della Valle, G. (2020). Rheological and Microstructural Characterization of Batters and Sponge Cakes Fortified with Pea Proteins. *Food Hydrocholloids*.