Impact of Processing on the Stability and Bioaccessibility of Pro-Vitamin A Carotenoids in Biofortified Cassava Roots (Manihot esculenta, Crantz)

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Abstract

Carotenoid content in cassava roots has been increased through biofortification programs as a strategy to combat vitamin A deficiency. However, the stability of biofortified cassava into both traditional and industrial food processing has yet to be fully assessed. The objective of this study was to examine the impact of fermentation and thermal processing on the stability and bioaccessibility of pro-vitamin A carotenoids from distinct biofortified cassava roots. Unfermented (UF) and fermented (F) flours were produced from 10 biofortified cassava cultivars (Table 1 & Figure 2). Gas (G) flours were produced by heating two of the fermented cultivars above 150-160°C during 10-20 min. Test portions were prepared with UF, F and G (22.2% W/W) in boiling water for 5 min. Bioaccessibility of pro-vitamin A carotenoids was then evaluated from finished products using a three-stage in vitro digestion model (Figure 3). Overall, cassava cultivars contained 23.4±12.7 μg of β-carotene equivalents (μg BCE) g⁻¹ on dry weight basis (dw). BCE retention after fermentation was 72.6±2.9% after oven-drying were 18.3-77.3% and 45.8-80.4% for UF and F roots, respectively; after boiling in Gari preparation was 67.7-88.3%, after cooking in porridge preparations were 42.7-74.5%, 20.7-77.3% and 87.2-110.3% for UF, F and G, respectively (Figure 4 & 5). Cassava flours, which involved fermentation showed lower β-CCE content (μg BCE g⁻¹ on dry dw) during oven-drying than with UF flours. However, no significant differences were found in β-CCE retention during porridge preparation (p>0.05). Test portions made from UF, F and G flours ranged from 18.4-67 μg BCE g⁻¹ of 100 g FW with bioaccessibility content ranging from the porridge groups ranging from 3.3-4.4, 3.6-5.1 and 20.5-36.5 μg BCE g⁻¹ of 100 g FW for UF, F and G, respectively (Figure 6). In general, bioaccessibility β-CCE content from porridge prepared with UF and F flours were similar with levels of 15-18 μg BCE g⁻¹ of 100 g FW (p>0.05). Select cultivars showed improved bioaccessibility of β-CCE content with the fermentation process, these results suggest that genotype factor and/or another factors in the matrix merit further investigation as they may play a significant role in facilitating bioaccessibility of carotenoids from biofortified cassava products.

Introduction

Vitamin A deficiency (VAD) affects approximately 190 million preschool-age children and 19 million pregnant women globally.1 VAD is the primary cause of blindness in children, as well as stunting of growth and contributing to morbidity and mortality in these populations. 2 Biofortification of staple crops is one of the strategies proposed to address VAD along other strategies such as supplementation and fortification. Biofortification is a strategy focused on developing of nutrient dense staple crops (e.g. increased pro-vitamin A carotenoids content) that can be leveraged as cost-effect alternative to combat vitamin A deficiency. The strategy is able to incorporate biofortification into the current food systems by developing into traditional and industrial food preparations. Insights into acceptability by consumers as well as recovery/bioaccessibility of pro-vitamin A carotenoids in these foods is lacking.

Cassava (Manihot esculenta Crantz) is a staple crop consumed for more than 70 million people in developing countries and has been included into biofortification programs with the goal of increasing its pro-vitamin A carotenoid content.2 Cassava roots are traditionally subjected to both thermal and fermentation processes in order to minimize cyanogen content, extend shelf-life and facilitate marketing of cassava products in urban areas. However, the impact of such processes on retention of provitamin A biofortified cassava is not well understood.

Objective

The specific objective of this study was to examine the impact of fermentation and thermal processing on the stability and bioaccessibility of pro-vitamin A carotenoids from a selected group of biofortified cassava roots.

Materials & Methods

Table 1: Cassava root cultivars

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>Raw</th>
<th>Fermentation</th>
<th>Oven-Drying</th>
<th>Porridge</th>
</tr>
</thead>
<tbody>
<tr>
<td>GM 4414-6</td>
<td>31.2 ± 2.4</td>
<td>18.8 ± 0.9</td>
<td>6.5 ± 0.2</td>
<td>6.5 ± 0.2</td>
</tr>
<tr>
<td>GM 4473-1</td>
<td>32.0 ± 0.7</td>
<td>17.7 ± 0.4</td>
<td>6.5 ± 0.2</td>
<td>6.5 ± 0.2</td>
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<tr>
<td>GM 5194-5</td>
<td>24.6 ± 0.7</td>
<td>15.6 ± 2.6</td>
<td>6.5 ± 0.2</td>
<td>6.5 ± 0.2</td>
</tr>
<tr>
<td>GM 5194-13</td>
<td>23.8 ± 0.7</td>
<td>16.5 ± 2.6</td>
<td>6.5 ± 0.2</td>
<td>6.5 ± 0.2</td>
</tr>
<tr>
<td>GM 5212-6</td>
<td>32.8 ± 0.7</td>
<td>17.7 ± 0.4</td>
<td>6.5 ± 0.2</td>
<td>6.5 ± 0.2</td>
</tr>
<tr>
<td>SM 3575-75</td>
<td>24.6 ± 0.7</td>
<td>15.6 ± 2.6</td>
<td>6.5 ± 0.2</td>
<td>6.5 ± 0.2</td>
</tr>
<tr>
<td>SM 3793-43</td>
<td>23.8 ± 0.7</td>
<td>16.5 ± 2.6</td>
<td>6.5 ± 0.2</td>
<td>6.5 ± 0.2</td>
</tr>
<tr>
<td>SM 3793-15</td>
<td>23.8 ± 0.7</td>
<td>16.5 ± 2.6</td>
<td>6.5 ± 0.2</td>
<td>6.5 ± 0.2</td>
</tr>
<tr>
<td>SM 3793-84</td>
<td>23.8 ± 0.7</td>
<td>16.5 ± 2.6</td>
<td>6.5 ± 0.2</td>
<td>6.5 ± 0.2</td>
</tr>
</tbody>
</table>

Results

Figure 2. Cassava root processing

Dry 40°C, 24h – Unfermentedfermented
Sieved 30 mesh – Grated (Parcel)
Grated (Fine) – Washed
Grated (Coarse) – Toasted 150°C, 30 min
Dried 40°C, 24h – Grated (Parcel)
Grated (Fine) – Washed
Grated (Coarse) – Toasted 150°C, 30 min

Figure 3. Three stages in vitro digestion

Unfermented flour (UF): Cassava flour, which involved fermentation showed lower β-CCE content during oven-drying than with UF flours. However, no significant differences were found in β-CCE retention during porridge preparation (p>0.05). Test portions made from UF, F and G flours ranged from 18.4-67 μg BCE g⁻¹ of 100 g FW with bioaccessibility content ranging from the porridge groups ranging from 3.3-4.4, 3.6-5.1 and 20.5-36.5 μg BCE g⁻¹ of 100 g FW for UF, F and G, respectively (Figure 6). In general, bioaccessibility β-CCE content from porridge prepared with UF and F flours were similar with levels of 15-18 μg BCE g⁻¹ of 100 g FW (p>0.05). Select cultivars showed improved bioaccessibility of β-CCE content with the fermentation process, these results suggest that genotype factor and/or another factors in the matrix merit further investigation as they may play a significant role in facilitating bioaccessibility of carotenoids from biofortified cassava products.

Conclusions

Both thermal and fermentation processes retained β-carotene content. Fermented cassava showed higher β-carotene retention after oven-drying (p<0.001) in comparison to unfermented cassava. However, no significant difference (p>0.05) was observed either in the bioaccessibility or total carotenoids content. This significant difference (p<0.05) in the total β-carotene equivalent retention was observed between fermented and unfermented biofortified cassava roots when they were processed into porridge. Gas processing however, seems to promote higher retention and bioaccessibility of β-carotene equivalents.

Selected cassava cultivars showed higher bioaccessibility of pro-vitamin A carotenoids following the fermentation process, suggesting that genotypic and/or another factors merit further investigation for their role in facilitating carotenoid stability and bioaccessibility from biofortified cassava products.

Acknowledgments

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References