ORIGINAL ARTICLE

Chemical Composition and Antinutrient Content of three Lupinus Species from Jalisco, Mexico

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In this study, the proximal chemical analysis and contents of antinutritional factors (lectins, antitrypsin activity, cyanogenic glycosides, alkaloids, phytates and α-galactosides) of Lupinus exaltatus, L. reflexus, and L. mexicanus seeds were determined. The seeds of these lupins comprised 384.1, 388.0, 367.0 g/kg protein, which contained all the essential amino acids for human beings except glutamine and asparagine in their seed protein. Only L. exaltatus was free from lectins. Trypsin inhibitor concentrations ranged from 1.12 to 2.05 TIU/mg. Cyanogenic glycosides were present at low concentrations in the studied lupins. Total alkaloid content ranged from 14.0 to 44.0 g/kg and phytate content ranged from 11.1 to 1.856 g/kg. The main α-galactosides found in seeds were raffinose, stachyose, verbascose and ajucose. Stachyose was the predominant sugar in the studied species. Therefore, these wild lupins could be considered a good source of protein after a suitable reduction in the content of alkaloids.

Key Words: wild lupins; proximal composition; antinutritional factors.

INTRODUCTION

In the past, Greeks, Romans, Egyptians and Andean people cultivated lupins for soil improvement and human consumption. Today, people of some Mediterranean countries such as Spain and Italy eat domesticated lupins as snack (Cowling et al., 1998; Gladstones, 1970) and in Chile, lupin flour is consumed as an adjunct with bakery products (Ballester et al., 1988). In Peru, wild lupins were consumed by the Incas and are still consumed by the current population. In Mexico, although wild lupins are abundant throughout the country, neither wild nor domesticated lupins have been consumed or cultivated. However, they could represent an important source of good-quality protein and could be utilized as oil source.

Wild lupins are known to contain toxic alkaloids and several antinutritive factors and must be properly processed before consumption (Rahma and Narasinga, 1984;
Muzquiz et al., 1993a, b); however the properties and chemical composition of Mexican wild lupins are poorly understood. Therefore, the objective of the present work was to determine the proximate composition and the antinutrient content of Lupinus exaltatus, L. reflexus, and L. mexicanus from the state of Jalisco, Mexico, in order to compare them with those observed in lupins from other areas of the world.

MATERIAL AND METHODS

Material

Whole plants and pods of L. exaltatus, L. reflexus, and L. mexicanus were collected from July to September of 1997 at several locations of the state of Jalisco, Mexico. After collection, plants were botanically identified and properly archived at the Botanical Institute of the Universidad de Guadalajara for future reference. Samples of seeds of the collected species were removed and dried for 48 h at 60°C. After drying, the seeds were pooled and ground into a flour using a mortar and pestle and stored at 10°C until all assays were performed.

Methods

Proximate composition. Protein, moisture, ether extract, ash and crude fiber contents were determined as described in the AOAC methods. Defatted seed flour from each of the lupins under study were hydrolyzed with 6 N HCl or 4 N NaOH (tryptophan) at 105°C during 24 h in order to hydrolyze proteins to further identify amino acids by thin-layer chromatography (Sotelo and Lucas, 1988).

Lectins. Hemaglutinins were semiquantitatively determined in accordance with a modified method (Sotelo and Lucas, 1988) using defibrinated sheep and rabbit red-blood cells. After defibrination, cells were treated with 0.1% trypsin solution in 0.85% NaCl for 30 min at 37°C. Suspensions of trypsinized and 0.85% NaCl-washed red-blood cells were added to a serial dilution of a lupin extract which was prepared by shaking 1 g of raw lupin flour with 10 mL of 1% NaCl solution for 2 h at 25°C. Results were expressed as the maximal dilution capable of producing a hemaglutination reaction.

Trypsin inhibitors. The activity of trypsin inhibitors in lupin seeds was determined following a method described elsewhere (Kakade et al., 1974). The antitrypsin activity was expressed as TIU/mg of sample.

Cyanogenic glycosides. The cyanogenic glycosides were determined by the measurement of released HCN from lupin flour (Tejada De Hernandez, 1990).

Alkaloids. Lupin alkaloids were quantitatively analyzed as described elsewhere (Baer et al., 1979). Soybean was used as a negative control in this assay.

Phytic acid. Inositol phosphates were determined according to Cuadrado et al. (1996). Lupin samples (0.5 g) were extracted with 5 mL of 0.5 M HCl for 3 h at room temperature. The hydrochloric acid extract was purified and concentrated using an ion-exchange SAX column (Varian). The inositol tri (IP3), tetra (IP4), penta (IP5) and hexaphosphate (IP6) were measured by ion-pair reverse-phase HPLC, using a C18 column (PRP-1, 5 μm, 150 × 4.1 mm, Hamilton). The mobile phase was 0.8% tetrabutylammonium hydroxide (TBN-OH) in methanol:water (51.5:48.5).
TABLE 1

Chemical proximate analysis of seeds of *Lupinus exaltatus*, *L. reflexus* and *L. mexicanus* (g/kg dry matter basis, N = 3)

<table>
<thead>
<tr>
<th></th>
<th><em>L. exaltatus</em></th>
<th><em>L. reflexus</em></th>
<th><em>L. mexicanus</em></th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry matter</td>
<td>948.1</td>
<td>828.4</td>
<td>818.0</td>
</tr>
<tr>
<td>Protein (N × 6.25)</td>
<td>384.1</td>
<td>388.0</td>
<td>367.0</td>
</tr>
<tr>
<td>Ether extract</td>
<td>71.1</td>
<td>66.1</td>
<td>80.2</td>
</tr>
<tr>
<td>Ash</td>
<td>185.2</td>
<td>152.0</td>
<td>168.0</td>
</tr>
<tr>
<td>NFE1</td>
<td>321.6</td>
<td>321.7</td>
<td>343.7</td>
</tr>
</tbody>
</table>

1Nitrogen-free extract.
tyrosine and arginine, were found in wild lupin seeds. Therefore, all essential amino acids are present in these seeds in agreement with the information reported in the literature (Muzquiz et al., 1989b; Haq, 1993).

**Antinutritive Factors**

Concentration of lectins, trypsin inhibitors, cyanogenic glycosides and total alkaloids are shown in Table 2. When sheep erythrocytes were used, a positive lectin response was found only for *L. mexicanus*. Conversely, only *L. reflexus* gave a positive lectin response (at 3 titer) when rabbit erythrocytes were used. Seeds of all the lupins gave positive results when tested for trypsin inhibitors. *L. exaltatus, L. reflexus* and *L. mexicanus* were found to contain 2.05, 1.37 and 1.12 TIU/mg of flour, respectively. The titer of lectins and content of trypsin inhibitors in seeds of wild lupin were lower than those found in *L. mutabilis* and potatoes (*Solanum tuberosum*) cultivars (Shoeneberger et al., 1982; Sotelo et al., 1998).

A negligible cyanogenic glycosides content in seeds of wild lupin species has been reported (Kingsbury, 1964). The low concentration (< 0.01 mg HCN per 100 g of flour) found in three of the lupin species studied here is in agreement with this report.

Total alkaloid concentration, determined as lupanine, for *L. exaltatus, L. reflexus* and *L. mexicanus* was 14.0, 21.0 and 44.0 g/kg, respectively. However, the alkaloid values of the three Jalisco wild lupin species are higher than the concentration permitted for safe human consumption which is 0.2 g/kg (Chango et al., 1993). Intoxication and birth defects in human beings and cattle have been reported after

### TABLE 2

Toxic and antinutritional factors present in seeds of *Lupinus exaltatus, L. reflexus* and *L. mexicanus* (*N* = 3)

<table>
<thead>
<tr>
<th></th>
<th><em>L. exaltatus</em></th>
<th><em>L. reflexus</em></th>
<th><em>L. mexicanus</em></th>
</tr>
</thead>
<tbody>
<tr>
<td>Lectins</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sheep blood</td>
<td>—</td>
<td>—</td>
<td>3</td>
</tr>
<tr>
<td>Rabbit blood</td>
<td>—</td>
<td>3</td>
<td>—</td>
</tr>
<tr>
<td>Trypsin inhibitors</td>
<td>2.05 ± 0.36</td>
<td>1.37 ± 0.36</td>
<td>1.12 ± 0.68</td>
</tr>
<tr>
<td>(TUI/mg of flour)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cyanogenic glycosides</td>
<td>&lt;0.01</td>
<td>&lt;0.01</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>(mg HCN per 100 g of flour)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alkaloids (g/kg)</td>
<td>14 ± 0.06</td>
<td>21 ± 0.50</td>
<td>44 ± 0.10</td>
</tr>
</tbody>
</table>

1Titer = maximal dilution at which agglutination is observed.
2Determined as lupanine.
Means ± standard deviation of three determinations for each sample.

### TABLE 3

Inositol phosphate content (g/kg) in seeds of *Lupinus exaltatus, L. reflexus* and *L. mexicanus* (*N* = 3)

<table>
<thead>
<tr>
<th>Sample</th>
<th>IP3</th>
<th>IP4</th>
<th>IP5</th>
<th>IP6</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>L. exaltatus</em></td>
<td>n.d.</td>
<td>n.d.</td>
<td>0.35 ± 0.02</td>
<td>11.34 ± 0.30</td>
<td>11.69 ± 0.32</td>
</tr>
<tr>
<td><em>L. reflexus</em></td>
<td>n.d.</td>
<td>n.d.</td>
<td>0.35 ± 0.06</td>
<td>10.74 ± 0.49</td>
<td>11.09 ± 0.55</td>
</tr>
<tr>
<td><em>L. mexicanus</em></td>
<td>0.011 ± 0.000</td>
<td>n.d.</td>
<td>0.45 ± 0.04</td>
<td>16.13 ± 0.36</td>
<td>16.63 ± 0.37</td>
</tr>
</tbody>
</table>

n.d. = Undetectable.
Means ± standard deviation of three determinations for each sample.
The total content of phytates ranged from 11.09 g/kg for *L. reflexus* to 16.63 g/kg for *L. mexicanus*. IP5 and IP6 were found in all three lupin species while IP3 only appeared in *L. mexicanus* (Table 3). The relative proportion of IP6 was around 97% of the total inositol phosphates, while IP5 was only around 3%. IP4 was not detectable in any of the three lupins. All three wild lupin species had a higher phytate content than that reported for *L. luteus* or *L. albus* (De la Cuadra et al., 1994). However, phytate concentration was similar to those reported for *L. angustifolius* (Dagnia et al., 1992) and *L. albus* cv. Multolupa (Camacho et al., 1991).

The oligosaccharide composition of the studied *Lupinus* species is shown in Table 4. The α-galactosides found in these seeds were raffinose, stachyose, verbascose and ajucose. Stachyose was the predominant sugar in all species. Verbascose content was highest in *L. reflexus* (24.87 g/kg) while raffinose content was highest in *L. mexicanus* (13.62 g/kg). The ajucose content ranged from 0.41 g/kg in *L. mexicanus* to 1.56 g/kg in *L. reflexus*, representing only the 0.78–2.27% of whole-seed oligosaccharides. The sucrose content ranged from 9.92 g/kg in *L. reflexus* to 26.1 g/kg in *L. mexicanus*. The total α-galactoside content of *L. reflexus* and *L. exaltatus* was similar to that reported for *L. albus* and *L. luteus* (Saini, 1989; De la Cuadra et al., 1994). *L. mexicanus* showed lower α-galactoside values than *L. reflexus* and *L. exaltatus*, similar to those reported elsewhere for *L. albus* cv. Multolupa (Camacho et al., 1991).

In conclusion, our results have demonstrated that *L. mexicanus*, *L. exaltatus* and *L. reflexus* could be an important source of high-quality proteins and edible oil with negligible trypsin inhibitors, lectin and cyanogenic compounds. However, soaking or some processing will be necessary to eliminate or reduce the risk of alkaloid toxicity.

### REFERENCES


