Determination of β-carotene by High Performance Liquid Chromatography in Six Varieties of Mango (Mangifera indica L) from Western Region of Burkina Faso

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Abstract Six varieties of mangoes (Amelia, Brooks, Kent, Keitt, Lippens, Springfield) harvested from different pedological areas of the western region of Burkina Faso (Bobo-Dioulasso, Orodara, Banfora) were analyzed by high performance liquid chromatography in order to determine the β-carotene content. The study revealed a variability in β-carotene content between different varieties and regions. The Amelia variety is the richest in β-carotene content and is a good source of provitamin A.

Keywords: β-carotene, mangoes, liquid chromatography, vitamin A


1. Introduction

Micronutrient deficiency is a major worldwide public health problem. It is estimated that more than two billion people of all ages are affected to different degrees by micronutrient deficiencies, particularly iron, vitamin A, iodine and zinc (Le Bihan et al., 2002; Von Braun, 2005). According to WHO estimations, about 250 million children of school age are deficient in vitamin A and almost 500,000 become blind every year (Bendech et al., 2000). In French speaking countries in West Africa alone, it is estimated that vitamin A deficiency (VAD) contributes to 57,000 deaths among children aged from 6 to 59 months (MLaren and Frigg, 2002). Burkina Faso is one of the most affected countries due to gradually deteriorating nutritional status (Department of Nutrition, 2005), and is classified by WHO as one of the 39 countries in which vitamin A deficiency is a major public health problem (WHO / UNICEF / IVACG, 1998). Recent studies conducted in Burkina Faso showed that vitamin A deficiency (VAD) is still a public health problem (Nana et al., 2005; Hotz et al., 2012). One of the strategies to alleviate VAD is the promotion and the consumption of foods rich in vitamin A and provitamin A. Animal sources are inaccessible to population due to the increasing poverty. Vegetable sources are more available and seasonal. So consumption of vegetables is more prone to success and is favored by governments and NGOs.

The burden of VAD in Burkina Faso is tackled mainly by the distribution of vitamin A capsules during National immunization days and fortification of staple foods. It should be noted that distribution programs targeted populations of children aged from 0 to 5. Edible, fortified oils and foods are not affordable to target populations due to poverty in our countries. Promoting the production of foods rich in carotenes and consuming these are considered as a sustainable strategy in a country such as Burkina Faso. Provitamins A are found in dark-green vegetables orange-fleshed potatoes, red palm oil and especially in seasonal fruits. Several studies have shown their interest in the care and prevention of vitamin A deficiency (Zagré et al, 2003; Millset et al., 2009; Nana et al., 2005; Zéba et al., 2006). Moreover, in Africa 70-90% of dietary vitamin A comes from carotenoids (Bendech et al., 2000). Among the provitamin A carotenoid, beta-carotenes are by far those that contribute most to the vitamin A activity of plants (MLaren and Frigg, 2002).

The mangoes are seasonal fruit of the tropics which are consumed in harvest times. Compared to other sources of vitamin A, mango is characterized by a low production cost, a significantly high content in β-carotene, improved bioavailability of β-carotene compared to vegetables (Chen and Chen, 1993) and direct consumption even without being cooked. In Burkina Faso, more than thirty varieties of mangoes have already been identified.

The purpose of this study is to compare the carotenoid content of six (6) varieties of mangoes in three different
pedological characteristic regions namely Bobo-Dioulasso, Orodara and Banfora.

2. Materials and Methods

2.1. Materials and HPLC Conditions

Analytical standards of lycopene (LYCO), zeaxanthin (ZEA), cryptoxanthin (CRYP), echinone (ECHI) and β-carotene (BCAR) were obtained either from Sigma (Germany), or a generous gift from Hoffmann-La Roche (Basel, Switzerland). HPLC grade of methanol, acetonitrile, dichloromethane and hexane were from Sigma (France).

Mangoes were harvested from April to July. The following varieties of mangoes (Anacardiaceae) have been studied: Mangifera indica var. Amelia, Mangifera indica var. Brooks, Mangifera indica var. Kent, Mangifera indica var. Keitt, Mangifera indica var. Lippens, Mangifera indica var. Springfield. All the varieties are not found in all the pedological regions. The samples of mangoes were more or less similar as regards their maturity status in the pedological regions. The samples of mangoes were more or less similar as regards their maturity status in the pedological regions namely Bobo-Dioulasso, Orodara and Banfora.

2.2. Methods

2.2.1. Extraction of Carotenoids from Samples of Mangoes

Mangoes weighed, then butchered, crushed and kneaded with a mixer grinder (Moulinex®). The extracts for analysis were prepared as follows: one (1) g of the grounded product is mixed with 1 mL hexane, 1 mL of sodium chloride (3M) and 1 mL ethanol; a stirrer (Vortex®) is used to stir the whole for 2 min. The mixture was then centrifuged at 3000 rpm / min for 5 min at -5°C (Jouan®) to separate the hexane phase containing carotenoids and the aqueous phase. A pipette is used to remove and collect the hexane phase in a small Pasteur test tube. A second extraction is done through the same procedure. The hexane phases are mixed, homogenized and 1 mL mixture is removed and evaporated under nitrogen flux. The residue obtained after evaporation is dissolved in 1 mL of acetonitrile and injected into the chromatograph after being thoroughly mixed. Two injections are performed and the average area value for the calculation of β-carotene content is considered Somé et al (2004), Mills et al (2009).

2.2.2. Chromatographic Analysis

The chromatographic system consists of a JASCO PU-980 pump (Tokyo, Japan) equipped with a 20 μL loop injection, a chromatographic column Supelcosil LC-18 (Bellefonte, USA) of 25 cm length, 4.6 mm in diameter and a particle size equal to 5 μm. The mobile phase used is a ternary mixture consisting of acetonitrile (70% v/v), methanol (20% v/v) and dichloromethane (10% v/v). The mobile phase flow rate was set at 2 mL per minute. The carotenoid detection was carried out at 450 nm with a UV detector JASCO 975 (Tokyo, Japan). The system is coupled with a computer system and data processing software (Galaxy WorkStation). The measurement of the optical density (OD) of standard solutions was done with a UV-visible spectrophotometer A-160 Type CECIL (UK).

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3. Results and Discussion

The weights and the percentage of pulp (w/w) for samples of mangoes from different varieties and pedological regions were estimated (Table 3). In the three areas, the Springfield variety is the weightiest one followed by the Kent and Keitt varieties. The Lippens variety presented the lowest weight. Except for Lippens, the mangoes from Banfora are heavier compared to the two other areas. However, the proportion of pulp was relatively homogeneous for all the samples (p > 0.05).

When we consider the three regions, we can find out that Orodara area has the highest frequency of varieties with the highest β-carotene content: three out of the six varieties (Kent, Lippens, and Amelia). The samples of these varieties from Orodara are more concentrated in β-carotene compared to those collected in Banfora and Bobo-Dioulasso. As regards the β-carotene contents of the three regions in mangoes the details are shown in Table 4. The Amelia variety is the most concentrated in β-carotene in Banfora and Orodara and the Brooks in Bobo-Dioulasso. In the region of Bobo-Dioulasso, the Brooks variety has the highest content. Samples of the Brooks variety harvested in this area are more concentrated in β-carotene than those from Orodara and Banfora. But, except for the Brooks variety, the region of Bobo-Dioulasso showed the lowest concentration in β-carotene for all the other varieties. The highest concentration was found for Amelia in Orodara.

Table 3. Average weight of mangoes and their pulp (in bracket) from the 3 pedological regions

<table>
<thead>
<tr>
<th>Mango variety</th>
<th>Bobo-Dioulasso</th>
<th>Orodara</th>
<th>Banfora</th>
</tr>
</thead>
<tbody>
<tr>
<td>Springfield</td>
<td>628 ± 59 (74 ± 6)</td>
<td>650±83 (74 ± 4)</td>
<td>709±185 (81±2)</td>
</tr>
<tr>
<td>Kent</td>
<td>398 ± 43 (75 ± 5)</td>
<td>464 ± 47 (79 ± 1)</td>
<td>560 ± 173 (80 ± 4)</td>
</tr>
<tr>
<td>Keitt</td>
<td>391 ± 55 (81 ± 1)</td>
<td>497 ± 8 (77±5)</td>
<td></td>
</tr>
<tr>
<td>Brooks</td>
<td>312 ± 33 (73 ± 4)</td>
<td>298 ± 36 (67 ± 6)</td>
<td>333 ± 48 (71 ± 1)</td>
</tr>
<tr>
<td>Amélie</td>
<td>287 ± 69 (75 ± 3)</td>
<td>287 ± 69 (76 ± 3)</td>
<td>467 ± 87 (80 ± 1)</td>
</tr>
<tr>
<td>Lippens</td>
<td>280 ± 19 (74 ± 5)</td>
<td>251 ± 40 (75 ± 2)</td>
<td>254 ± 27 (79 ± 4)</td>
</tr>
</tbody>
</table>
Table 4. β-carotene content in the six varieties of mangoes from the three pedological regions

<table>
<thead>
<tr>
<th>Mango variety</th>
<th>Bobo Dioulasso</th>
<th>Orodora</th>
<th>Banfora</th>
</tr>
</thead>
<tbody>
<tr>
<td>Springfield</td>
<td>0.421 ± 0.067</td>
<td>0.431 ± 0.115</td>
<td>0.702 ± 0.218</td>
</tr>
<tr>
<td>Kent</td>
<td>1.212 ± 0.258</td>
<td>2.044 ± 0.637</td>
<td>1.703 ± 0.665</td>
</tr>
<tr>
<td>Brooks</td>
<td>1.984 ± 0.423</td>
<td>1.512 ± 0.439</td>
<td>1.297 ± 0.212</td>
</tr>
<tr>
<td>Lippens</td>
<td>0.815 ± 0.502</td>
<td>1.344 ± 0.242</td>
<td>0.850 ± 0.365</td>
</tr>
<tr>
<td>Keitt</td>
<td>ND</td>
<td>0.577 ± 0.153</td>
<td>0.763 ± 1.40</td>
</tr>
<tr>
<td>Amelia</td>
<td>1.068 ± 0.109</td>
<td>5.442 ± 0.800</td>
<td>3.952 ± 0.654</td>
</tr>
</tbody>
</table>

ND: Not Determined

These concentrations in β-carotene for the Keitt and Springfield varieties cultivated in Burkina Faso are lower than those reported by Mercadante in Brazil who found concentrations of 1.500 ± 0.200 mg/100 g (Mercadante and Rodriguez-Amaya 1998). The pedological area therefore influences the quantitative composition in β-carotene. A significant difference between the levels of β-carotene can be found depending on the geographical origin in Kenya Muoki et al., (2009) and Brazil (Mercadante and Rodriguez-Amaya 1998).

The variation of β-carotene content between the different varieties was also revealed in this study. The Amelia and Kent varieties are the richest in β-carotene with respective values of 3.487 ± 1.932 mg/100 g and 1.653 ± 0.638 mg/100 g. The lowest values are found for the Springfield variety whose β-carotene content is 0.518 ± 0.195 mg/100 g. A statistical difference was found between varieties (p < 0.05) in β-carotene content. In previous studies, Amelia and Brooks varieties were found to have respective content of β-carotene of 1.260 ± 0.090 mg/100 g and 1.290 ± 0.220 mg/100 g in ripe fresh mangoes Zagre et al., (2003), which values match those of this study (1.597 ± 0.464 mg/100 g). The content found in the Springfield variety in the three (3) regions seems to be comparable with those reported elsewhere Muoki et al. (2009). The β-carotene content of mango is related to several factors including the genetic, the stage of maturity, climate and the geographical location of production and cultivation techniques used (Mercadante and Rodriguez-Amaya 1998), Muoki et al., (2009), (Rodriguez-Amaya 1997), Nestel et al., (2006).

In comparison with other sources, the β-carotene content in the varieties was higher than those found in fruits like banana (0.04 mg – 0.1 mg/100 g), grapes (0.006 – 0.150 mg/100 g) and watermelon (0.228 – 0.324 mg/100 g) (UNICEF 1998). However, these contents were lower than the content reported by Tawata et al. (2003) in carrot (Daucus carota: 7.8 mg/100 g). Furthermore, the Kent variety in Orodora and Banfora and the Brooks variety in Bobo-Dioulasso and Banfora had similar content compared to potato (1.9 - 2.3 mg/100 g) and spinach (2.2 mg/100 g). The concerned varieties for potato are: Ipomoea batata var. Jewel, Ipomoea batata var. Narumintang, Ipomoea batata var. Caromex Niger Somé et al., (2004).

Based on its β-carotene content, 100 g of the Amelia variety provides retinol equivalent (RE) of 582 µg; the Springfield strain is the one that provides the delivery of the least important retinol equivalent with 86 RE. The daily requirement is around 450-500 µg RE and the consumption of only 100 g of the Amelia variety mango can cover a daily requirement that provides efficient biotransformation from carotene to retinol is done.

Furthermore, no correlation between the weight of mango and β-carotene content was found. The Springfield variety with the lowest content of β-carotene has the most important weight in the 3 regions. On the other hand, the Amelia that is the richest one variety in β-carotene is found to have the lowest weight. The β-carotene content from a mango is not linked to its weight percentage of pulp.

4. Conclusion

The study showed that the β-carotene content depends on the varieties of mango and the area of growth. This variability is attributable to several factors including differences in plant genetic material, stage of maturity, climate and the geographical location of production and cultivation techniques that are used. The Amelia variety is the richest one in β-carotene content and Orodara is the region with the richest varieties of mangoes. Promotion of culture and consumption of this variety of mango would enhance and meet the need for vitamin A in general and that of the region of Bobo Dioulasso in particular are the poorest one in β-carotene. However, The Springfield variety has the highest mass values. No correlation was found between the mass of the mango and carotenoid content. High acceptability of mango, especially for young children, is a definite advantage for the promotion of its consumption in the intervention programs.

References


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