Phytochemical constituents of methanol and aqueous extracts of *Lupinus termis* L. Seeds using GC-MS

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**ABSTRACT**

Lupine (*Lupinus termis* L.; Fabaceae) is a plant with high nutritional, pharmaceutical and medicinal values. The present investigation was designed to determine the bioactive constituents present in the methanol extract of each of the seed coat (testa) and cotyledon and the aqueous extract of whole seed of the commonly used lupine in Egypt (cv. Giza 1), using Gas Chromatography-Mass Spectrometry (GC-MS). The GC-MS provided different peaks in the methanol extract of testa and cotyledon that revealed the presence of 32 and 50 compounds, respectively. The aqueous extract of whole lupine seed showed the occurrence of 47 compounds. Interest was devoted to the compounds of predominant occurrence in each extract. The results indicated the presence of the alkaloid lupanine in the methanol extract of testa and cotyledon as well as the aqueous extract of whole seed. Furthermore, the seed testa was characterized by unique occurrence of valeric acid and a relatively high proportion of hydroxyl-9, 11 octadecadienoic acid, as compared to the cotyledon. The latter (cotyledon) is characterized by the occurrence of a relatively high ratio of hexanoic acid and xanthosine and a lower amount of 17-[(trimethylsilyl) oxy] spartein-2-one. The aqueous extract of seed was characterized by the presence of multiflorine, 1-acetyl-1, 2, 3,4-tetrahydro-5-(2-piperidinyl)-pyridine, mesitylquinoline, and Mome inositol. These results indicate that each of the seed fractions (testa and cotyledon) exhibited certain unique compounds using methanol as an extraction solvent. Certain compounds that were not detected in the methanol extract did appear in the aqueous extract of seed. Thus, besides its known nutritional value, the presence of various chemical compounds having significant pharmacological and biological activities confirms the application of lupine (Giza 1) as a plant of pharmaceutical value and medical application.

**Key words:** *Lupinus termis*, GC-MS analysis, Chemical constituents, Alkaloids, Pharmaceutics.

**Introduction**

Lupine attracted people in the world as a crop of a great food ingredient. Lupine has many advantages: a. it can grow on marginal agricultural lands in diverse environmental conditions (Nelson and Hawthorne, 2000), b. it is a nonstarchy grain legume, containing lower amounts of fat (~6%), rich in essential amino acids, dietary minerals, with relatively high protein (~40%) and dietary fibre (~28%) contents (Guemes-Vera *et al.*, 2012), it has an advantage over soybean as it contains dietary fibre contents (~28%), compared to soya bean (~19%) (Bähr *et al.*, 2014), c. recently, lupine has been extensively used in food industries, for eg. lupin-enriched noodles (Jayasena *et al.*, 2010), biscuits (Jayasena and Nasar-Abbas, 2011), pasta (Jayasena and Nasar-Abbas, 2012), tofu (Jayasena *et al.*, 2014), bread (Villarino *et al.*, 2015b), muffins (Rumiyati *et al.*, 2015), d. on the bases of its nutritional use, various reviews on lupine species have recently been published concerning their composition (e.g. Kohajdova *et al.*, 2011), possible usages (Villarino *et al.*, 2015a), allergenecity (Verma *et al.*, 2013) and nutraceutical properties associated with proteins (Bouchenak and Lamri-Senhadj, 2013). Therefore, the industrial shift of lupine seed utilization from feed to food has recently increased the scientific interest to explore its phytochemical composition and biological activities (Khan *et al.*, 2015).

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Edible plants, besides being of nutritional significance, mostly have bioactive properties due to exhibiting phytochemical compounds that attracted the attention of research workers in the few last decades (Abdallah et al., 2017). Lupine seeds are used in traditional medicine in Africa and the Middle East as an anti-diabetic agent, and used topically to treat acne, whereas it is used traditionally in the USA for curing foot eczema (Quiles et al., 2010). In recent years, lupine seeds have drawn attention due to their nutritional value, richness in protein, pharmaceutical properties and high alkaloid content (Omer et al., 2016).

In Egypt, lupine seeds are boiled and soaked in water several times to get rid of the bitter taste, then salted, spiced and consumed as a snack food. In the present work, the phytochemicals of the dry seed testa, cotyledons, and whole water soaked seeds were separately analysed using the Gas chromatography-Mass Spectrometry (GC-MS) technique.

Materials and Methods

Plant Materials

A pure lot of Egyptian bitter lupine seeds (*Lupinus termis* L. cultivar Giza1) were kindly provided by the Legume Research Department, Agricultural Research Center, Ministry of Agriculture, Cairo, Egypt.

Preparation of methanolic and aqueous extract

*Methanol extract:*

Dry mature lupine seeds (50 g) were used and their coats (testa) were separated from the cotyledons. The Weight of seed testa was (9.25 g) and weight of cotyledons was (40.75 g). Each of seed testa and cotyledon was separately coarsely powdered using a household mill (Braun, Germany). Powdered samples were successively extracted with 80% methanol using a shaker extractor apparatus. Extraction was carried out for about five days with daily filtration and evaporation of the solvent. The solvent was evaporated under reduced pressure using rotatory evaporator apparatus according to the method described by Sukhdev et al. (2008). Finally, the extract was air dried in a large Petri dish till complete dryness. The yield percentage was calculated according to the following equation:

\[
\text{Yield } \% = \frac{\text{Weight of extract obtained}}{\text{Weight of plant sample}} \times 100
\]

*Aqueous extract:*

Dry lupine seeds were ground as mentioned above and powdered seeds were extracted by soaking in warm distilled water (200 ml for 50 g seed powder) for 48 hrs at room temperature according to El-Mahmoud (2009). The extract was filtered through Whatman No.1 filter paper. The obtained aqueous extract was concentrated under vacuum using a rotary evaporator. Finally, the extract was allowed to be air dried in Petri dishes till complete dryness and the yield percentage was calculated according to the previous equation. All the dried extracts were kept at -40°C till used for GC-MS analysis.

Gas Chromatography- Mass Spectrometric Analysis (GC-MS)

The phytochemical constituents of the fractionated (methanol extracts of seed coats and cotyledons and water extracts of whole seeds) were analyzed using Gas Chromatography-Mass Spectrometry (GC-MS) (model 7890A/5975B), USA was used. The instrument has the following characteristics: Sample inlet: GC, injection source: GC ALS, Spectrometer. Oven equilibration time 0.5 min., Maximum temperature 280 degrees C. Oven program: 40 °C for 30 min, 10 °C/ min to 150 °C for 3 min, and then 10 °C/ min to 220 °C for 6 min, and then 15 °C/ min to 260°C for 15 min. Run time 47.667 min and 2 min (post run). The database of the used GC-MS (NIST, USA) consisted of
more than 62000 patterns. The spectra of unknown components were compared with those of the known components inherent in the ACAL library (Analytical Chemistry Assuit University Lab.). The names, molecular weights and structures of the components of the test materials were ascertained according to the IUPAC International Chemical Identifier (IUPAC Standards InChI) approved by the international Union of Pure and Applied Chemistry in Collaboration with the National Institute of Standards and Technology (NIST) version 1.04.

Results and Discussion

The compounds present in the methanol (seed testa and seed cotyledon) and aqueous extract (whole seed) of *Lupinus termis* were identified by GC-MS analysis. The nomenclature of each compound, its retention time (RT) value, molecular formula, molecular weight (MW), and concentration (%) are shown in Tables 1, 2 for the methanol extracts of seed testa, cotyledons, respectively and in Table 3 for the water extract of whole seed. These constituents are shown in their corresponding chromatographs in Figures 1, 3 and 5, respectively. The structures of the respective chemical compounds of each extract are shown in Figures 2, 4, 6, in the same sequence mentioned above. The significance of each compound will also be further discussed.

1. Seed testa

Thirty two compounds were identified unequivocally in the methanol extract of lupine seed testa by comparing mass spectral data to those the GC-MS library search (Wiley library databank) as revised with those of reference data in the literature (Wink *et al.*, 1995). Six compounds showed pronounced amounts, where the remainders (26 compounds) were of minor occurrence. The results obtained with these 6 compounds are shown in Table 1 and Figures 1 and 2. The names and synonyms followed are computerized according to the International Union of Pure and Applied Chemistry (IUPAC) and Chemical Abstracts (CA) index guide. As shown in Table 1, the components of interest in the aqueous methanol extract fraction of lupine seed coat are lupanine (33.74%), 9, 11-octadecanoic acid, 8-hydroxy- methyl (29.49%), valeric acid (14.81%), 11-chloroundecanoic acid, (octahydroquinolizin-1-yl) methyl ester (6.97%), hydroxyl lupanine (2.02%), and octadecanoic acid (1.40%).

Table 1: The components of pronounced contents in the GC/MS analysis of the aqueous methanol extract fraction of lupine seed coat (testa), showing nomenclature, molecular formula (MF), molecular weight (MW), Retention time (RT), and percent.

<table>
<thead>
<tr>
<th>No.</th>
<th>Chemical compounds</th>
<th>MF</th>
<th>MW</th>
<th>RT (min.)</th>
<th>% of total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Lupanine</td>
<td>C₁₅H₂₈N₂O₂</td>
<td>248.189</td>
<td>33.59</td>
<td>33.740</td>
</tr>
<tr>
<td>2</td>
<td>Hydroxylupanine</td>
<td>C₁₅H₂₈N₂O₂</td>
<td>264.369</td>
<td>37.402</td>
<td>2.023</td>
</tr>
<tr>
<td>3</td>
<td>9,11-Octadecadiynoic acid, 8-hydroxy-, methyl</td>
<td>C₁₀H₁₆O₃</td>
<td>310.4710</td>
<td>27.284</td>
<td>29.486</td>
</tr>
<tr>
<td>4</td>
<td>Valeric acid</td>
<td>C₅H₁₀O₂</td>
<td>102.13</td>
<td>24.632</td>
<td>14.814</td>
</tr>
<tr>
<td>5</td>
<td>11-Chloroundecanoic acid, (octahydroquinolizin-1-yl) methyl ester</td>
<td>C₁₂H₁₃ClO₃</td>
<td>248.746</td>
<td>37.356</td>
<td>6.971</td>
</tr>
<tr>
<td>6</td>
<td>Octadecanoic acid</td>
<td>C₁₈H₃₆O₂</td>
<td>284.484</td>
<td>21.636</td>
<td>1.399</td>
</tr>
</tbody>
</table>

Lupanine and its derivatives represent quinolizidine alkaloids (QAs) known as “lupine alkaloids” with reference to main occurrence in lupine species. The results obtained in the present work generally matched with those obtained by Hirai *et al.* (2000) who reported that 13α-Hydroxylupanine (50.78%) and lupanine (23.55%) were determined as the main alkaloids in the aerial parts of *Lupinus angustifolius*. However, the authors mentioned that antibacterial and antifungal activities of *L. angustifolius* alkaloid extract showed significant activity on *B. subtilis*, *S. aureus* and *P. aeruginosa* but was weakly active on *E. coli*.

On the other hand, the alkaloid extract of *Lupinus angustifolius* possessed moderate activity against *C. albicans* and *C. Krusei* (Erdemoglu *et al.*, 2007).
Fig. 1: Chromatograph of the GC/MS analysis of the aqueous methanol fraction of testa (seed coat) of lupine seeds (*Lupinus termis* L. cultivar Giza1), showing six predominant phytochemicals.
Fatty acids are well known active metabolites. In the present work, 9,11-octadecadienoic acid (9-hydroxylinoleic acid methyl ester) was found in the methanol fraction devoted to the seed testa. In this connection, Abubakar and Majinda (2016) recorded the existence of 9,12-octadecadienoic acid (Z,Z)-methyl ester in the crude n-hexane and chloroform extracts of the heart wood of *Albizia adianthifolia* (Schumach) and the stem bark of *Pterocarpus angolensis* (DC). The n-hexane and chloroform extracts of *A. adianthifolia* showed best activity against *E. Coli*.

Valeric acid (pentanoic acid) is a straight chain alkyl carboxylic acid predominantly occurring in *Valeriana wallichii* and *V. officinalis*. Volatile esters of valeric acid tend to have pleasant odors and are used in perfumes and cosmetics. Ethyl valerate and pentyl valerate are used as food additives because of their fruity flavours (Pub.Chem Open Chemistry Database). Valeric acid could achieve a neuroprotective effect and had a significant effect in amelioration of experimental dementia in rats (Vishwakarma *et al.*, 2016) and reducing anxiety in women undergoing hysterosalpingography (Gharib *et al.*, 2015). Extracts of *Valeriana officinalis* were found to have potent anxiolytic effects in rats (Murphy *et al.*, 2010), cytoprotective effect against Parkinson disease (De Oliveria *et al.*, 2009), antidepressant-like effect (Müller *et al.*, 2012), neuroprotective activity (Wang *et al.*, 2014), and ameliorative effect of neuronal damage by suppressing lipid peroxidation (Yoo *et al.*, 2015).

11-chloroundecanoid acid methyl ester or undecanoic acid is a medium-chain fatty acid that has been used in the treatment of dermatophytes in humans. Undecanoic acid is outstandingly most toxic with regard to fungitoxicity against five dermatophytes (Garg and Müller, 1993). Methyl ester and derivatives of undecanoic acid have been mentioned among the environmentally friendly biobased metal lubricity improvers (MAK Collection, 2012). Among the synthesized products, n-butyl epithio undecanoate exhibited superior antioxidant property (229.2°C), compared to butylated hydroxytoluene (BHT, 193.8°C) (Geethanjali *et al.*, 2014).

Octadecanoic acid (stearic acid) is a saturated fatty acid with an 18-carbon chain. From pharmaceutical and medical views, its nanoparticles represent very potential drug carriers (Zhang *et al.*, 2000). It is used for drug delivery, as reducing drug dissolution due to its hydrophobic nature (Dave *et al.*, 2004) and for improving drug loading capacity (Hu *et al.*, 2005). Stearic acid—grafted chitosan oligosaccharide could compact the plasmid DNA to form micelle/DNA complexes.
nanoparticles, which could efficiently protect the condensed DNA from enzymatic degradation by DNase I (Hu et al., 2006). In chemotherapy, nano stearic acid-g-chitosan oligosaccharide polymeric micelles were conjugated to the anticancer drug doxorubicin where it suppressed tumour growth and reduced the toxicity against animal body than commercial doxorubicin hydrochloride injection (Hu et al., 2009).

2. Seed cotyledon

Fifty compounds were identified in the methanol extract of lupine seed cotyledon. Six compounds showed pronounced amounts, where the remainders (44 compounds) were of minor occurrence. The results obtained with these 6 compounds are shown in Table 2 and Figures 3 and 4. The components of interest in the aqueous methanol extract fraction of lupine seed cotyledon are xanthosine (13.14%), hexanoic acid (33.81%), 9, 12-octadecadienoic acid (2.57%), lupanine (38.19%). 13-hydroxyspartein-2-one (8.118%), and 17-[(trimethylsilyl)oxy]spartein-2-one (1.107%).

Xanthosine (Xanthine riboside; 9-beta-D-Ribofuranosylxanthine; Beta-D Ribofuranoside) is a nucleoside derived from xanthine and ribose. It is the biosynthetic precursor to 7-methylxanthosine, that in turn is the precursor to theobromine (THB) (active alkaloid in chocolate), which then represents the precursor to caffeine, the alkaloid in coffee and tea. These compounds belong to the family of purines where xanthine and its derivatives are intermediates in the production of GMP, GDP, and GTP in cells via a salvage pathway that recycles intermediates of degradation back into GTP and nucleic acids (Zrenner et al., 2006). Tetsuo et al. (2016) recommended the use of theobromine as an ingredient of dentifrices and even if swallowed accidentally would be without adverse effects. Clough et al. (2017) revealed that THB enhanced skeletal development and increased the osteogenic potential of bone marrow osteoprogenitors.

Hexanoic acid (caproic acid), the constituent recorded in the present work, is the carboxylic acid derived from hexane. The primary use of hexanoic acid is in the manufacture of its esters for artificial flavors and in the manufacture of hexyl derivatives. The caproic acid derivative epsilon amino caproic acid (ε-aminocaproic acid) was used as an effective antifibrinolytic agent for the management of haemophilic patients (Ghosh et al., 2004). It was also applied as an antifibrinolytic therapy in cardiac surgeries (Martin et al., 2011) and for preventing oral bleeding in patients with haemophilia or Von Willebrand disease undergoing minor oral surgery or dental extractions (van Galen et al., 2015). As carriers for anti-cancer agents, polymeric micelles of caproic acid displayed more potent anti-cancer activity than free doxorubicin when tested in a tumor xeno graft model in mice (Chen et al., 2013).

Table 2: The components of pronounced contents in the GC/MS analysis of the aqueous methanol extract fraction of lupine cotyledon, showing nomenclature, molecular formula (MF), molecular weight (MW), Retention time (RT), and percent.

<table>
<thead>
<tr>
<th>No.</th>
<th>Chemical compounds</th>
<th>MF</th>
<th>MW (g·mol⁻¹)</th>
<th>RT (min.)</th>
<th>% of total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Xanthosine</td>
<td>C₁₅H₂₈N₄O₆</td>
<td>284.23</td>
<td>22.259</td>
<td>13.141</td>
</tr>
<tr>
<td>2</td>
<td>Hexanoic acid</td>
<td>C₆H₁₂O₂</td>
<td>116.16</td>
<td>25.914</td>
<td>33.81</td>
</tr>
<tr>
<td>3</td>
<td>8-Hydroxy-9,11-Octadecadienoic acid, methyl</td>
<td>C₁₅H₂₈O₃</td>
<td>296.45</td>
<td>26.981</td>
<td>2.574</td>
</tr>
<tr>
<td>4</td>
<td>Lupanine</td>
<td>C₁₅H₂₈N₄O</td>
<td>248.189</td>
<td>33.818</td>
<td>38.197</td>
</tr>
<tr>
<td>5</td>
<td>13-Hydroxyspartein-2-one</td>
<td>C₁₅H₂₈N₄O₂</td>
<td>264.363</td>
<td>37.461</td>
<td>8.118</td>
</tr>
<tr>
<td>6</td>
<td>17-[(Trimethylsilyl)oxy]spartein-2-one</td>
<td>C₁₅H₂₈N₄O₂Si</td>
<td>336.551</td>
<td>40.935</td>
<td>1.107</td>
</tr>
</tbody>
</table>

8-Hydroxy-9, 11-Octadecadienoic acid, methyl ester and Lupanine compounds have been previously described with the testa.

13-hydroxyspartein-2-one (13-hydroxy-lupanine, 13alpha-hydroxylupanine) is a quinolizidine alkaloid found in lupine cotyledons. Sundararajan and Koduru (2014) reported the occurrence of 13-hydroxyspartein in the different organs of Cytisus scoparius with other phytochemicals. This plant had immense potential in the treatment of diarrhea, fungal infection, wounds, dental plaque, malaria,
Fig. 3: Chromatograph of the GC/MS analysis of the aqueous methanol fraction of lupine seed (*Lupinus termis* L. cultivar Giza1) cotyledons showing six predominant phytochemicals.
allergies, coughs, diabetes, cardiovascular disorder, degenerative muscular diseases, inflammatory ailments including rheumatism, menstrual pain, liver diseases and cancer, etc. Xiao and Jia (2008) reported that seven alkaloids were isolated from the seeds of *Ammopiptanthus mongolica* including 3α-hydroxysparteine. This plant has pharmaceutical significance, mainly as antioxidant and anti-lipid peroxidation agent (Li *et al.*, 2010). López *et al.* (2004) demonstrated a significant effect of 13-α-OH lupanine at high glucose concentrations that showed an additional value when considering treatments of type 2 diabetes (López *et al.*, 2004).

![Xanthinosine](image1.png)

![Hexanoic acid](image2.png)

![9,11-octadecadienoic acid](image3.png)

![Lupanine](image4.png)

![13-hydroxyspartein-2-one](image5.png)

![17-[(Trimethylsilyloxy] spartein-2-one](image6.png)

**Fig. 4:** Structures of the chemical compounds listed in Table 2.

Knecht *et al.* (2006) found that quinolizidine alkaloids including hydroxyspartein in the extracts of seeds of the white lupine [*Lupinus albus (L. termis L.)*] and the tailcup lupine (*L. caudatus*) showed antihyperglycemiac activity in white mice. Similar conclusions were also mentioned by Kinder and Knecht (2011) and Brunmair *et al.* (2015), where the extracts of lupine seeds could lower blood glucose levels in rats to normal levels and could blunt the glucose spike following a meal.

17-[(Trimethylsilyloxy] spartein-2-one (13-Hydroxy-lupanine TMS derivative) is a compound consisted of a trimethylsilyl group abbreviated TMS as a functional group. Trimethylsilyl groups on a molecule have a tendency to make it more volatile, often making the compounds more amenable to analysis by gas chromatography or mass spectrometry. Trimethylsilyl groups may also be used as temporary protecting groups during chemical synthesis or some other chemical reactions. Otherwise very reactive molecules can be isolated when enveloped by bulky trimethylsilyl groups (Boxer and Yamamoto, 2006). The rest of the molecule is the lupin alkaloid sparteine. Sparteine has found prominent use in chemistry, where it is employed as a chiral ligand in asymmetric synthesis (Chuzel and Riant, 2005; Firth *et al.*, 2014). Sparteine is reported to possess antimicrobial activity against bacteria and phytopathogenic fungi. Sparteine sulphate administered by intravenous infusion to patients with type 2 diabetes caused a fall in plasma glucose levels (Borelli, 2004).

### 3-Water extract of whole seed

Forty seven compounds were identified in the aqueous extract of whole lupine seed. Seven compounds showed pronounced amounts, where the remainders (40 compounds) were of minor occurrence. The results obtained with these 7 compounds are shown in Table 3 and Figure 5 and 6. The components of interest in the aqueous extract fraction of whole lupine seed are mome inositol (1.21%), lupanine (46.09%), multiflorine (4.49%), 1-acetyl-1,2,3,4-tetrahydro-5-(2-piperidinyl)-pyridine(2.53%), hydroxy lupanine (12.02%), 17-[(trimethylsilyloxy]sparteine-2-one (1.35%) and 2-(2,4,6-trimethylphenyl)quinoline (2.07%).

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In the present work, the water extract of the whole seed included mome inositol (1.21%). It is a six hydroxyl group polysaccharide that is highly abundant in other medicinal plants. Mome inositol has been detected in the methanol extract of Cycas beddomei cones (Kumar et al., 2012), ethanol extract of Macrotyloma uniflorum seeds (Das et al., 2014), and methanolic extract of Gisekia pharaceoides stem (Sunita and Manju, 2017). These authors referred to the antialopecic, antipyretic, anti-neuropathic, cholesterolytic, lipotropic and sweetening properties of the source plants. Anticancer activity was recorded by the extracts of Clitoria ternatea flowers (Neda et al., 2013), and leaf extracts of Thevetia neriifolia (Kumar, 2015) and Sophora interrupta (Mathi et al., 2015).

**Table 3:** The components of pronounced contents in the GC/MS analysis of the aqueous extract fraction of whole lupine seeds, showing nomenclature, molecular formula (MF), molecular weight (MW), Retention time (RT), and percent.

<table>
<thead>
<tr>
<th>No.</th>
<th>Chemical compounds</th>
<th>MF</th>
<th>MW (g·mol⁻¹)</th>
<th>RT (min.)</th>
<th>% of total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Mome inositol</td>
<td>C₆H₁₂O₆</td>
<td>194.000</td>
<td>27.377</td>
<td>1.208</td>
</tr>
<tr>
<td>2</td>
<td>Lupanine</td>
<td>C₁₅H₂₃N₅O</td>
<td>248.189</td>
<td>34.057</td>
<td>46.090</td>
</tr>
<tr>
<td>3</td>
<td>Multiflorine</td>
<td>C₁₅H₂₃N₅O</td>
<td>246.349</td>
<td>36.371</td>
<td>4.497</td>
</tr>
<tr>
<td>4</td>
<td>1-Acetyl-1,2,3,4-tetrahydro-5-(2-piperidinyl)-pyridine</td>
<td>C₁₂H₂₀N₂O</td>
<td>208.300</td>
<td>37.018</td>
<td>2.530</td>
</tr>
<tr>
<td>5</td>
<td>Hydroxylupanine</td>
<td>C₁₃H₂₃N₅O₂</td>
<td>264.369</td>
<td>37.536</td>
<td>12.018</td>
</tr>
<tr>
<td>7</td>
<td>2-(2,4,6-Trimethylphenyl)quinoline</td>
<td>C₁₅H₁₇N</td>
<td>247.341</td>
<td>40.981</td>
<td>2.073</td>
</tr>
</tbody>
</table>

Lupanine has been discussed previously within the seed testa.

Multiflorine is a tetracyclic lupine alkaloid resulting from oxidative cyclization of three units of cadaverine. Kubo et al. (2000) found that some lupine alkaloids such as multiflorine are responsible for hypoglycaemic activity. Lupanine, 13-hydroxyupanine and multiflorine have been reported to have pharmacological activities such as anticonvulsant, antipyretic and hypoglycemic (Garcia et al., 2004 and Kubo et al., 2006). Ruiz-López et al. (2010) reported that multiflorine was found in all lupine species.

1-Acetyl-1,2,3,4-tetrahydro-5-(2-piperidinyl)-pyridine (Ammodendrine, Spherocarpine) is a teratogenic piperidine alkaloid (saturated heterocyclic ring structure) found in lupine species as a mixture of enantiomers (Green et al., 2012). Our results agreed to a similar extent with those of Hamed and Ayoub (2015) who found ammodendrine, lupanine, 13-hydroxyupanine and 13-methoxyupanine in semi-purified alkaloid methanolic extract of Lupinus termis root and the extract was assessed for antimicrobial activity and certain microorganisms (Staphylococcus aureus, Bacillus subtilis, Klebsiella pneumonia and Aspergillus flavus) were moderately sensitive to the methanolic extract. Ammodendrine is a minor alkaloid in seeds of Lupinus albus, Lupinus luteus and Lupinus mutabilis (Blaschek et al., 2016).

Hydroxylupanine has been discussed previously within the seed testa and 17-[(Trimethylsilyl)oxy]spartein-2-one has been discussed previously within the seed cotyledon.

2-(2,4,6-Trimethylphenyl)quinoline (2-Mesitylquinoline), recorded in the present work, is among quinolines. Quinoline derivatives constitute an important category of heterocyclic compounds and are widely used as pharmaceuticals, fungicides, herbicides, corrosion inhibitors and functional chemicals (Kouznetsov, 2005). They have amazing intrinsic pharmacological and biological activities such as antimalaria, anti-inflammatory, antiasthmatic, antibacterial and anti-hypersensitive activities (Franzen, 2000, Heravi, 2009). Farther, quinoline derivatives were synthesized and explored for their analgesic activity (Roma et al., 2008) as antiallergetic agents (Reddy et al., 2009) for treating Alzheimer’s disease (AD) (Tomasoli et al., 2011), anticancer (Zhang et al., 2003, Bu et al., 2005, Marchalant et al., 2012), antitinephritic (Tsuji et al., 2002). Several quinoline derivatives were identified as potent inhibitors of the Pim-1 kinase which is involved in the control of cell growth, differentiation, proliferation and apoptosis (Marchalant et al., 2012).
Fig. 5: Chromatograph of the GC/MS analysis of the aqueous fraction of lupine (*Lupinus termis* L. cultivar Giza1) whole seeds showing seven predominant phytochemicals. *1-Acetyl-1,2,3,4-tetrahydro-5-(2-piperidinyl)-pyridine.*
Conclusion

Various organic compounds have been identified by GC-MS in the methanol extract of either the seed coat (testa) or the cotyledons and the water extract of whole seeds of lupine (*Lupinus termis*, cv. Giza 1). These are mainly alkaloids (lupanine, 13-hydroxylupanine, 13-hydroxy spartein-2-one, multiflorine and 1-acetyl-1,2,3,4-tetrahydro-5-(2-piperidinyl)-pyridine), fatty acids (9, 11-octadecanoic acid, 11-chloroundecanoic acid and octadecanoic acid), carboxylic acids (valeric acid and hexanoic acid), nucleosides (xanthosine), polysaccharides (mome inositol), silyl derivatives (17-[(Trimethylsilyl)oxy]spartein-2-one) and quinoline derivatives (2-(2,4,6-Trimethylphenyl)quinoline). Some of these compounds were characteristic of the methanol extract of either the seed coat or the cotyledon, whereas others occurred only in the water extract of seed. However, all the detected compounds have been mentioned to exhibit pharmaceutical properties and others to be useful in various industries. The presence of such bioactive compounds substantiates lupine use in traditional medicine. Isolation of such compounds may also initiate the formulation of new drugs to treat certain diseases. In this connection, the finding of a high urinary recovery of unchanged lupanine or 13-hydroxy lupanine suggested that clinical toxicity is unlikely to result from the use of lupine seed in foodstuffs (Petterson et al., 2009).

References


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