Impact of Milling Procedure on Breading Potential of Cassava Flour in Wheatless Breads

I. DEFOOR and J. A. DELCOUR

Several problems are associated with the partial or total substitution of wheat by cassava flour for the production of bread. It is clear that a gradual loss of gluten in the recipes leads to lower breading potential. In earlier work at this laboratory (Defloor et al. 1991), we investigated the role of emulsifiers and extruded starch as bread improvers in cassava bread. The flour used was from a homogeneous lot. Breads of acceptable quality were obtained using glyceryl monostearate or extruded starch as improving agents.

A review of the literature showed that, in papers describing the production of cassava wheatless (Kim and de Ruiter 1968, 1969; Kim 1971; Satin 1988) or composite flour breads (Olatunji and Akinrele 1978, Almazan 1990), processing dried cassava chip into flour was never considered. Apparently it was taken for granted that dried cassava would yield a constant quality flour for bread production.

The present undertaking was to study the impact of the milling procedure on the breading potential of cassava flour in wheatless bread recipes. Indeed, cassava starch and cassava flour have different breading potential (Kim and de Ruiter 1968). Thus, it could be argued that fractionation of cassava in different milling streams could yield a starch-enriched cassava flour particularly suitable for baking. Furthermore, the impact of the milling procedure on starch damage of the resulting flour and, subsequently, the baking performance is unclear.

Therefore, fractions obtained by milling cassava chips at two moisture levels with a Buhrer mill were analyzed and tested in wheatless bread recipes. Also evaluated was cassava flour obtained from chips that were ball- and hammer-milled.

MATERIALS AND METHODS

Materials

Materials used were described earlier (Defloor et al. 1991). Cassava chips were obtained from the International Institute of Tropical Agriculture (Ibadan, Nigeria), courtesy of Y. Jeon. Cassava roots, harvested 13 months after planting, were peeled, washed, chopped, and sun-dried. The final moisture content of the chips was 11.5%.

Milling of Cassava Chips

Chips were milled at 11.5 and 15.9% moisture level. Conditioning was carried out at room temperature by continuous mixing overnight to allow for a uniform distribution. Enough water was added to 20 kg of chips to obtain a final moisture content of 15.9%.

Roller mill. The chips were milled with a Buhrer MLU-202 laboratory roller mill (Uzwil, Switzerland) adjusted for soft wheat milling (method 26-31, AACC 1983). The milling flow sheet and flour sieves were as given in Delcourt et al. (1989).

Ball mill. Chips were ball-milled (30 g batches, 5 min) in a Heidelberg Colloidmühle (Hormuth-Vetter, Heidelberg, Germany). The flour obtained (15.9% mc) was sieved (aperture 1.5 mm) before use to remove remaining lumps.

Hammer mill. We used a President 4K (Ieper, Belgium) with a 1.5-mm sieve to hammer mill only chips of low moisture content.

Analyses of Flour Composition

Ash content (in duplicate) of the respective flours was determined according to method 08-01 (AACC 1983). The samples were incinerated at 560°C. Soluble and insoluble dietary fiber content were determined (in triplicate) according to the procedure described by Asp et al. (1983). Starch was determined enzymatically (in quadruplicate) according to the procedure described by Boehringer-Mannheim (1986). Percent damaged starch was determined according to method 76-30A (AACC 1983). Protein content was determined by a semimicro Kjeldahl method.

α-Amylase activity. The Phadebas colorimetric method (Analytica 1987) was used to determine the α-amylase activities of the flour samples. Six replicates were taken.

Pasting properties of flour. The Brabender visco-amylograph was used to study the pasting properties of the flour samples obtained under different conditions. Flour (50 g, 14% mc) was suspended in 450 ml of disodium phosphate-citric acid buffer solution, pH 5.30-5.35 (method 22-10, AACC 1983). The suspension was heated uniformly from 30 to 95°C, held at 95°C for 20 min, cooled to 50°C, and held for 20 min.

Gelatinization properties of flour. A Seiko DSC 120 instrument (Kawasaki, Kanagawa, Japan) was used to record the gelatinization properties of the flour samples. Samples were weighed in aluminum pans (Seiko, P/N 50-023) and heated at 2°C/min. The dry matter-buffer ratio was 0.47. Samples were run with the same buffer solution as the Brabender visco-amylograph.

Wheatless bread. Wheatless bread was prepared according to the procedures by Defloor et al. (1991). Loaves were baked with 80 g of cassava flour and 20 g of defatted soy flour. Glyceryl monostearate (3%) or extruded corn starch (12%) were incorporated in the formula to improve the gas retention capacity of the dough and the quality of the baked product.

RESULTS AND DISCUSSION

Analysis of Different Flours

The yields for the different milling streams of the roller mill are given in Table I.

B2 and B3 flour samples, as well as C2 and C3 flour samples, were mixed because the yields for these milling streams were low. In addition to break roll and reduction roll flours, we obtained two milling streams with fibrous material (F1 and F2) that corresponded to the traditional wheat terminology of bran and short fractions.

<table>
<thead>
<tr>
<th>TABLE I</th>
<th>Yields and Moisture Levels for Different Milling Streams of the Roller Mill for Cassava Chips</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milling Stream</td>
<td>Milled at 11.5% mc</td>
</tr>
<tr>
<td>Yield</td>
<td>Moisture</td>
</tr>
<tr>
<td>B1</td>
<td>27.5</td>
</tr>
<tr>
<td>B2</td>
<td>5.5</td>
</tr>
<tr>
<td>B3</td>
<td>1.5</td>
</tr>
<tr>
<td>C1</td>
<td>40.0</td>
</tr>
<tr>
<td>C2</td>
<td>11.5</td>
</tr>
<tr>
<td>C3</td>
<td>4.5</td>
</tr>
<tr>
<td>F1</td>
<td>8.0</td>
</tr>
<tr>
<td>F2</td>
<td>0.5</td>
</tr>
</tbody>
</table>

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TABLE II
Ash, Fiber, Starch, Damaged Starch, and Protein Contents* of the Flour Samples Obtained by Milling Cassava Chips Using Different Milling Techniques at 11.5% mc

<table>
<thead>
<tr>
<th>Flour</th>
<th>Ash</th>
<th>Soluble</th>
<th>Insoluble</th>
<th>Starch</th>
<th>Damaged Starch</th>
<th>Protein (N × 6.25)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roller mill</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B1</td>
<td>2.13</td>
<td>1.79 ± 0.48</td>
<td>2.73 ± 0.01</td>
<td>85.9 ± 0.7</td>
<td>13.5 ± 0.7</td>
<td>1.15 ± 0.01</td>
</tr>
<tr>
<td>B2+B3</td>
<td>2.15</td>
<td>1.42 ± 0.21</td>
<td>2.19 ± 0.04</td>
<td>88.6 ± 2.6</td>
<td>14.5 ± 0.5</td>
<td>1.23 ± 0.02</td>
</tr>
<tr>
<td>C1</td>
<td>2.43</td>
<td>2.65 ± 0.20</td>
<td>3.18 ± 0.17</td>
<td>85.9 ± 1.5</td>
<td>15.6 ± 0.3</td>
<td>1.39 ± 0.02</td>
</tr>
<tr>
<td>C2+C3</td>
<td>2.34</td>
<td>2.77 ± 0.14</td>
<td>4.19 ± 0.16</td>
<td>83.1 ± 1.1</td>
<td>14.8 ± 0.3</td>
<td>1.41 ± 0.01</td>
</tr>
<tr>
<td>F1</td>
<td>2.76</td>
<td>4.15 ± 0.04</td>
<td>11.80 ± 0.34</td>
<td>72.3 ± 0.7</td>
<td>nd*</td>
<td>nd</td>
</tr>
<tr>
<td>F2</td>
<td>3.25</td>
<td>3.11 ± 0.16</td>
<td>28.34 ± 2.37</td>
<td>61.6 ± 0.5</td>
<td>nd*</td>
<td>nd</td>
</tr>
<tr>
<td>Ball mill</td>
<td>2.30</td>
<td>2.96 ± 0.31</td>
<td>4.16 ± 0.55</td>
<td>84.4 ± 1.5</td>
<td>13.9 ± 0.2</td>
<td>1.33 ± 0.02</td>
</tr>
<tr>
<td>Hammer mill</td>
<td>2.38</td>
<td>2.40 ± 0.55</td>
<td>4.69 ± 0.34</td>
<td>nd</td>
<td>13.6 ± 0.3</td>
<td>1.60 ± 0.01</td>
</tr>
</tbody>
</table>

* Results expressed as % dry matter.

Millling of cassava chips at 11.5% mc resulted in lower yields of break roll flours (B1, B2, and B3) but higher yields of reduction roll flours than did milling carried out at 15.9% mc. The yields of F1 and F2 were also lower when the chips were milled at 11.5% mc.

The extraction yields (sum of break and reduction flours) for the milling at 11.5 and 15.9% mc were 91 and 87%, respectively.

Softer material (higher moisture content) was liberated more readily in the breaking stage and less in the reduction stage. These actions apparently compensated for each other, resulting in extraction yields that differed only to a small extent.

Ash, fiber, starch, damaged starch, and protein content of the flour obtained by milling cassava chips of 11.5% mc with different mills are listed in Table II. Similar results were obtained at the 15.9% mc milling experiment.

The insoluble fiber content of the C1, C2 + C3, ball mill, and hammer mill flour samples was higher than that in the break flour samples (B1 and B2 + B3). Differences in soluble fiber content between the flour samples were less pronounced. However, the C1, C2 + C3, ball mill, and hammer mill flour samples had slightly higher insoluble fiber content than the B1 and B2 + B3 flour samples. This was true at both chip moisture levels investigated. The soluble fiber content of the B1, B2 + B3, and C1 flours was slightly lower than the insoluble fiber content. This effect was more pronounced for the C2 + C3, ball mill, and hammer mill flour samples.

Gelatinization and Pasting Properties of the Flour Samples

Gelatinization enthalpies and peak temperatures, as measured by differential scanning calorimetry, did not vary with milling procedure.

The viscosity of flour suspensions at different steps of the heating and cooling cycle described above showed no significant differences attributable to the milling procedure applied. α-Amylase activity averaged between 2.0 and 5.4 units per 100 g of dry matter. It was slightly lower for the flour samples obtained from chips milled at 15.9% mc. This was more pronounced for the C1, C2 + C3, and ball mill flour samples.

We suspect that the α-amylase data did not correlate with the peak viscosity results because the levels of α-amylase were not significantly different; they were too low to be expected to have a relevant effect on the starch pasting properties.

Wheatless Bread

The breadmaking capacity was not significantly altered by milling conditions. No real differences in crumb structure were observed for either the 3% glyceryl monostearate or the 12% extruded corn starch formulas. Loaves were comparable to those obtained earlier (Defloor et al. 1991). Loaves obtained with hammer-milled flour showed a slightly greyish crumb color in contrast to the yellowish crumb color of loaves from flour obtained by other milling procedures.

Even with some noticeable differences in loaf volumes, no clearly important improvement in crumb structure was observed for the different flour samples.

CONCLUSION

The differences in milling procedures of cassava chips affected analytical data (ash, fiber, starch, and protein content), α-amylase activity, starch damage, pasting and gelatinization properties, and breadmaking potential to only a limited extent.

LITERATURE CITED


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