Optimizing Chemical Leavening in Whole Grain Bakery Products

Sharon Book - June 25, 2015
Bakery Products

Muffins, biscuit, cakes, flour tortillas, doughnuts, pizza crust, pancakes, waffles, cookies, crackers, etc.
Bakery Ingredients

• Flour & water
  – Wheat – all purpose or whole grain
• Other ingredients to enhance
  – Sweeteners
    • Sugar, corn syrups, etc
  – Fats
    • Shortening, oil, margarine
    • Produce substitute (Applesauce, pumpkin)
  – Others
    • Milk
    • Eggs
  – Flavor
    • Vanilla, etc
  – Leavening
    • Chemical
    • Biological (yeast)
    • Mechanical (air incorporation)
What to do with ingredients?

- Measure
- Mix dry ingredient
- Combine wet and dry ingredients
- Form
- Bake
What is Chemical Leavening?

• A chemical reaction that results in the production of gas

• Leavening means to rise

• Baking Powder – the complete reaction
Why we need leavening
The leavening equation

\[ HX + NaHCO_3 \xrightarrow{\text{Heat}} \text{Heat} \xrightarrow{\text{Water}} \text{NaX} + H_2O + CO_2 \]

- Acid has many options and controls the reaction

[Image of Baking Soda box]
Profile of CO2 Release

Carbon Dioxide Release Amount

Product Set

Mixing  Formation  Holding  Baking
Leavening acid options

- Listed on ingredient statements (sometimes as part of leavening with sodium bicarbonate)
  - Monocalcium phosphate (MCP)
  - Cream of Tartar (tartaric acid)
  - Calcium acid pyrophosphate (CAPP)
  - Dicalcium phosphate dihydrate (DCPD)
  - Glucono delta lactone (GDL)
  - Sodium acid pyrophosphate (SAPP)
  - Sodium aluminum phosphate (SALP)
  - Sodium aluminum sulfate (SAS)
Leavening acid

• Differ in when and how they react
  – Some are fast
  – Some are slow
  – Some only react when heated

• Other acid sources
  – Buttermilk
  – Fruits
  – Vinegar
# Effect of AP:WW flour on muffin

<table>
<thead>
<tr>
<th>All purpose flour</th>
<th>Whole wheat flour</th>
<th>Height (mm)</th>
<th>Hardness (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>0</td>
<td>47.9</td>
<td>723</td>
</tr>
<tr>
<td>80</td>
<td>20</td>
<td>44.4</td>
<td>418</td>
</tr>
<tr>
<td>60</td>
<td>40</td>
<td>43.1</td>
<td>476</td>
</tr>
<tr>
<td>40</td>
<td>60</td>
<td>42.8</td>
<td>459</td>
</tr>
<tr>
<td>20</td>
<td>80</td>
<td>41.7</td>
<td>514</td>
</tr>
<tr>
<td>0</td>
<td>100</td>
<td>40.9</td>
<td>585</td>
</tr>
</tbody>
</table>
Flour and acid effect on muffin appearance

<table>
<thead>
<tr>
<th>Flour</th>
<th>All Purpose</th>
<th>Whole Wheat</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAPP</td>
<td><img src="image1" alt="Muffin" /></td>
<td><img src="image2" alt="Muffin" /></td>
</tr>
<tr>
<td>SAPP-28</td>
<td><img src="image3" alt="Muffin" /></td>
<td><img src="image4" alt="Muffin" /></td>
</tr>
<tr>
<td>MCP-SALP</td>
<td><img src="image5" alt="Muffin" /></td>
<td><img src="image6" alt="Muffin" /></td>
</tr>
</tbody>
</table>
# Flour and acid effect on muffin properties

<table>
<thead>
<tr>
<th>Flour/acid</th>
<th>Volume (ml/g)</th>
<th>Hardness (g)</th>
<th>Springiness</th>
<th>Cohesiveness</th>
<th>Width (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AP/CAPP</td>
<td>2.48</td>
<td>476</td>
<td>0.943</td>
<td>0.586</td>
<td>65.5</td>
</tr>
<tr>
<td>AP/SAPP-28</td>
<td>2.25</td>
<td>416</td>
<td>0.922</td>
<td>0.568</td>
<td>66.8</td>
</tr>
<tr>
<td>AP/MCP-SALP</td>
<td>2.33</td>
<td>564</td>
<td>0.943</td>
<td>0.620</td>
<td>66.8</td>
</tr>
<tr>
<td>WW/CAPP</td>
<td>2.42</td>
<td>583</td>
<td>0.886</td>
<td>0.524</td>
<td>66.2</td>
</tr>
<tr>
<td>WW/SAPP-28</td>
<td>2.27</td>
<td>508</td>
<td>0.858</td>
<td>0.515</td>
<td>68.7</td>
</tr>
<tr>
<td>WW/MCP-SALP</td>
<td>2.33</td>
<td>593</td>
<td>0.898</td>
<td>0.582</td>
<td>68.7</td>
</tr>
</tbody>
</table>
## Flour & acid effect on biscuit properties

<table>
<thead>
<tr>
<th>Flour/acid</th>
<th>Height (mm)</th>
<th>Hardness (g)</th>
<th>Springiness</th>
<th>Cohesiveness</th>
</tr>
</thead>
<tbody>
<tr>
<td>AP/SALP</td>
<td>35.7</td>
<td>361</td>
<td>0.869</td>
<td>0.632</td>
</tr>
<tr>
<td>WW/SALP</td>
<td>32.8</td>
<td>340</td>
<td>0.598</td>
<td>0.479</td>
</tr>
<tr>
<td>WW/CAPP</td>
<td>33.2</td>
<td>368</td>
<td>0.683</td>
<td>0.522</td>
</tr>
<tr>
<td>WW/SAPP-40</td>
<td>31.4</td>
<td>409</td>
<td>0.735</td>
<td>0.472</td>
</tr>
</tbody>
</table>
Conclusions

- Chemical leavening is a simple acid-base reaction
  - The base is sodium bicarbonate
  - The acid has many options to control the reaction and influence final product characteristics
- Ingredient changes of flour and acid have mixed effects on final product characteristics
  - Always test!
Legal Disclaimer

NOTICE: Although the information and recommendations set forth herein (hereinafter “Information”) are presented in good faith and believed to be correct as of the date hereof, ICL Performance Products LP makes no representations or warranties as to the completeness or accuracy thereof. Information is supplied upon the condition that the persons receiving same will make their own determination as to its suitability for their purposes prior to use. In no event will ICL Performance Products LP be responsible for damages of any nature whatsoever resulting from the use of or reliance upon Information or the product to which Information refers. Nothing contained herein is to be construed as a recommendation to use any product, process, equipment or formulation in conflict with any patent, and ICL Performance Products LP makes no representation or warranty, express or implied, that the use thereof will not infringe any patent.

NO REPRESENTATIONS OR WARRANTIES, EITHER EXPRESS OR IMPLIED, OR MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR OF ANY OTHER NATURE ARE MADE HEREUNDER WITH RESPECT TO INFORMATION OR THE PRODUCT TO WHICH INFORMATION REFERS. © 2015 ICL Performance Products LP. All rights reserved.