POTASSIUM BROMATE has been the oxidizing agent of choice for American bakers because of its slow action, good oven spring, and high tolerance. Current baking technology has been developed around the use of bromate, and its voluntary or mandatory elimination poses a major challenge.

Bromate works on the gluten in flour to increase its strength and produce larger, more uniform finished products. It can be mixed into flour, added with yeast food to the sponge or brew stage, or added separately at mixing. No matter when it is added, bromate’s slow action means it works primarily during proofing and baking.

Most other oxidizing agents act faster than bromate, making them less versatile and effective. As a result, most bromate replacers have to use a combination of ingredients to control the amount and timing of oxidation. Here is a summary of ingredient pros and cons, with additional data given in the table below.

**Ascorbic acid** is a natural oxidizing agent that is probably the most widely used bromate replacer ingredient. It is label-friendly but gives longer mix times, less oven spring, and firmer crumb than bromate.

**Chemical oxidizing agents** include ADA, iodate, and calcium peroxide. They can be used to enhance the effectiveness of ascorbic acid but are faster, stronger oxidizing agents. They are not label-friendly and have less tolerance than ascorbic acid.

**Enzymes** are natural ingredients that can be used with ascorbic acid to enhance oxidation and compensate for its shortcomings. They improve oven spring, soften crumb, and are label-friendly. Enzymes (especially fungal enzymes) are more tolerant than chemicals, but their variety of functions and characteristics can make evaluation more complex.

**Other ingredients** include dough relaxers like cysteine and multipurpose conditioners like DATEM. These ingredients have characteristics that make up for ascorbic acid’s shortcomings but may also conflict with other dough conditioners and ingredients.

### Bromate Replacement Ingredients

<table>
<thead>
<tr>
<th>Compound</th>
<th>Function</th>
<th>Considerations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Potassium Bromate</td>
<td>Slow oxidizer</td>
<td>Used alone as the oxidative agent of choice</td>
</tr>
<tr>
<td>Ascorbic Acid</td>
<td>Intermediate oxidizer</td>
<td>Requires oxygen, so is less effective in continuous mix</td>
</tr>
<tr>
<td>Calcium Peroxide</td>
<td>Fast oxidizer</td>
<td>Usually used with ascorbic acid</td>
</tr>
<tr>
<td>ADA (Azodicarbonamide)</td>
<td>Fast oxidizer</td>
<td>Critical dosing with limited tolerance</td>
</tr>
<tr>
<td>Potassium and Calcium Iodate</td>
<td>Fast oxidizer</td>
<td>Critical dosing with limited tolerance</td>
</tr>
<tr>
<td>Oxidative Enzymes (lipooxygenase, glucose oxidase, sulfhydryl oxidase)</td>
<td>Form oxygen via hydrogen peroxide</td>
<td>Usually used with ascorbic acid</td>
</tr>
<tr>
<td>Carbohydrase Enzymes (fungal alpha-amylase, hemicellulase)</td>
<td>Act on starch and fiber during baking</td>
<td>Used with ascorbic acid to improve oven spring and freshness</td>
</tr>
<tr>
<td>Cysteine and Glutathione</td>
<td>Act on gluten during mixing to relax dough</td>
<td>Used with fast chemical oxidizers to shorten mix time and improve handling</td>
</tr>
<tr>
<td>Yeast Components</td>
<td>Natural source of glutathione and enzymes</td>
<td>Used with fast chemical oxidizers and enzymes for an all-natural system</td>
</tr>
</tbody>
</table>
**International Perspective:**  
**BRITISH BROMATE REPLACEMENT EXPERIENCE**

Bromate approval in Great Britain was withdrawn in 1990 with about one year's advance notice. The experience is interesting from an American perspective because Britain's baking industry is similar to the U.S. and Canada. It includes a large production of white pan bread by wholesale bakeries using high-speed equipment.

Iodates are not approved in Great Britain, and the most common replacer has been ascorbic acid. The most common problems have been increased mix time, incomplete dough development, poor gas retention, increased cripple rates, and faster staling. Direct costs for dough conditioners have increased about twenty percent with the use of ascorbic acid and the additional need for antistaling agents (emulsifiers and enzymes). Indirect costs for reformation and higher cripple rates have also increased.

Some of the British problems and costs are a result of the widespread use of the Chorleywood process. This process depends on mechanical dough development and takes place in the absence of air. Since air is required for ascorbic acid to work efficiently and iodates are not allowed, this application is especially challenging. The most similar American process is continuous mix, which also takes place in the absence of air and so presents some of the same problems.

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**Essential® PBR**

The Essential® PBR line of bromate replacers was developed based on the European experience with bromate-free baking and the British experience with bromate replacement. The products are derived from European bread improvers, but were developed in American bakeries for American recipes and processes.

Essential® PBR uses ascorbic acid to replace the oxidative action of bromate, and a combination of enzymes and yeast components to make up for ascorbate's shortcomings. The oxidative enzymes in Essential® PBR make ascorbic acid more effective by regenerating its active form when it's needed—during proofing and baking. The carbohydrase enzymes also act during proofing and baking to restore normal enzyme activity. The nonleavening yeast components contribute glutathione to restore normal mix time, dough development, and handling during makeup.

Essential® PBR is effective because it replaces the major functions of bromate in a balanced way with high tolerance. It is more forgiving during breakdowns and process changes than chemical systems that rely on stronger oxidizers. And because its fungal enzymes are inactivated during baking, it cannot cause stickiness or gumminess in the finished product.

Essential® PBR is an economical bromate replacement alternative. It's priced competitively against less effective chemical products, and it offers the potential for additional savings in recipes where it replaces other dough conditioners.

Essential® PBR is label-friendly because it contains only natural ingredients and is used with natural ascorbic acid. Because it does not rely on chemical components that may come under regulatory scrutiny in the future, Essential® PBR offers a long-term solution that may also avoid future reformulation and labeling costs.

Essential® PBR formulations are available for most products and systems, including sponge and dough, flour brew, straight dough, and frozen dough.

**Essential® PBR-200 DF**

A multifunctional bromate replacement system containing dough-improving yeast components and fungal enzymes (to be used with ascorbic acid and/or ADA).

**Essential® PBR-100**

A bromate replacement system to be used when there is no need for mix time reduction (to be used with ascorbic acid and/or ADA).

**Essential® PBR-30**

A bulk version bromate replacement system for ease of scaling (to be used with ascorbic acid and/or ADA).

**Essential® PBR-FD**

A bromate replacement system specially formulated for frozen dough.

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**Dough Oxidation Chemistry**

Flour proteins contain amino acids with reactive sulfhydryl groups. In the native or reduced state, the flour proteins exist as separate entities. During the oxidation process, pairs of sulfhydryls become linked together in disulfide bonds. Because each protein has several sulfhydryl groups, one protein can become linked to several other proteins resulting in the formation of a network of chemically bonded proteins.

This cross-linked network of protein molecules is the primary determinant of dough structure and rheology. The stretching and pulling that occurs during mixing is beneficial because it breaks some of the disulfide bonds so that they can be reformed during baking. The primary effect of bromate is probably to increase the number of cross-links, especially during baking.

The wheat variety, milling conditions, flour age, and baking process all affect dough oxidation chemistry. In general, low extraction older flours and dough processing require less oxidation. In general, high extraction younger flours with no-time dough processing require more.