Carotenoid retention and vitamin A activity in dried orange-fleshed sweet potato that is cooked, fried or stored

Aurélie Bechoff\textsuperscript{1}, Keith Tomlins\textsuperscript{1}, Claudie Dhuique-Mayer\textsuperscript{2} & Andrew Westby\textsuperscript{1}

\textsuperscript{1}Natural Resources Institute, UK;  \textsuperscript{2}CIRAD, France
Background

- Provitamin A carotenoids (pVACs) important for health
- Visible trait (yellow or orange)
- pVACs can be degraded during cooking or processing
Issues

• Provit. A retention
  – after storage of dried OFSP?
  – after food preparation using dried OFSP (flour)?

• Little information in the literature (i.e. regarding the developing countries situation)
Background

• Main preparation of SP in Africa: boiling, steaming & drying
• Drying: facilitate transport & storage during off-season.
• Variety of products can be made from dried sweet potato
Dried & stored chips

Carotenoid loss
- Drying
- Storage
- Food preparation

Roots

Drying

Preparation

Dried chips

Food ready for consumption

Storage

Dried & stored chips
• Two studies; 1 storage; 1 food preparation - Journal publications:
  • *Journal of Agricultural & Food Chemistry* (2011)
  • *Food Chemistry* (2010)
• part of PhD thesis (2006-2010)

Storage study

Storage under controlled conditions

Ugandan dried chips (Ejumula variety)

- 4 temperatures (10; 20; 30; 40°C)
- 4 aw (0.1; 0.3; 0.5; 0.7)
- 4 oxygen levels: 0% (N₂), 2.5% et 10% O₂, 21% (air)

Kilner jar (metal lever catch and rubber seal)

Humidity sensors

Sweet potato chips in thin cotton fabric bag

Saturated salt solution

Top-cut plastic Cup
Carotenoid degradation during storage was influenced by temperature (T): Arrhenius model

\[
\ln \frac{C}{C_0} = -kt
\]

1st order kinetic

\[
k = k_\infty e^{-\frac{Ea}{RT}}
\]

Arrhenius equation

- \(k\) = constant degradation (day\(^{-1}\))
- \(Ea\) = Activation energy (kJ.mol\(^{-1}\))
- \(R\) = universal molar gas constant

Experimental data validated model

- 4.3 % difference
- 9.3 % difference

88 days at ambient temperature (recorded) in laboratory

125 days at ambient temperature (recorded) in Uganda
Chemical degradation of trans-B-carotene

Trans-β-carotene

\[ \text{Trans-β-carotene} \rightarrow k_1 \rightarrow 13\text{-cis-β-carotene} \]

\[ \text{Trans-β-carotene} + \frac{1}{2} O_2 \rightarrow k_2 \rightarrow β\text{-carotene-5,8-epoxide} \]

\[ β\text{-carotene-5,8-epoxide} + \frac{1}{2} O_2 \rightarrow k_3 \rightarrow \text{unidentified} \ β\text{-carotene-epoxide} \]

\[ \text{Trans-β-carotene} + O_2 \rightarrow k_4 \rightarrow β\text{-apo-8′-carotenal} \]

\[ β\text{-apo-8′-carotenal} \rightarrow k_5 \rightarrow β\text{-apo-10′-carotenal} + β\text{-cyclocitrinal} \]

\[ β\text{-apo-10′-carotenal} + O_2 \rightarrow β\text{-ionone} \]

\[ β\text{-ionone} \rightarrow k_6 \rightarrow 5,6\text{-epoxy-β-ionone} \]

\[ β\text{-ionone} + \frac{1}{2} O_2 \rightarrow k_7 \rightarrow \text{dihydroactinidiolide} \]
Effect of temperature, aw and oxygen

Fewest carotenoid breakdown
- Lowest temperature
- Highest aw
- Lowest oxygen level
Conclusion for storage study

- Carotenoid degradation in dried sweet potato could be predicted
- Degradation was fast under ambient conditions (about 70% after 4 months).
Food preparation study

Food preparation

- 2-week field study (Feb-Mar10) in Uganda funded by NRIF
- Interview of 10 chapatti processors and 10 porridge makers (households)
- Samples made by processors using the same initial ingredients (30% Ejumula flour)
- Explore the variability between processors and influence of cooking parameters on carotenoid retention
Findings: food preparation

• Whilst the retention of trans-B-carotene varied in the methods of preparation (chapattis or porridge), there was no impact of method on carotenoid retention: 69-93% or 70-97% respectively for chapattis and porridge

• Both could provide significant provit. A to diet
<table>
<thead>
<tr>
<th>OFSP&lt;sup&gt;1&lt;/sup&gt; product</th>
<th>Fat (%)</th>
<th>BC content (µg·g&lt;sup&gt;-1&lt;/sup&gt;)</th>
<th>BC bioaccessibility (%)</th>
<th>Unit</th>
<th>Recommended Daily Allowance (RDA)</th>
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</thead>
<tbody>
<tr>
<td></td>
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<td></td>
<td>Classical estimate&lt;sup&gt;5&lt;/sup&gt;</td>
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<td>Estimate taking into account bioaccessibility (in vitro digestion of product)&lt;sup&gt;6&lt;/sup&gt;</td>
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<tr>
<td>Boiled OFSP</td>
<td>-</td>
<td>95.0 ±2.4</td>
<td>7.4 ±0.2</td>
<td>43.5±4.5</td>
<td>Puree portion (100g)</td>
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<tr>
<td>Porridge</td>
<td>-</td>
<td>8.7 ±0.3</td>
<td>1.2 ±0.1</td>
<td>16.3±0.9</td>
<td>30.3±6.1</td>
</tr>
<tr>
<td>Chapati</td>
<td>7.4 ±1.0</td>
<td>31.5 ±1.4</td>
<td>2.5 ±0.5</td>
<td>72.7±5.4</td>
<td>96.2±5.9</td>
</tr>
<tr>
<td>Mandazi</td>
<td>3.3 ±0.2</td>
<td>32.9 ±1.7</td>
<td>3.7 ±0.4</td>
<td>49.0±3.0</td>
<td>98.1±7.7</td>
</tr>
</tbody>
</table>

*< 6 years (to meet 400RE); **pregnant or lactating (to meet 800RE)

Fat: better absorption of pVACs
100% wheat flour chapatti

70% wheat flour / 30% Ejumula flour chapatti
Overall conclusions/recommendations

- Losses can be as high as 70% after 4 months of storage but degradation can be predicted based on temperature; humidity and oxygen (air) data. **Packaging (i.e. under vaccum) will be critical to limit air into the product.**

- Losses can be as high as 30% during food preparation. Boiled sweet potato, or porridge and chapattis made from freshly dried SP flour could provide a significant amount of provitamin A to the diet (1/2 chapatti/day or 2 mugs of porridge/day or 100g of puree = 50% RDA).

- **Fat** (chapatis or mandazis) is **good** for increasing the absorption of pVACs and therefore the nutritional benefit.
Acknowledgments

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