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Formula Optimization

Practical technology from Lallemand Inc., parent of American Yeast Sales, producers and distributors of Eagle® yeast, fresh and instant.

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Bread Formula Optimization

THERE are many different processes and formulas for making bread. The particular process and formula used depend upon many factors, including tradition, equipment choices, flour quality, the type of bread desired, and the time between production and eating of the baked bread. Most of the bread in the U.S. is produced by larger industrial bakeries using automated high-speed lines to produce bread (pan bread, buns and rolls) that is sold in supermarkets and that has to stay soft and edible for up to seven days after baking. All bread is produced by mixing a dough containing wheat flour, yeast, salt, and water, proofing the dough to produce carbon dioxide gas and to fully develop its gas-retaining properties, and then baking the fully proofed dough. The gluten protein in the flour is the main structural component responsible for forming the viscoelastic dough that retains the carbon dioxide gas produced by yeast.

INGREDIENT FUNCTIONALITY

Apart from a basic formula with flour, salt, yeast, and water, many other ingredients are used to improve bread quality. These ingredients can be classified according to their functionality into four major categories.

Oxidizing and reducing agents react with the disulfide bridges and sulfhydryl groups of the gluten protein. Oxidizing agents like bromate, ascorbic acid, azodicarbonamide, and iodates will make the dough less extensible and more elastic by oxidizing sulfhydryl groups into disulfide bridges. Reducing agents like L-cysteine and glutathione (nonleavening yeast) make the dough more extensible and less elastic by splitting disulfide bridges. During mixing, sheeting, and moulding the dough needs to be extensible, while at the end of the final proof, when the proofed dough goes into the oven, optimal gas retention will depend on the optimal balance between extensibility and elasticity.

Emulsifiers and oils/shortenings are fat-based ingredients that function both as dough stabilizers when the emulsifier interacts with the gluten protein in the dough and as crumb softeners when the emulsifier complexes with the gelatinizing starch during baking. The emulsifiers with the best dough stabilizing effect (DATEM, EMG) are usually the worst crumb softeners, while the emulsifiers with the best crumb softening effect (monoglycerides) are usually inferior dough stabilizers. SSL is the most commonly used emulsifier in white pan bread, having both fair dough stabilizing and crumb softening action. Monoglycerides can be added to further improve crumb softness, while DATEM can be added in case dough stability is lacking. DATEM is therefore mainly used in frozen dough applications, in high-fiber bread where the fiber interferes with the gluten development, in hearth bread where the dough is baked without the support from a pan, or in bread produced from weak flours.

Enzymes modify specific wheat flour fractions to improve their functionality in breadmaking, thus improving final bread quality. Enzymes are biocatalysts with narrowly defined specificity and action patterns and are used to improve loaf volume, crumb structure, dough stability, tolerance, taste and flavor, and crumb softness. Many different enzymes (amylases, hemicellulases/pentosanases/xylanases, oxidases, proteases, lipases) have become available, and it is expected that more and better enzymes will be developed in the future. Enzyme-based dough conditioners are available to address specific needs of bakeries such as bromate replacement, shelf-life extension, improvement of dough machinability, emulsifier reduction, and gluten reduction.

Other ingredients used in breadmaking are organic acids for antimolding (calcium propionate) and for taste and flavor enhancement (acetic acid, lactic acids in sour dough bread), minerals and buffering agents (yeast foods), malt flour (flavor and source for amylase), soy flour, milk protein, sugar, gluten, seeds, fibers, spices, fruits, nuts, raisins, etc. Most of these ingredients are used mainly to give bread a characteristic taste and flavor or nutritional value.

WHY REFORMULATE?

Bakers have to deal with some variation in flour quality, use different production processes and equipment to produce the broad assortment of bread that is demanded by consumers, and at the same time respond to great pressure to lower costs as much as possible. Understanding the functionality of the various ingredients used is important when bakers try to optimize their formulas while keeping the following objectives in mind:

Reducing costs is the first priority for many bakers who are constantly exposed to

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FUNCTIONAL INGREDIENTS AND TYPICAL COSTS

INGREDIENTS	TYPICAL DOSAGE	TYPICAL COSTS/CWT	IMPROVEMENTS: LOAF VOLUME	CRUMB STRUCTURE	CRUMB SOFTNESS	TOLERANCE
Oxidizing and Reducing agents	10–75 ppm	$0.01–0.05	++	++	+	++
Enzymes						
Bromate replacers	varies	$0.10–0.25	+++	+++	+	+++
Crumb softeners	varies	$0.25–1.00	+	+	++++	+
Emulsifiers						
Monoglycerides	0.25–0.5%	$0.20–0.40	+	+	+++	++
SSL	0.25–0.5%	$0.20–0.40	++	++	++	++
DATEM	0.2–0.5%	$0.30–0.75	+++	+++	+	+++
Gluten	0–5%	$0.00–3.75	++	++	+	+++

+ improved → ++++ greatly improved

HOW TO OPTIMIZE FORMULAS

• **Use the most cost-effective ingredients first.** When trying to save costs, it is more important to look at total formula costs than the costs of a single ingredient. The table shows that oxidizing/reducing agents are usually far more economical than emulsifiers or gluten, while enzymes are usually in between. So adding an oxidant like ascorbic acid to an otherwise lean formula of flour, yeast, salt, and water will improve bread quality to a similar extent as adding gluten, but the costs of the latter addition are about fifty times higher to get a similar improvement. Therefore, the most economical dough conditioners contain only oxidants and enzymes. High levels of ingredients like gluten and emulsifiers should only be used after fully exploiting the effect of the more cost-effective ingredients like enzymes and oxidants and there is no other way left to attain a desired quality level.

• **Dose critical ingredients accurately.** For some ingredients, overall quality will be lower both below and above an optimal dose level, so these ingredients have to be dosed accurately. Other ingredients are more forgiving and can be dosed over a broader range. This is what many bakers have experienced when switching from bromate to bromate replacers containing faster-acting oxidants like ascorbic acid and/or ADA.

• **Don't use higher levels that increase cost but not performance.** While some ingredients can be dosed at high levels without giving negative side effects, this can become very costly. So, while costs are proportional to the dose rate, the quality-improving effects are not but tend to level off toward a maximum.

• **Understand ingredient functionality in relation to the functionality that is lacking in a formula.** Many ingredients have similar but not exactly the same functionality (see Table). While most emulsifiers and enzymes will improve loaf volume, crumb structure, and crumb softness, they will do this according to a different mechanism. When increasing the level of a particular ingredient is no longer effective, another ingredient that gives similar improvements but by a different mechanism can be used to further improve quality.

• **Don't solve one problem by creating another.** For example, loaf volume may be reduced when using L-cysteine to reduce mixing time or to improve dough handling or machinability, especially if oxidation levels are not adjusted. So, when optimizing formulations these effects should not be treated as separate issues.

• **Don't exclude process or equipment changes.** When problems cannot easily be solved through reformulation, it is advised to consider changes in equipment or process conditions. Faster equipment and processes to increase output, higher dough temperatures, shorter overhead proof, etc., have cost advantages but make process control more difficult. Changes in process conditions (for example, lowering proof box temperature and using slightly more yeast) are often more effective in improving product quality than adding more ingredients.

Lallemand Dough Conditioners

AS A LEADING producer of yeast, baking powders, and dough conditioners, Lallemand supplies a full range of products for improving bread quality. All Fermaid®, Essential®, and Eagle® dough conditioners are backed by technical support from experienced bakery technicians.

Essential® PBR-FD, PBR 100, PBR 200 DF, PBR-175, PBR-150, PBR-100 Tab and ***PBR-150 Tab,*** and ***Eagle® CM-100*** are enzyme-based dough conditioners used for bromate replacement, gluten reduction, and emulsifier reduction. Various formulations (powders and tablets) and different products designed for certain breadmaking applications (frozen dough, continuous mix, flour brew/sponge and dough) are available.

Essential® SOFT II, SOFT V, SOFT VI, and ***SOFT VII*** are enzyme-based dough conditioners designed for improving crumb softness and extending shelf life of breads and buns.

Fermaid® PLUS, XTR, and ***ALPHA*** are bromate-free multipurpose dough conditioners that are convenient to use for improving bread quality.

LBI 2130 and ***LBI 2133*** are label-friendly dough relaxers based on inactive yeast that are used to reduce mixing time and improve dough machinability and pan flow in the production of breads and buns.

Formula Optimization *(Continued)*

competitive pressures. Often, it is possible to exchange one ingredient in a formula for another or to adjust levels of the various ingredients already in use, while reducing total costs and maintaining the same overall quality of a particular product. In this respect it is important to look at total formula costs and to realize that certain types of ingredients are more cost-effective than others (see Table).

Improving quality becomes important if product quality doesn't fully meet the consumer requirements and starts to affect sales.

Improving tolerance and consistency becomes important if there is too much variation in product quality, resulting in too much off-spec product that can only be sold at a lower price. Rejected products can become very costly for bakeries, so there is a tendency to use much higher levels of various ingredients than would be required if processes were better controlled. Yet, building in extra tolerance and consistency by adding more ingredients is usually not the best way to address this problem. Usually, not the normal variations will cause such costly product rejects, but the incidental (uncontrolled) variations or an improper response to such variations.

Making formulations more label-friendly becomes important when health-conscious consumers ask for cleaner labels. Additives like potassium bromate and several emulsifiers have already been banned in many countries, while issues like trans-fatty-acids, GMO, and allergens are becoming increasingly important.

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Lallemand Baking Update is produced by Lallemand Inc. to provide bakers with a source of practical technology for solving problems. If you would like to be on our mailing list to receive future copies, or if you have questions or comments, please contact us at:

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