An Insight into On-Trend Applications of Whole-Grain: Frozen Dough Bread and Noodles

Suyong Lee
Department of Food Science & Technology
Sejong University
Seoul, Korea

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Whole grain

- Whole grains are cereal grains which are composed of the intact, ground, cracked or flaked caryopsis.
- They contain cereal germ, endosperm, and bran, in contrast to refined grains which retain only endosperm.
- US-FDA approved a whole-grain health claim for the foods containing 51 percent or more whole grains by weight.

Health benefits:

- Heart health
- Reduced cancer risk
- Diabetes management
- Weight management

<Grain anatomy>
Processing performance of whole-grain flour

- There is a lack of fundamental processing knowledge on whole-grain flour. → The application of whole-grain flour is still limited.
- Whole-grain foods has a tendency to have undesirable quality attributes, compared to refined flour products.

Why?

1. Less gluten and more fibers (dough stability, extensibility etc.)
2. Worse sensory qualities (odor, color, texture, etc.)

⇒ Therefore, there is a need to effectively improve the processing performance of whole-grain flour.
Research objectives

Evaluation of whole-grain flour as a functional ingredient in a processed food system

Characterization

→ Physicochemical characterization of refined white and whole-grain flours

Development

→ Application of whole-grain flour to frozen dough bread
→ Development of whole-grain noodles (extruded and instant fried noodles)

Improvement

→ Establishment of experimental procedures to improve the quality attributes of whole-grain products
## Chemical composition of whole-grain flour

<table>
<thead>
<tr>
<th>(%)</th>
<th>Moisture</th>
<th>Ash</th>
<th>Protein</th>
<th>Fat</th>
<th>CHO</th>
</tr>
</thead>
<tbody>
<tr>
<td>White wheat flour</td>
<td>13.05&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.56&lt;sup&gt;b&lt;/sup&gt;</td>
<td>13.13&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1.03&lt;sup&gt;b&lt;/sup&gt;</td>
<td>85.36&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Whole grain wheat flour</td>
<td>11.55</td>
<td>0.97&lt;sup&gt;a&lt;/sup&gt;</td>
<td>15.89&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.83&lt;sup&gt;a&lt;/sup&gt;</td>
<td>85.65&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>White rice flour</td>
<td>8.3&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.3&lt;sup&gt;b&lt;/sup&gt;</td>
<td>6.1&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.2&lt;sup&gt;b&lt;/sup&gt;</td>
<td>85.1&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Brown rice flour</td>
<td>8.2&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1.1&lt;sup&gt;a&lt;/sup&gt;</td>
<td>6.4&lt;sup&gt;a&lt;/sup&gt;</td>
<td>2.2&lt;sup&gt;a&lt;/sup&gt;</td>
<td>82.1&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
</tbody>
</table>
Whole-grain flours exhibited lower pasting profiles.
## Mixing properties of whole-grain dough

<table>
<thead>
<tr>
<th>Torque (Nm)</th>
<th>Control</th>
<th>50% Whole</th>
<th>100% Whole</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1</td>
<td>1.09±0.01a</td>
<td>1.10±0.03a</td>
<td>1.10±0.00a</td>
</tr>
<tr>
<td>C2</td>
<td>0.51±0.01a</td>
<td>0.46±0.01b</td>
<td>0.44±0.00b</td>
</tr>
<tr>
<td>C3</td>
<td>1.84±0.01a</td>
<td>1.78±0.01b</td>
<td>1.74±0.01c</td>
</tr>
<tr>
<td>C4</td>
<td>1.97±0.00a</td>
<td>1.89±0.03b</td>
<td>1.88±0.03b</td>
</tr>
<tr>
<td>C5</td>
<td>3.10±0.10a</td>
<td>3.08±0.03a</td>
<td>3.07±0.05a</td>
</tr>
</tbody>
</table>

| Water absorption (%) | 51.40±0.17c | 52.30±0.17b | 52.90±0.00a |
| Dough stability (min) | 9.84 ±0.03a  | 9.20±0.18b  | 8.74±0.09c  |
| Development time (min) | 7.94±0.91a   | 5.84±0.78b  | 5.69±0.43b  |
Rheological property of whole-grain dough

√ Whole-grain flour reduced the elastic property of dough (extensibility ↓, G’↓).
Frozen dough bread

The segment of ‘Bake off’ products that use frozen dough is one of the fastest growing areas at the industrial level.

<Straight-dough method (AACC 10-10)>

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Flour basis (%)</th>
<th>Shortening</th>
<th>Salt</th>
<th>Sugar</th>
<th>Yeast</th>
<th>Water</th>
<th>Ascorbic acid</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flour</td>
<td>300.0</td>
<td>9.0</td>
<td>4.5</td>
<td>18.0</td>
<td>3.0</td>
<td>182.47</td>
<td>200ppm</td>
</tr>
</tbody>
</table>

<Procedure>

Ingredients ➔ Mixing ➔ Dividing ➔ Freezing (-18 °C) ➔ 1st fermentation

Molding ➔ Punching ➔ 2nd fermentation ➔ Punching

Panning ➔ Proofing ➔ Baking ➔ Cooling
Computed Tomography

- 2D cross-sectional images of white and whole-grain bread

Porosity (%) = \[\frac{\text{Volume of void space}}{\text{Total volume of material}}\]

<table>
<thead>
<tr>
<th>(%)</th>
<th>Wheat bread</th>
<th>Whole wheat bread</th>
</tr>
</thead>
<tbody>
<tr>
<td>Closed porosity</td>
<td>4.60</td>
<td>3.62</td>
</tr>
<tr>
<td>Open porosity</td>
<td>79.49</td>
<td>60.40</td>
</tr>
<tr>
<td>Total porosity</td>
<td>80.43</td>
<td>61.84</td>
</tr>
</tbody>
</table>
Loaf volume and texture of frozen dough bread

The use of whole-grain flour produced bread with low loaf volume and firm texture.
Quality improvement of whole-grain bread

A new enzyme-based baking improver + Whole-grain wheat flour = Frozen dough bread

G4-amylase

- A novel enzyme used in this study is commercially called Optimalt 4G. (EC3.2.1.60; glucan 1,4-alpha-maltotetraohydrolase)
- Optimalt 4G hydrolyzes alpha-1,4 glucosidic bonds of conventional liquefied starch, producing high concentrations of maltotetraose.
  - Optimum pH : 5.0 – 5.5
  - Optimum temperature : 61 - 65°C
Maltooligosaccharide profiles of bread

< Control >

< G4-amylose 0.04 BMK >

< G4-amylose 0.08 BMK >

< G4-amylose 0.12 BMK >
Improvement of bread volume

The volume of bread was improved by G4-amylase, compared to other commercial improvers.
Anti-retrogradation mechanisms

- <Firmness>
- <Gelatinized starch>
- G4-amylase
- <Reduced molecular size>
- <Steric hindrance>
- <High hydroscopicity>

Graph showing hardness over time (days) with a 28% reduction.
Extruded noodles
(Brown rice flour)

Physicochemical characterization
- Chemical compositions
- Pasting property (Starch pasting cell)
- Thermo-mechanical property (Mixolab)
- Rheological property (Rheometer)

Instant fried noodles
(Whole wheat flour)

Functional characterization of noodles
- Antioxidant characteristics (DPPH, ABTS, and FRAP assays)
- Expansion ratio and breaking stress (Snapping test)
- Tensile property (Kieffer dough and gluten extensibility rig)
- Cooking loss
- Peroxide value
- In-vitro stimulated digestion (glucose release and pGI)
Application of brown flour to extruded noodles

< Twin-screw extruder >

< Antioxidant characteristics >

28-fold higher
Application of brown flour to extruded noodles

< Expansion ratio >

White rice noodles

Brown rice noodles

< Cooking loss >

- Brown rice noodles → greater cooking loss and lower extensibility
The quality attributes of brown rice noodles were distinctly enhanced by controlling extrusion parameters.
The fried noodles prepared with the whole-grain flour had a less porous structure, which contributed to reduced oil uptake during frying.
The use of whole-grain wheat flour was effective in suppressing the hydrolysis of starch in the noodles, lowering the predicted glycemic index.
Thank you