ANALYSIS OF ELEMENTS IN COMMON BEAN (*Phaseolus vulgaris* L.) THAT PROMOTE AND INHIBIT IRON ASSIMILATION


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INTRODUCTION

Common bean seeds contain antinutritional compounds, such as proteinase inhibitors, saponins, polyphenols and phytates that reduce the nutritional potential by diminishing digestibility or nutrients bioavailability. Phytates and some phytate degradation products as well as iron-binding polyphenols are well-known inhibitors for minerals absorption, particularly non-heme iron (2, 11). However, there are other compounds that can enhance iron absorption or reverse the effect of dietary inhibitors (2, 5) such as ascorbic acid (4, 5), EDTA (8) or by degradation or removal of phytic acid (7, 12). The analysis of elements that promote and inhibit iron assimilation in bean has been oriented mainly to seeds; however, understanding the levels of these elements in bean leaves considering the high levels of iron found in this plant structure, would provide valuable information to nutritional breeding programs about, not only the actual iron content, but also regarding other components that would make this microelement bioavailable. The objective of this study was to compare total phytate, tannins and ascorbic acid contents in leaf and seed in four bean cultivars and plant developmental stages, in order to establish those elements and levels that are critical in bean consumption.

MATERIALS AND METHODS

Leaves (L) and seeds (S) of 4 cultivars: Flor de Junio Marcela (FJM), Azufrado Higuera (AH), Negro Jamapa (NJ) and Pinto Villa (PV) were sampled in four different developmental stages; 50% flowering (EI), pod seed filling (EII), full pod filling (EIII) and physiological maturity (EIV). Sampling was done in four replicates; all tissues were lyophilized at -50 °C and 50x10^-5 M BAR and ground in a stainless steel grinder. Condensed tannins were quantified according to the vanillin test (3), and detection was done by spectrophotometry (500 nm). Phytic acid extraction was done with trichloride acetic acid (ATA 3%), and detection by spectrophotometry (480 nm) (14). Finally, ascorbic acid detection was performed by HPLC at 200-300 nm (13).

RESULTS AND DISCUSSION

Leaf tissue had 9 to 12-fold more iron than seeds regardless of cultivar (Table 1). Iron content in leaves showed significant differences among cultivars (p=0.001) where PV had the highest iron content (643±31 ppm) followed by FJM, AH and NJ, but there was no difference among developmental stages (p=0.527). This suggests that leaves can be consumed for its iron content at any developmental stage due to its constant level across plant development.

Tannins showed similar levels in leaves of all four cultivars (372-436 mg/100g) (p=0.542). These values were higher than in seeds (NJ, FJM and AH, 313-344 mg/100g) except PV which had superior values (>500 mg/100g) (Figure 1a). In the analysis by developmental stage leaf and seed had similar tannins content (p=0.569).

Phytic acid content indicated differences between leaf and seeds. Seeds of NJ, FJM and AH showed up to 4 mg/g, this indicates a difference of up to twelve times above that of leaf values. On the other hand, differences among leaf developmental stages were observed, where EII-L had higher values (1.92 mg/g) than the other three stages. Leaves of FJM and NJ showed higher content of phytic acid, with a 6:1 and 4:1 relationship, respectively, in comparison to AH. However, seeds of AH showed higher phytic acid content than the other three cultivars. In general, seeds have higher levels of tannins (from 2 to 20 times more than leaf) (Figure 1b).
Table 1. Iron content in different plant organs and developmental stages of four cultivars of common bean (Phaseolus vulgaris L.).

<table>
<thead>
<tr>
<th>CULTIVAR</th>
<th>LEAF</th>
<th>SEED</th>
<th>DEV. STAGE</th>
<th>LEAF</th>
<th>SEED</th>
</tr>
</thead>
<tbody>
<tr>
<td>AH</td>
<td>490±31</td>
<td>52±3</td>
<td>El</td>
<td>489±31</td>
<td>-</td>
</tr>
<tr>
<td>FJM</td>
<td>516±31</td>
<td>53±3</td>
<td>EII</td>
<td>516±31</td>
<td>-</td>
</tr>
<tr>
<td>PV</td>
<td>643±31</td>
<td>51±3</td>
<td>EIII</td>
<td>510±31</td>
<td>-</td>
</tr>
<tr>
<td>NJ</td>
<td>439±31</td>
<td>52±3</td>
<td>EIV</td>
<td>573±31</td>
<td>52±3</td>
</tr>
</tbody>
</table>

Ascorbic acid was not detected in seeds of the four cultivars; however, leaves of FJM (EII L) (2.38 mg/g) and NJ (EIII L) (2.13 mg/g) showed modest levels. Ascorbic acid reverses the effect of iron assimilation inhibitors and is one of the most powerful and efficient well known promoters of non-heme iron absorption (8, 9, 10). The interaction observed in different investigations between ascorbic acid and phytates has wide nutritional implications. In diets with high phytates content, the desired levels in ascorbic acid should also be higher (2:1, ascorbic acid:phytates, respectively) (6, 10). In iron deficient populations an increased intake of foods with ascorbic acid and iron could have important public health implications, especially in populations subsisting mainly on plant food based diets.

CONCLUSIONS

- Bean leaf tissue had 9-12 times more iron content than seeds; this suggests that leaves can be consumed as an iron source.
- Tannins showed higher values in leaves than seeds. The highest phytic acid content was present in seeds.
- Both antinutritional compounds reduce the nutritional potential by diminishing digestibility or bioavailability of iron.
- Ascorbic acid reverses the effect of iron inhibitors and is one of the most powerful and efficient well known promoters of iron absorption. However, the levels observed are not enough to reverse the antinutritional effects of the other compounds.
- Leaf could be consumed as iron source with foods containing ascorbic acid.

REFERENCES