Rec. Pharm. Biomed. Sci. 6 (2), 147-162, 2022

REVIEW ARTICLE

RECORDS OF PHARMACEUTICAL AND BIOMEDICAL SCIENCES

Chemical constituents and biological activities of genus *Lotus:* An updated review

Rokia M. Abdallah[a], Hala M. Hammoda[a], Nahla S. El Gazzar[a]*, Shaimaa M. Sallam[a]

[a] *Department of Pharmacognosy, Faculty of Pharmacy, Alexandria University, Alexandria, Egypt*

Received on: 18. 07. 2022

Revised on: 20. 08. 2022

Accepted on: 28. 08. 2022

*Correspondence Author:

E-mail address:

shawky.nahla@yahoo.com

Abstract

Genus *Lotus* (Fabaceae) comprises several species, which are widely distributed in north temperate regions of the world, especially the Mediterranean region and West Asia. Lotus is represented in Egypt by 18 species: *L. edulis, L. polyphyllos, L. ornithopodioides, L. angustissimus, L. peregrinus, L. halophilus, L. creticus, L. cytissoides, L. palustris, L. corniculatus, L. pedunculatus, L. lanuginosus, L. nubicus, L. glinoides, L. lalambensis, L. arabicus, L. hebranicus and L. tetragonolobus*. Plants of this genus exhibited a significant role in traditional medicine. *Lotus* has a history of folkloric medicinal uses as contraceptives, prophylaxis and treatment of sexually transmitted diseases and peptic ulcers. Flavonoids, saponins, phenolic acids, coumarins and sterols were reported as the main bioactive constituents of this genus with a wide range of biological activities. Anti-inflammatory, anti-platelet aggregation, antibacterial, antifungal, estrogenic, hepatoprotective, anticancer and antioxidant activities were reported for *Lotus*. The present work is an overview of the reported biological activities together with the isolated compounds from genus *Lotus*.

Keywords: *Lotus, Mediterranean region, flavonoidal constituents, biological activities.*

1. Introduction:

Genus *Lotus* is belonging to family Fabaceae, subfamily Faboideae. It includes approximately about 100 species distributed in north temperate regions especially the Mediterranean region and West Asia **(Boulos 1999; El-Youssef et al. 2008)**. *Lotus* is represented in Egypt by 18 species **(Täckholm 1974; Boulos 1999)**: *L. edulis, L. polyphyllos* (*L. argenteus*), *L. ornithopodioides, L. angustissimus, L. peregrinus* (*L. carmeli*), *L. halophilus* (*L. villosus, L. pusillus*), *L. creticus* (*L. commutatus, L. salzmannii*), *L. cytissoides* (*L. prostratus, L. allionii, L. patens*), *L. palustris* (*L. lamprocarpus, L. palustris*), *L. corniculatus* (*L. glaber, L. tenuis, L. tenuifolius*), *L. pedunculatus* (*L. uliginosus, L. decumbens*), *L. lanuginosus, L. nubicus, L. glinoides* (*L. schimperi, L. ehrenbergii*), *L. lalambensis, L. arabicus* (*L. roseus, L. mossamedensis*), *L. hebranicus* (*L. deserti*) and *L. tetragonolobus* (*L. palaestinus*).

Lotus has a history of folkloric medicinal uses as contraceptives, prophylaxis and treatment of sexually transmitted diseases and peptic ulcers **(El Mousallami et al. 2002)**. Literature survey on *Lotus* revealed the presence of different types of flavonoids, saponins, phenolic acids, coumarins, sterols and miscellaneous compounds. Literature survey revealed that no updated review was published reporting the isolated compounds and biological activities of genus *lotus*. The present work is an updated overview of the isolated compounds from *Lotus* together with the reported biological activities of that genus.

Literature survey databases

All information on chemical constituents and biological activities of genus *Lotus* was compiled from electronic databases such as Medline, Google scholar, ScienceDirect, Springer Link, PubMed and SCOPUS.

Results

Different types of flavonoids, saponins, phenolic acids, coumarins, sterols and miscellaneous compounds were previously isolated from genus *Lotus*. Table 1 highlights the flavonoidal constituents isolated from *Lotus* (Figures 1-4). Table 2 highlights the triterpenoidal saponins, coumarins and phenolic compounds isolated from *Lotus* (Figures 5-6). Table 3 highlights the sterols, alkylated sugars, cyanogenic glycosides and miscellaneous compounds isolated from *Lotus* (Figures 7-9).

Biological activities of genus Lotus

Anti-inflammatory activity

The light petrol fraction of *L. lalambensis* showed an excellent anti-inflammatory effect against inflammation induced by carrageenan **(El-Youssef et al. 2008)**. Studies investigated the anti-inflammatory effects of the ethanol extract of *Lotus corniculatus*, its derived hexane, ethyl acetate, *n*-butanol and aqueous fractions, in addition to, the isolated compounds kaempferitrin, oleanolic acid and *β*-sitosterol in a mouse model of pleurisy induced by carrageenan. Results revealed that The ethanol extract of *L. corniculatus*, its derived fractions and its isolated compounds, inhibited leukocytes, exudation, pro-inflammatory enzymes and mediators such as myeloperoxidase (MPO), adenosine-deaminase (ADA), interleukin-1 beta (IL-1b) mediator level and nitrite/nitrate concentration **(Fröde and Medeiros 2001; Koelzer et al. 2009)**. The hexane and ethyl acetate fractions revealed a more pronounced anti-inflammatory response than the other fractions, since they were able to inhibit all the studied inflammatory parameters. On the contrary, the butanol fraction did not inhibit either MPO activity or nitrite/nitrate concentration. In conclusion, *L. corniculatus* showed an important anti-inflammatory property, and its constituent's kaempferitrin, oleanolic acid and *β*-sitosterol may well account for this anti-inflammatory activity **(Koelzer et al. 2009; Pereira et al. 2011)**. These compounds have potential as novel lead compounds for the future development of therapeutic intervention in the treatment of patients with inflammatory disorders.

Anti-platelet aggregation

The aqueous fraction of *L. lalambensis* showed a strong inhibition of platelet aggregation **(El-Youssef et al. 2008)**. Platelet aggregation was induced by ADP (adenosine diphosphate) in blood samples of male wistar rats and the percentage inhibition of platelet aggregation induced by the ethanolic extract, the light petrol, chloroform, ethyl acetate, *n*-butanol and aqueous fractions were then calculated.

Antibacterial activity

The butanol extract of the aerial parts of *L. halophilus* exhibited a good antimicrobial activity against both Gram-positive and Gram-negative bacteria (**Mahasneh 2002)**. However, the hexane fraction of *L. corniculatus* demonstrated effective inhibition against *Bacillus cereus, Enterococcus faecalis, Listeria monocytogenes, Staphylococcus aureus, Staphylococcus epidermidis, Acinetobacter calcoaceticus* and *Providencia alcalifaciens*. Also, the ethyl acetate fraction showed an important antibacterial activity against *Bacillus cereus, Enterococcus faecalis* and *Cinetobacter calcoaceticus*. The oleanolic acid isolated from hexane fraction showed the same effect against methycillin-resistant *Staphylococcus aureus, Listeria monocytogenes* and *Bacillus cereus*. Furthermore, Kaempferitrin isolated from ethyl acetate fraction also shown antibacterial activity against *Shighella flexinerii, Salmonella typhimurium, Acinetobacter calcoaceticus, Enterococcus faecalis* and *Bacillus cereus*. These results confirmed that *L. corniculatus* have important antibacterial activity against Gram-positive and Gram-negative bacteria **(Dalmarco et al. 2010)**. Another study showed that Kaempferitin which was isolated from the ethyl acetate extract of *L. corniculatus* aerial parts exhibited antibacterial effects against *Escherichia coli* **(El-Ghani et al. 2001)**.

Antifungal activity

The butanol extract of the aerial parts of *L. halophilus* has a good antifungal activity against *Candida albicans* and *Aspergillus flavus* **(Mahasneh 2002)**. Another study showed that the methanol extract of *L. tenuis* inhibited the mycelia growth of *Alternaria species* and *Fusarium graminearum* **(Girardi et al. 2014)**. The greatest contents of coumarins, flavonoids and tannins in these plants are directly related to their antifungal activity. The antimicrobial action of the flavonoids may be related to the ability to bind to extracellular, soluble proteins and cell wall structures **(Sandhar et al. 2011; Girardi et al. 2014)**. Moreover, The ethanol, ethyl acetate, butanolic and aqueous extracts of *L. garcinii* were active against *Aspergillus niger*, *Alternaria solani*, *Penicillium funiculosium*, *Microsporum canis* and *Pleuroetus oustreatus* **(Azhar et al. 2004)**.

Estrogenic activity

The chloroform fraction of *L. lalambensis* showed the highest estrogenic activity compared to the light petrol, the ethyl acetate and the aqueous fractions of the same plant **(El-Youssef et al. 2008)**. Another study showed that mature legumes of *L. corniculatus* had significant anti-estrogenic and estrogenic activities after dissolving in physiological saline with or without 17-*β*- estradiol, respectively. It was injected subcutaneously into immature rats. Six hours after injection, the animals were killed by ether inhalation and the uteri were removed and weighed. The estrogenic and the antiestrogenic activities were assessed by the increase or decrease of the uterine weight expressed as percent of body weight when compared with the appropriate controls (physiological saline with or without 17-*β*- estradiol). The results revealed that the degree of anti-estrogenic activity was related to the date of harvest and stage of growth of the plant. An inverse relation between estrogenic and antiestrogenic activity was indicated **(Biely and Kitts 1964)**.

Hepatoprotective activity

It was found that 70% ethanol extract and different fractions of *L. polyphyllos* aerial parts exhibited high hepatoprotective activity compared with standard silymarin at a dose of 300 mg/kg body weight using carbon tetrachloride (CCl_4) intoxicated rats. This study depended on measuring the level of the biochemical parameters; asparatate aminotransferase (AST, serum glutamate oxaloacetate transaminase or SGOT), alanine aminotransferase (ALT, serum glutamate pyruate or SGPT) and alkaline phosphatase (ALP). The hepatoprotective activity was also supported by the histological examining of liver tissues **(Osman et al. 2013)**.

Anticancer activity

An acetylated Kaempferol glycoside of *L. edulis* showed a significant inhibition of the growth of human cancer cell lines; MCF7 (breast cancer cells), HeLa (cervical cancer cells), and HepG2 (liver cancer cells). In addition, this compound was a strong catalytic inhibitor of topoisomerase enzymes. These enzymes are essential for all processes of DNA metabolism, and their inhibitors have been identified as potential anticancer agents **(Tselepi et al. 2011)**. The antiproliferative activity of chloroform and butanol extracts of *L. corniculatus* aerial parts was evaluated using three continuous murine and human culture cell lines; J774A1 (murine monocyte/macrophage), HEK-293 (human epithelial kidney cells) and WEHI-164 (murine fibrosarcoma), the butanol extract showed a moderate cytotoxic activity **(Aissaoui et al. 2014)**. Moreover, a lectin (tetrameric galactose) isolated from *L. corniculatus* seeds showed a strong antiproliferative activity towards human leukemic (THP-1), lung (HOP62) and colon (HCT116) cancer cells with IC_{50} of 39 µg/ml, 50 µg/ml and 60 µg/ml respectively **(Rafiq et al. 2013)**.

Antioxidant activity

The antioxidant activity of the aqueous fraction of *L. corniculatus* was evaluated by the ESR (Electron Spin Resonance) spectroscopy method **(Yamaguchi et al. 2000)** in order to visualize the inhibition of the DPPH (1,1-diphenyl-2 picrylhydrazyl), superoxide and hydroxyl radicals. Also, it is evaluated by comparison with reference molecules, e.g. vitamin E and quercetin. It showed moderate antioxidant activity. Antioxidant effects were correlated with the total amount of phenolic compounds contained in the extract **(Trouillas et al. 2003)**.

2. Chemical constituents reported from species of genus *Lotus*

Table 1. Flavonoidal constituents:

Compound Name	Occurence	Reference
1. Kaempferol	*L. corniculatus* leaves and flowers *L. lalambensis* aerial parts *L. borbasii*	**(Harney and Grant 1964; Jay et al. 1978; Strittmatter et al. 1992; El-Ghani et al. 2001; Reynaud and Lussignol 2005)** **(Reynaud and Lussignol 2005) (El-Youssef et al. 2008)** **(Harney and Grant 1964)**
2. Kaempferol-3-*O*-glucoside (Astragalin)	*L. corniculatus* leaves	**(Reynaud et al. 1982; Strittmatter et al. 1992; Reynaud and Lussignol 2005)**
3. Kaempferol-3-*O*-glucoside-7-rhamnoside	*L. corniculatus* seeds and aerial parts *L. lalambensis* aerial parts	**(Strittmatter et al. 1992; Reynaud and Lussignol 2005)** **(El-Youssef et al. 2008)**
4. Kaempferol-3,7 dirhamnoside (Kaempferitin)	*L. corniculatus* seeds *Lotus lalambensis* aerial parts *L. ornithopodioloides* aerial parts	**(Reynaud et al. 1982; El-Ghani et al. 2001; Reynaud and Lussignol 2005; Dalmarco et al. 2010)** **(El-Youssef et al. 2008)** **(Abdel-Kader et al. 2007)**
5. Kaempferol -7-*O*-rhamnoside	*L. corniculatus* leaves *L. hebranicus*	**(Reynaud et al. 1982; Reynaud and Lussignol 2005)** **(Kasem 2001)**
6. Kaempferol -3-*O*-rhamnoside	*L. corniculatus* leaves *L. lalambensis* aerial parts *L. hebranicus*	**(Reynaud et al. 1982; Reynaud and Lussignol 2005)** **(El-Youssef et al. 2008)** **(Kasem 2001)**
7. Kaempferol-3-*O*-rhamnoside-7-*O*-glucoside	*L. corniculatus* leaves	**(Reynaud et al. 1982; Reynaud and Lussignol 2005)**
8. Kaempferol-7-*O*- glucoside	*L. corniculatus* seeds and leaves	**(Reynaud and Lussignol 2005)**
9. Kaempferol -3,7-diglucoside	*L. corniculatus* seeds and leaves *L. polyphyllos*	**(Reynaud and Lussignol 2005)** **(El Mousallami et al. 2002)**
10. Kaempferol-3-*O*-*α*-[*β*-D-glucopyranosyl -(1''''→2''')-L-rhamnopyranoside]-7-*O*-*α*-L-rhamnopyranoside	*L. lalambensis* aerial parts	**(El-Youssef et al. 2008)**
11. Kaempferol-3-*O*-[*β*-D-xylopyranosyl(1'''-2'')-*β*-D-galactopyranoside]-7-*O*-*α*-rhamnopyranoside	*L. corniculatus* legumes	**(Kadry et al. 2007)**
12. Kaempferol-3-*O*-[*β*-D-xylopyranosyl(1'''-2'')-*β*-D-galactopyranoside]	*L. corniculatus* aerial parts	**(El-Gazzar 2016)**
13.Kaempferol-3-*O*-*β*-D-glucopyranoside-7-*O*-*α*-[*β*-D-glucopyranosyl -(1''''→2'')- L-rhamnopyranoside]	*L. lalambensis* aerial parts	**(El-Youssef et al. 2008)**
14. Kaempferol -3-*O*-*β*-(6''-*O*-E-*p*-coumaroylglucoside)-7-*O*-*β*-glucoside	*L. polyphyllos*	**(El Mousallami et al. 2002)**
15. Kaempferol 3-*O*-*α*-rhamnoside-7-*O*-sophoroside	*L. hebranicus*	**(Kasem 2001; El Mousallami et al. 2002)**
16. Kaempferol -3-*O*-sophoroside	*L. hebranicus*	**(Kasem 2001; El Mousallami et al. 2002)**
17. Kaempferol -3-*O*-(3''-*O*-*α* -L-rhamnopyranosyl)-*α*-L-rhamnopyranosyl (Garcintin)	*L. garcinii*	**(Ali et al. 2000)**
18. Quercetin	*L. corniculatus* leaves and flowers *L. polyphyllos* roots *L. japonicus*	**(Harney and Grant 1964; Jay et al. 1978; El-Ghani et al. 2001; Reynaud and Lussignol 2005)** **(Abdel-Kader et al. 2008)** **(Morris and Lanot 2005)**
19. Quercetin-3-*O*-rhamnoside (Quercitrin)	*L. corniculatus* seeds and leaves	**(Reynaud et al. 1982; El-Ghani et al. 2001; Reynaud and Lussignol 2005)**
20.Quercetin-3-*O*-rhamnoglucoside (Rutin)	*L. corniculatus* leaves	**(Reynaud et al. 1982; Reynaud and Lussignol 2005)**

21. Quercetin -7-*O*-rhamnoside	*L. corniculatus* seeds and leaves	**(Reynaud et al. 1982; Reynaud and Lussignol 2005)**
22. Quercetin-3-*O*-galactoside	*L. corniculatus* seeds and leaves	**(Reynaud et al. 1982; Reynaud and Lussignol 2005)**
23. Quercetin-3,7-dirhamnoside	*L. corniculatus* seeds and leaves	**(Reynaud et al. 1982; Reynaud and Lussignol 2005)**
24. Quercetin-3-*O*-rhamnoside -7-*O*-glucoside	*L. corniculatus* leaves	**(Reynaud et al. 1982; Reynaud and Lussignol 2005)**
25. Quercetin-3-*O*-arabinoside	*L. corniculatus* seeds	**(Reynaud and Lussignol 2005)**
26. Quercetin-3-*O*-glucoside-7-*O*-rhamnoside	*L. corniculatus* seeds	**(Reynaud and Lussignol 2005)**
27. Quercetin 3-*O*-*β*-(6"-*O*-E-*p*-coumaroylglucoside)-7-*O*-*β*-glucoside	*L. polyphyllos*	**(El Mousallami et al. 2002)**
28. Quercetin 3,7-diglucoside	*L. polyphyllos*	**(El Mousallami et al. 2002)**
29. Quercetin 3-*O*-methyl-7-*β*-D-glucopyranoside (Transilin)	*L. corniculatus* aerial parts	**(Aissaoui et al. 2014)**
30. Isorhamnetin	*L. corniculatus* leaves and flowers	**(Jay et al. 1978; Reynaud and Lussignol 2005)**
31. Isorhamnetin 3-*O*-*β*-(6"-*O*-E-*p*-coumaroyl glucoside)-7-*O*-*β*-glucoside	*L. polyphyllos*	**(El Mousallami et al. 2002)**
32. Isorhamnetin 3,7-diglucoside	*L. polyphyllos* *L. hebranicus*	**(El Mousallami et al. 2002)** **(Kasem 2001)**
33. Desoxy-5-kaempferol	*L. corniculatus* leaves and flowers	**(Jay et al. 1978; Reynaud and Lussignol 2005)**
34. Desoxy-5-quercetin (Fisetin)	*L. corniculatus* leaves	**(Jay et al. 1978; Reynaud and Lussignol 2005)**
35. Desoxy-5-isorhamnetin (Geraldol)	*L. corniculatus* leaves and flowers	**(Jay et al. 1978; Reynaud and Lussignol 2005)**
36. 6,7,4'-Trihydroxy-3,3'-dimethoxyflavonol	*L. corniculatus* aerial parts	**(El-Ghani et al. 2001)**
37. 8-Methoxy kaempferol (Sexangularetin)	*L. corniculatus* flowers	**(Jay et al. 1978; Jay and Ibrahim 1986; Reynaud and Lussignol 2005)**
38. 8-Methoxy quercetin (Corniculatusin)	*L. corniculatus* flowers	**(Jay et al. 1978; Jay and Ibrahim 1986; Reynaud and Lussignol 2005)**
39. 8-Methoxy isorhamnetin (Limocitrin)	*L. corniculatus* flowers	**(Jay et al. 1978; Jay and Ibrahim 1986; Reynaud and Lussignol 2005)**
40. 8-Hydroxy quercetin (Gossypetin)	*L. corniculatus* flowers	**(Jay and Ibrahim 1986; Reynaud and Lussignol 2005)**
41. Gossypetin-3-*O*-galactoside	*L. corniculatus* flowers	**(Reynaud and Lussignol 2005)**
42. 5,7, 3',4'-tetrahydroxy-8-methoxy-flavonol-3-*O*-*β*-D-galactoside (Corniculatusin-3-*O*-galactoside)	*L. corniculatus* flowers and leaves	**(Nielsen 1970; Reynaud et al. 1982; Reynaud and Lussignol 2005)**
43. Corniculatusin-3-*O*-glucoside	*L. corniculatus* leaves	**(Reynaud et al. 1982; Reynaud and Lussignol 2005)**
44. Sexangularetin-3-*O*-glucoside	*L. corniculatus* leaves	**(Reynaud et al. 1982; Reynaud and Lussignol 2005)**
45. Sexangularetin-3-*O*-rhamnoside-7-*O*-glucoside	*L. corniculatus* leaves	**(Reynaud et al. 1982; Reynaud and Lussignol 2005)**
46. Formononetin	*L. corniculatus*	**(Sarelli et al. 2003; Reynaud and Lussignol 2005)**
47. Biochanin A	*L. corniculatus*	**(Sarelli et al. 2003; Reynaud and Lussignol 2005)**
48. 4'-Methyl wighteone	*L. creticus* roots	**(Yang et al. 1989)**
49. Lupinalbin A	*L. creticus* roots	**(Yang et al. 1989)**
50. Lupinalbin B	*L. creticus* roots *L. pusillus* aerial parts	**(Yang et al. 1989)** **(Golea et al. 2012)**
51. Lupinalbin C	*L. creticus* roots	**(Yang et al. 1989)**
52. Lupinalbin F	*L. polyphyllos* roots	**(Abdel-Kader et al. 2006)**
53. 4'-*O*-methylalpinum	*L. polyphyllos* roots	**(Abdel-Kader et al. 2006)**
54. 4'-*O*-methylerythrinin C	*L. polyphyllos* roots	**(Abdel-Kader et al. 2006)**
55. 4'-*O*-methyl-2"-hydroxydihydroalpinum	*L. polyphyllos* roots	**(Abdel-Kader et al. 2006)**
56. 4',7-Dimethoxy-5-hydroxyisoflavone	*L. polyphyllos* roots	**(Abdel-Kader et al. 2006)**
57. Euchrestaflavanone A	*L. creticus* roots	**(Yang et al. 1989)**

58. (-)-7,2'-Dihydroxy-4'-methoxyisoflavan (Vestitol)	*L. lalambensis* roots *L. Corniculatus* leaves *L. hispidus* leaves *L. uliginosus* *L. japonicas* *L. edulis* *L. angustissimus* leaves	**(Alqasoumi et al. 2013)** **(Bonde et al. 1973; Ingham 1977; Ingham and Dewick 1979, 1980)** **(Bonde et al. 1973; Ingham 1977; Ingham and Dewick 1979, 1980)** **(Bonde et al. 1973; Ingham 1977; Ingham and Dewick 1979, 1980)** **(Shimada et al. 2000; Morris and Lanot 2005)** **(Bonde et al. 1973; Ingham 1977; Ingham and Dewick 1979, 1980)** **(Bonde et al. 1973; Ingham 1977; Ingham and Dewick 1979, 1980)**
59. 5,7-Dimethoxy-2',4'-dihydroxyisoflavan (Lotisoflavan)	*L. lalambensis* roots *L. angustissimus* *L. edulis*	**(Alqasoumi et al. 2013)** **(Ingham and Dewick 1980)** **(Ingham and Dewick 1980)**
60. 7,2',4'-Trihydroxyisoflavan (Demethylvestitol)	*L. siliquosus* *L. corniculutus* *L. hipidus* *L. edulis* *L. angustissimus* leaves *L. uliginosus*	**(Ingham and Dewick 1979)** **(Bonde et al. 1973; Ingham 1977; Ingham and Dewick 1979, 1980)** **(Bonde et al. 1973; Ingham 1977; Ingham and Dewick 1979, 1980)** **(Bonde et al. 1973; Ingham 1977; Ingham and Dewick 1979, 1980)** **(Bonde et al. 1973; Ingham 1977; Ingham and Dewick 1979, 1980)** **(Bonde et al. 1973; Ingham 1977; Ingham and Dewick 1979, 1980)**
61. 5,4'-Dimethoxy-7,2'-dihydroxyisoflavan (5-Methoxyvestitol)	*L. hispidus* leaves	**(Ingham and Dewick 1979, 1980)** **(El-Youssef et al. 2008)**
62. 7-Hydroxy-2',4'-dimethoxyisoflavan (Sativan)	*L. corniculatus* leaves *L. hispidus* leaves *L. japonicus* *L. uliginosus* *L. edulis* *L. angustissimus* leaves	**(Bonde et al. 1973; Ingham 1977; Ingham and Dewick 1979, 1980)** **(Ingham and Dewick 1979)** **(Morris and Lanot 2005)** **(Bonde et al. 1973; Ingham 1977; Ingham and Dewick 1979, 1980)** **(Bonde et al. 1973; Ingham 1977; Ingham and Dewick 1979, 1980)** **(Bonde et al. 1973; Ingham 1977; Ingham and Dewick 1979, 1980)**
63. 7,4'-Dihydroxy-2'-methoxyisoflavan (Isovestitol)	*L. siliquosus*	**(Ingham and Dewick 1979)**
64. Medicarpin-3-*O*-*β*-D-glucopyranoside	*L. corniculatus* aerial parts	**(Aissaoui et al. 2014)**
65. 5'-(Dimethyl-allyl)-5-Methoxycoumestrol	*L. creticus* roots	**(Mahmoud et al. 1990)**
66. Catechin	*L. pedunculatus* *L. corniculatus*	**(Foo et al. 1997)** **(Foo et al. 1996)**
67. Epicatechin	*L. pedunculatus* *L. corniculatus*	**(Foo et al. 1997)** **(Foo et al. 1996)**
68. Gallocatechin	*L. pedunculatus* *L. corniculatus*	**(Foo et al. 1997)** **(Foo et al. 1996)**
69. Epigallocatechin	*L. pedunculatus* *L. corniculatus*	**(Foo et al. 1997)** **(Foo et al. 1996)**
70. Leucodelphinidin	*L. corniculatus* leaves	**(Harney and Grant 1964)**
71. Leucocyanidin	*L. corniculatus* leaves	**(Harney and Grant 1964)**
72. Catechin (4α→8) catechin	*L. pedunculatus*	**(Foo et al. 1997)**
73. Catechin(4α →8) epicatechin	*L. pedunculatus*	**(Foo et al. 1997)**
74. Gallocatechin(4α → 8) epigallocatechin	*L. pedunculatus*	**(Foo et al. 1997)**
75. Epicatechin (4β → 8)-catechin	*L. pedunculatus* *L. corniculatus*	**(Foo et al. 1997)** **(Foo et al. 1996)**
76. Epicatechin (4β → 8) epicatechin	*L. pedunculatus* *L. corniculatus*	**(Foo et al. 1997)** **(Foo et al. 1996)**
77. Epigallocatechin (4β → 8) catechin.	*L. pedunculatus*	**(Foo et al. 1997)**
78. Epigallocatechin (4β→8) Catechin peracetate	*L. pedunculatus*	**(Foo et al. 1997)**
79. Epigallocatechin (4β → 8) gallocatechin peracetate	*L. pedunculatus*	**(Foo et al. 1997)**

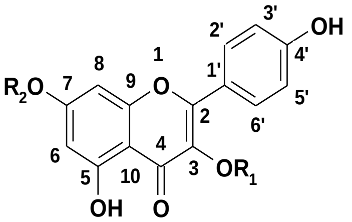
80. Epigallocatechin (4β → 8) epigallocatechin peracetate (Peracetate of the prodelphinidin)	*L. pedunculatus*	**(Foo et al. 1997)**
81. Catechin (4α → 2) phloroglucinol	*L. pedunculatus* *L. corniculatus*	**(Foo et al. 1997)** **(Foo et al. 1996)**
82. Gallocatechin (4α → 2) phloroglucinol	*L. pedunculatus*	**(Foo et al. 1997)**
83. Epicatechin (4β → 2) phloroglucinol	*L. pedunculatus* *L. corniculatus*	**(Foo et al. 1997)** **(Foo et al. 1996)**
84. Epigallocatechin- (4β → 2) phloroglucinol	*L. pedunculatus* *L. corniculatus*	**(Foo et al. 1997)** **(Foo et al. 1996)**
85. Epicatechin- (4β → 8)- Epicatechin- (4β →8)- catechin	*L. corniculatus*	**(Foo et al. 1996)**
86. Epicatechin- (4β → 8)- epicatechin- (4β → 2)- phloroglucinol	*L. corniculatus*	**(Foo et al. 1996)**
87. epicatechin- (4β → 8)- epicatechin- (4β → S)-benzylthioether	*L. corniculatus*	**(Foo et al. 1996)**
88. Epigallocatechin- (4β → 8)- epicatechin (4β →2)-phloroglucinol	*L. corniculatus*	**(Foo et al. 1996)**
89. epigallocatechin- (4β → 8) epicatechin- (4β → S)- benzylthioether	*L. corniculatus*	**(Foo et al. 1996)**
90. Epicatechin- (4β → 6)- epicatechin- (4β→ 2)-phloroglucinol	*L. corniculatus*	**(Foo et al. 1996)**
91. Epicatechin- (4β → 6) epicatechin- (4β →S)-benzylthioether	*L. corniculatus*	**(Foo et al. 1996)**
92. epicatechin- (4β → S)- benzylthioether	*L. corniculatus*	**(Foo et al. 1996)**
93. epigallocatechin- (4β → S)- benzylthioether	*L. corniculatus*	**(Foo et al. 1996)**

Table 2. Triterpenoidal saponins, coumarins and phenolic compounds:

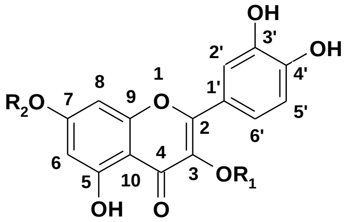
Chemical class	Compound Name	Occurence	Reference
Oleanane triterpenes	94. Soyasapogenol B	*L. corniculatus*	**(Walter 1961)**
	95. Soyasaponin I	*L. corniculatus* aerial parts	**(Aissaoui et al. 2014)**
	96. Astragaloside VIII	*L. pusillus* aerial parts	**(Golea et al. 2012)**
	97. dehydrosoyasaponin I	*L. corniculatus* aerial parts	**(Aissaoui et al. 2014)**
	98. Pharbitoside A	*L. corniculatus* aerial parts	**(Aissaoui et al. 2014)**
	99. Oleanolic acid	*L. lalambensis* aerial parts *L. corniculatus* aerial parts *L. ornithopodioloides* aerial parts *L. garcinii* *L. pusillus* aerial parts	**(El-Youssef et al. 2008)** **(Walter 1961; Dalmarco et al. 2010)** **(Abdel-Kader et al. 2007)** **(Ali et al. 2000; Ali et al. 2001)** **(Golea et al. 2012)**
	100. β-amyrin	*L. corniculatus* aerial parts	**(El-Ghani et al. 2001)**
Lupane triterpenes	101. Lupeol	*L. lalambensis* aerial parts *L. garcinii*	**(El-Youssef et al. 2008)** **(Ali et al. 2000; Ali et al. 2001)**
Lupane triterpenic acids	102. Betulinic acid	*L. ornithopodioloides* aerial parts *L. garcinii*	**(Abdel-Kader et al. 2007)** **(Ali et al. 2000; Ali et al. 2001)**
Ursane triterpenic acids	103. Ursolic acid	*L. corniculatus* aerial parts *L. criticus* roots	**(El-Ghani et al. 2001)** **(Ingham 1977)**
Coumarins	104. 4',6'-Dihydroxy-7,2'-dimethoxy-3-arylcoumarin	*L. polyphyllos* roots	**(Abdel-Kader et al. 2008)**
	105. 2',7-Dihydroxy-4',5-dimethoxy-3-arylcoumarin	*L. lalambensis* roots *L. polyphyllos* roots	**(Alqasoumi et al. 2013)** **(Abdel-Kader et al. 2008)**
Phenolics and phenolic acids	106. *n*-tetracosyl *p*-coumarate	*L. polyphyllos* roots	**(Abdel-Kader et al. 2006; Abdel-Kader et al. 2008)**
	107. Benzoic acid	*L. corniculatus* aerial parts	**(Aissaoui et al. 2014)**
	108. *p*-coumaric acid	*L. corniculatus* aerial parts *L. ornithopodioides*	**(Harney and Grant 1964; Aissaoui et al. 2014)** **(Araniti et al. 2014)**
	109. Gallic acid	*L. ornithopodioides*	**(Araniti et al. 2014)**
	110. Salicyl alcohol	*L. ornithopodioides*	**(Araniti et al. 2014)**
	111. Caffeic acid	*L. ornithopodioides*	**(Araniti et al. 2014)**
	112. Chlorogenic acid	*L. ornithopodioides*	**(Araniti et al. 2014)**
	113. Vanillic acid	*L. ornithopodioides*	**(Araniti et al. 2014)**
	114. Syringic acid	*L. ornithopodioides*	**(Araniti et al. 2014)**
	115. Sinapic acid	*L. alpinus*, *L. japonicus*, *L. krylovii*, *L. schoelleri* *L. ornithopodioides*	**(Harney and Grant 1964)** **(Araniti et al. 2014)**
	116. Ferulic acid	*L. borbasii* *L. ornithopodioides* *L. corniculatus* leaves	**(Harney and Grant 1964)** **(Araniti et al. 2014)** **(Harney and Grant 1964)**
	117. 2-Hydroxybenzyl-β-D-glucopyranoside (Isosalicin)	*L. pusillus* aerial parts *L. corniculatus* aerial parts	**(Golea et al. 2012)** **(Golea et al. 2012)**
	118. Maltol 3-*O*-[6-*O*-benzoyl]-β-D-glucopyranoside	*L. pusillus* aerial parts	**(Golea et al. 2012)**

Table 3. Sterols, alkylated sugars, cyanogenic glycosides and miscellaneous compounds:

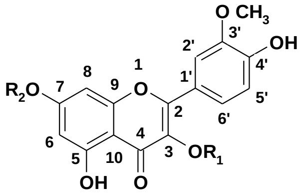
Chemical class	Compound Name	Occurence	Reference
Sterols	119. *β*-sitosterol	*L. polyphyllos* roots *L. lalambensis* aerial parts *L. corniculatus* aerial parts *L. ornithopodioloides* L. aerial parts *L. pusillus* aerial parts *L. creticus* roots	**(Abdel-Kader et al. 2008)** **(El-Youssef et al. 2008)** **(El-Ghani et al. 2001; Dalmarco et al. 2010)** **(Abdel-Kader et al. 2007)** **(Golea et al. 2012)** **(Ingham 1977)**
	120. *β*-sitosterol-3-*O*-*β*-D-glucopyranoside	*L. lalambensis* aerial parts *L. creticus* roots *L. pusillus* aerial parts	**(El-Youssef et al. 2008)** **(Ingham 1977)** **(Golea et al. 2012)**
	121. *β*-sitosterol-3-*O*-6'-palmitoyl-*β*-D-glucopyranoside	*L. pusillus* aerial parts	**(Golea et al. 2012)**
	122. Stigmasterol glucoside	*L. lalambensis* aerial parts	**(El-Youssef et al. 2008)**
	123. Cholesterol	*L. garcinii*	**(Ali et al. 2000; Ali et al. 2001)**
	124. Taraxasterol	*L. pusillus* aerial parts	**(Golea et al. 2012)**
Alkylated sugars	125. Butyl-*O*-*α*-L-rhamnoside	*L. lalambensis* aerial parts	**(El-Youssef et al. 2008)**
	126. Methyl-*O*-*α*-L-rhamnopyranoside	*L. lalambensis* aerial parts	**(El-Youssef et al. 2008)**
	127. Methyl-*O*-*β*-L-rhamnopyranoside	*L. lalambensis* aerial parts	**(El-Youssef et al. 2008)**
	128. Ethyl-*O*-*β*-D-glucopyranoside	*L. lalambensis* aerial parts	**(El-Youssef et al. 2008)**
	129. (+) D-pinitol	*L. lalambensis* aerial parts	**(El-Youssef et al. 2008)**
Cyanogenic glycosides	130. 2-(*β*-D-glucopyranosyloxy)-2-methypropionitrile (Linamarin)	*L. ornithopodioloides* aerial parts *L. creticus* roots *L. lalambensis* aerial parts	**(Abdel-Kader et al. 2007)** **(Ingham 1977)** **(El-Youssef et al. 2008)**
	131. 2-(*β*-D -glucopyranosyloxy) -2-methylbutyronitrile (Lotaustralin)	*L. ornithopodioloides* aerial parts *L. creticus* roots *L. lalambensis* aerial parts	**(Abdel-Kader et al. 2007)** **(Ingham 1977)** **(El-Youssef et al. 2008)**
	132. 2-(*β*-D-glucopyranosyloxy)-2-methylbutyronitrile (Epilotaustralin)	*L. lalambensis* aerial parts	**(El-Youssef et al. 2008)**
Miscellaneous compounds	133. 1-Hexacosanol	*L. polyphyllos* roots	**(Abdel-Kader et al. 2008)**
	134. Heptadecanol	*L. lalambensis* aerial parts	**(El-Youssef et al. 2008)**
	135. Garceine	*L. garcinii*	**(Ali et al. 2001)**
	136. Garoside	*L. garcinii*	**(Ali et al. 2001)**
	137. Garthiol	*L. garcinii*	**(Ali et al. 2001)**
	138. Hexadecanoic acid	*L. garcinii*	**(Ali et al. 2000; Ali et al. 2001)**
	139. Isophytol	*L. garcinii*	**(Ali et al. 2000; Ali et al. 2001)**
	140. Phytone	*L. ornithopodioides*	**(Araniti et al. 2014)**
	141. Methyl hexadecanoate	*L. ornithopodioides*	**(Araniti et al. 2014)**
	142. Ethyl hexadecanoate	*L. ornithopodioides*	**(Araniti et al. 2014)**
	143. Methyl octadecanoate	*L. ornithopodioides*	**(Araniti et al. 2014)**
	144. 4-Methyl-2-heptanone	*L. ornithopodioides*	**(Araniti et al. 2014)**



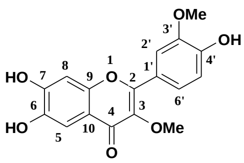
	R_1	R_2
1:	H	H
2:	Glc	H
3:	Glc	Rha
4:	Rha	Rha
5:	H	Rha
6:	Rha	H
7:	Rha	Glc
8:	H	Glc
9:	Glc	Glc
10:	Rha-glc	Rha
11:	Gal-xyl	Rha
12:	Gal-xyl	H
13:	Glc	Rha-glc
14:	6"-p-coumaroyl glc	Glc
15:	Rha	Glc-glc
16:	Glc-glc	H
17:	Rha-rha	H



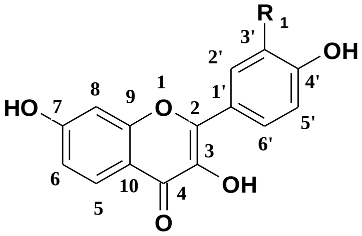
	R_1	R_2
18:	H	H
19:	Rha	H
20:	Glc-rha	H
21:	H	Rha
22:	Gal	H
23:	Rha	Rha
24:	Rha	Glc
25:	Ara	H
26:	Glc	Rha
27:	6"-p-coumaroyl glc	Glc
28:	Glc	Glc
29:	CH3	Glc



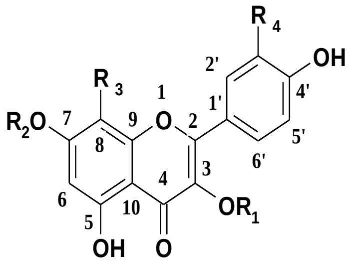
	R_1	R_2
30:	H	H
31:	6"-p-coumaroyl glc	Glc
32:	Glc	Glc



36

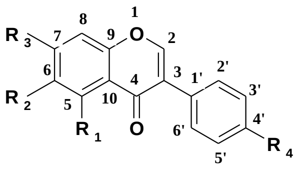


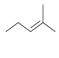
	R_1
33:	H
34:	OH
35:	OCH_3

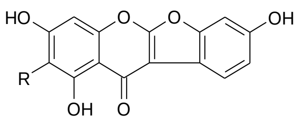


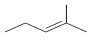
	R_1	R_2	R_3	R_4
37:	H	H	OCH_3	H
38:	H	H	OCH_3	OH
39:	H	H	OCH_3	OCH_3
40:	H	H	OH	OH
41:	Gal	H	OH	OH
42:	Gal	H	OCH_3	OH
43:	Glc	H	OCH_3	OH
44:	Glc	H	OCH3	H
45:	Rha	Glc	OCH3	H

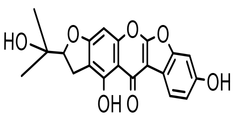
Figure 1. Chemical structures of flavonol derivatives isolated from genus *Lotus*.



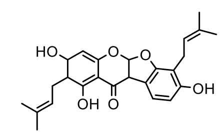
	R_1	R_2	R_3	R_4
46:	H	H	OH	OCH3
47:	OH	H	OH	OCH3
48:	OH		OH	OCH3



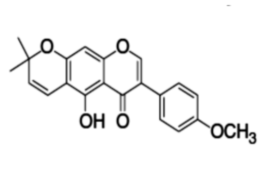
	R
49:	H
50:	



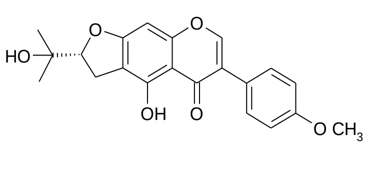
51



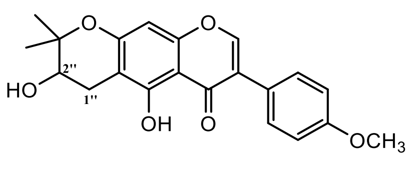
52



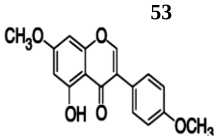
53



54

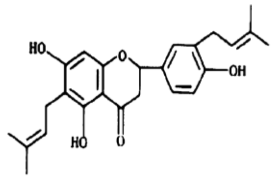


55

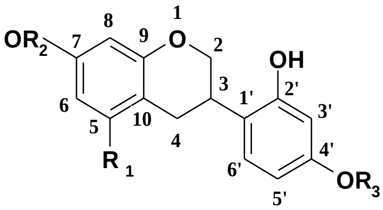


56

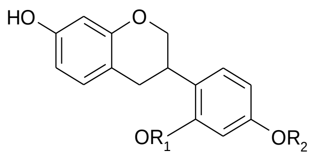
Figure 2. Chemical structures of isoflavone derivatives isolated from genus *Lotus*.



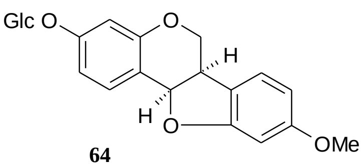
57



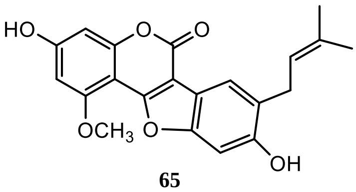
	R_1	R_2	R_3
58:	H	H	CH3
59:	OCH3	CH3	H
60:	H	H	H
61:	OCH3	H	CH3



	R_1	R_2
62:	CH3	CH3
63:	CH3	H

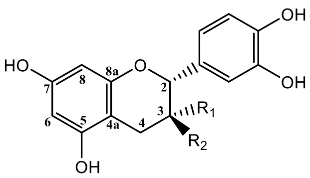


64

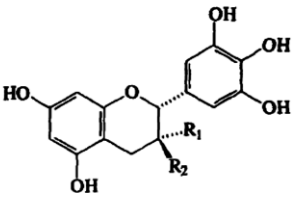


65

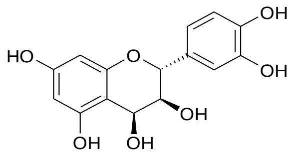
Figure 3. Chemical structures of flavanones, isoflavans, pterocarpans, coumestan isolated from genus *Lotus*.



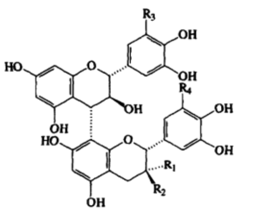
	R_1	R_2
66:	H	OH
67:	OH	H



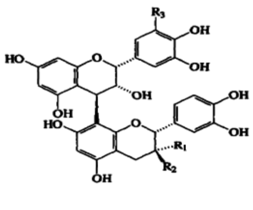
	R_1	R_2
68:	H	OH
69:	OH	H
70:	OH	OH



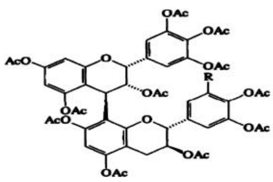
71



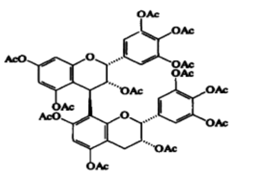
	R_1	R_2	R_3	R_4
72:	H	OH	H	H
73:	OH	H	H	H
74:	OH	H	OH	OH



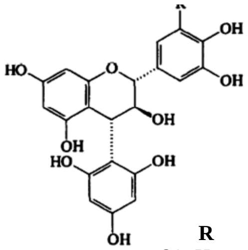
	R_1	R_2	R_3
75:	H	OH	H
76:	OH	H	H
77:	H	OH	OH



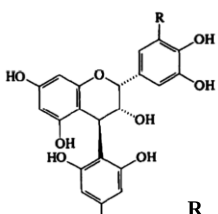
	R
78:	H
79:	OAc



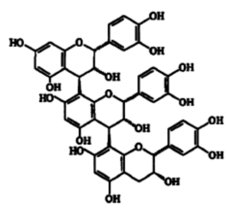
80



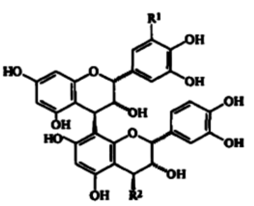
	R
81:	H
82:	OH

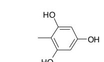
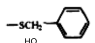
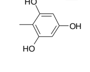
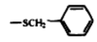


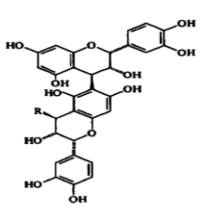
	R
83:	H
84:	OH

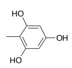
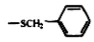


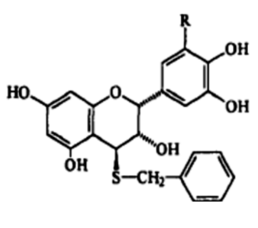
85



	R_1	R2
86:	**H**	
87:	**H**	
88:	**OH**	
89:	**OH**	

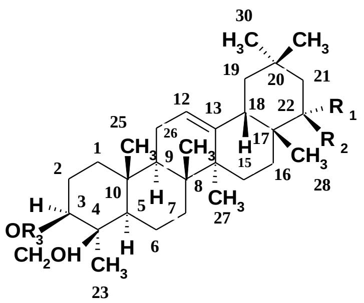


	R
90:	
91:	

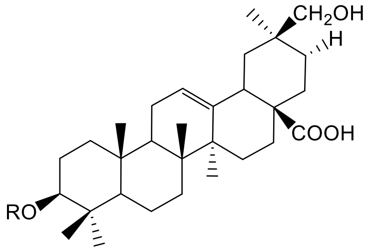


	R
92:	H
93:	OH

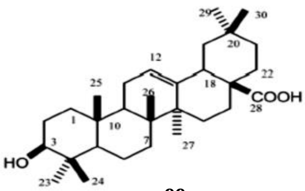
Figure 4. Chemical structures of flavans (Proanthocyanidins) isolated from genus *Lotus*.



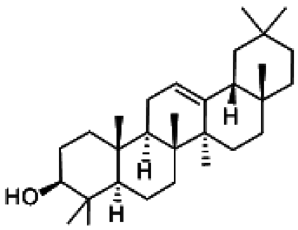
	R_1	R_2	R_3
94:	H	OH	H
95:	H	OH	GlcA-Gal -Rha
96:	H	OH	GlcA-Xyl-Rha
97:	R1+R2 =O		GlcA-Gal -Rha



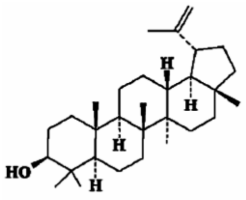
98: R
Glc-Glc-Rha



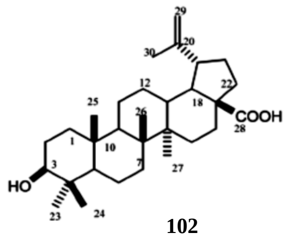
99



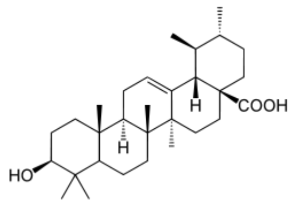
100



101

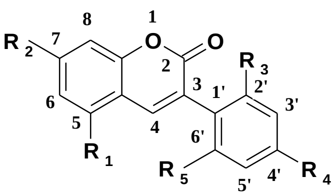


102

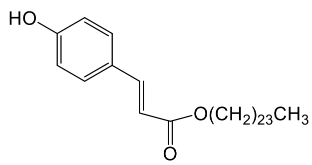


103

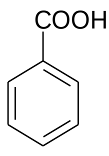
Figure 5. Chemical structures of triterpenoidal saponins isolated from genus *Lotus*.



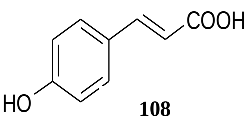
	R_1	R_2	R_3	R_4	R_5
104:	H	OCH3	OCH3	OH	OH
105:	OCH3	OH	OH	OCH3	H



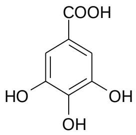
106



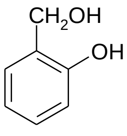
107



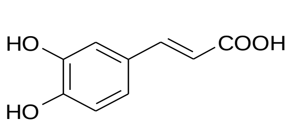
108



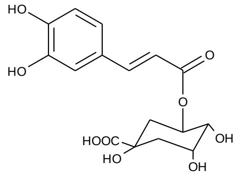
109



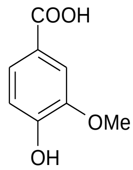
110



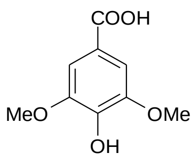
111



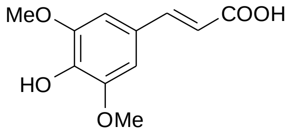
112



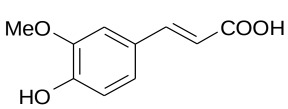
113



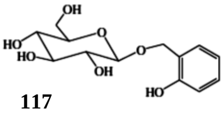
114



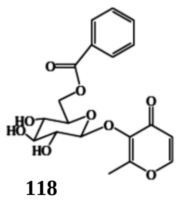
115



116

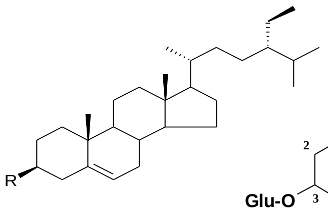


117

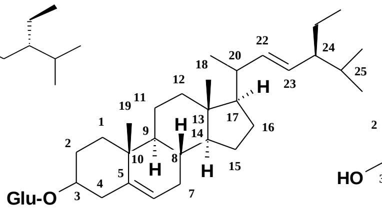


118

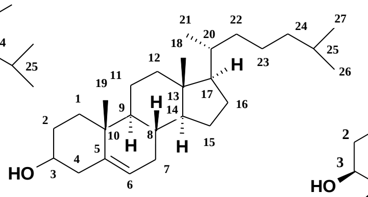
Figure 6. Chemical structures of coumarins and phenolic compounds isolated from genus *Lotus*.



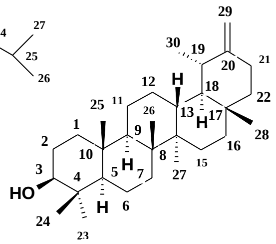
R
119: OH
120: Glc
121: -*O*-6'-Palmitoyl-Glc



122

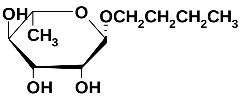


123

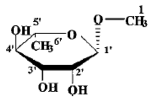


124

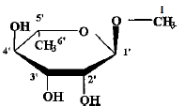
Figure 7. Chemical structures of sterols isolated from genus *Lotus*.



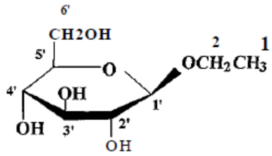
125



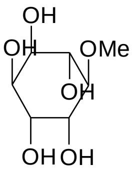
126



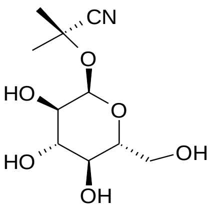
127



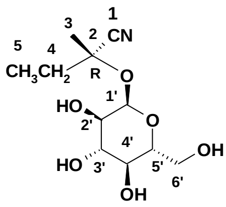
128



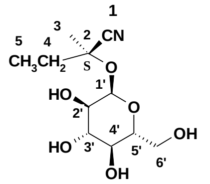
129



130



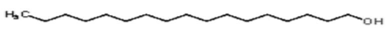
131



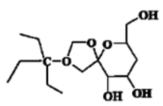
132

Figure 8. Chemical structures of alkylated sugars and cyanogenic glycosides isolated from genus *Lotus*.

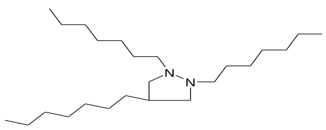
133



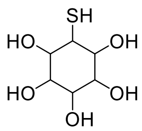
134



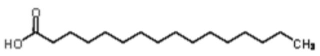
136



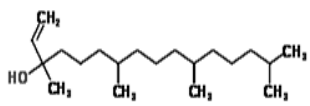
135



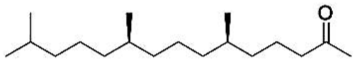
137



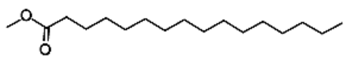
138



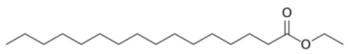
139



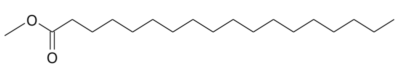
140



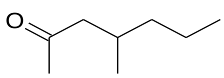
141



142



143



144

Figure 9. Chemical structures of miscellaneous compounds isolated from genus *Lotus*.

References:

Abdel-Kader MS, Amer ME, Tang S, Kingston DG. 2006. Two new isoflavone derivatives from the roots of an Egyptian collection of *Lotus polyphyllos*. Natural product research. 20(10):922-926.

Abdel-Kader MS, Basudan OA, Alqasoumi SI, Abou-Shoer MI. 2007. Phytochemical study of *Lotus ornithopodioloides* Natural Product Sciences. 13(4):317-321.

Abdel-Kader MS, Basudan OA, Parveen M, Amer ME. 2008. A new 3-arylcoumarin from the roots of an Egyptian collection of *Lotus polyphyllos*. Natural product research. 22(5):448-452.

Aissaoui M, Lorella S, Mezrag A, Mohamed B, Nicola M, Massimiliano DA. 2014. Phytochemical investigation and cytotoxic activity of *Lotus corniculatus*. Pharmacologyonline. 3:222-225.

Ali MS, Ahmad F, Ahmad VU, Azhar I, Usmanghani K. 2001. Unusual chemical constituents of *Lotus garcinii* (Fabaceae). Turkish Journal of Chemistry. 25(1):107-112.

Ali MS, Azhar I, Ahmad F, Jahangira M, Perveen S, Ahmad VU, Usmanghani K. 2000. Garcintin: A new flavonol glycoside from *Lotus garcinii* (Fabaceae). Natural medicines. 54(5):253-256.

Alqasoumi SI, Al-Rehaily AJ, Abdel-Kader MS. 2013. Two isoflavans and a 3-arylcoumarin from the roots of *Lotus lalambensis* growing in Saudi Arabia. Revista latinoamericana de química. 41(1):61-67.

Araniti F, Sunseri F, Abenavoli MR. 2014. Phytotoxic activity and phytochemical characterization of *Lotus ornithopodioides* L., a spontaneous species of Mediterranean area. Phytochemistry Letters. 8:179-183.

Azhar I, Mazhar F, Ahmad SW, Usmanghani K, Gill MA. 2004. Antifungal screening of *Lotus garcinii* DC Pakistan Journal of Pharmacology. 21(2):7-10.

Biely J, Kitts W. 1964. The anti-estrogenic activity of certain legumes and grasses. Canadian Journal of Animal Science. 44(3):297-302.

Bonde MR, Millar RL, Ingham JL. 1973. Induction and identification of sativan and vestitol as two phytoalexins from *Lotus corniculatus*. Phytochemistry. 12(12):2957-2959.

Boulos L. 1999. Flora of Egypt. Vol. Vol. 1. Cairo, Egypt: Al Hadara Publishing.

Dalmarco JB, Dalmarco EM, Koelzer J, Pizzolatti MG, Fröde TS. 2010. Isolation and identification of bioactive compounds responsible for the anti-bacterial efficacy of *Lotus corniculatus* var. São Gabriel. International Journal of Green Pharmacy (IJGP). 4(2).

El-Gazzar NS. 2016. Phytochemical investigation of some plants belonging to genus *Lotus* Fabaceae) [Master degree of Pharmaceutical Sciences]. Faculty of Pharmacy: University of Alexandria.

El-Ghani A, Hafez S, El-Aziz E, El-Shazly A. 2001. Phytochemical and biological studies of *Lotus corniculatus* var. tenuifolius L. growing in Egypt. Alexandria Journal of Pharmaceutical Sciences. 15(2):103-108.

El-Youssef HM, Murphy BT, Amer ME, Abdel-Kader MS, Kingston DJ. 2008. Phytochemical and biological study of the aerial parts of *Lotus lalambensis* growing in Saudi Arabia. Saudi Pharmaceutical Journal. 16(2):122-134.

El Mousallami AM, Afifi MS, Hussein SA. 2002. Acylated flavonol diglucosides from *Lotus polyphyllos*. Phytochemistry. 60(8):807-811.

Foo L, Lu Y, McNabb W, Waghorn G, Ulyatt M. 1997. Proanthocyanidins from *Lotus pedunculatus*. Phytochemistry. 45(8):1689-1696.

Foo L, Newman R, Waghorn G, McNabb W, Ulyatt M. 1996. Proanthocyanidins from *Lotus corniculatus*. Phytochemistry. 41(2):617-624.

Fröde TS, Medeiros Y. 2001. Myeloperoxidase and adenosine-deaminase levels in the pleural fluid leakage induced by carrageenan in the mouse model of pleurisy. Mediators of inflammation. 10(4):223-227.

Girardi FA, Tonial F, Chini SO, Sobottka AM, Scheffer-Basso SM, Bertol CD. 2014. Phytochemical profile and antimicrobial properties of *Lotus* spp.(Fabaceae). Anais da Academia Brasileira de Ciências. 86(3):1295-1302.

Golea L, Haba H, Lavaud C, Long C, Benkhaled M. 2012. Chemical constituents from *Lotus pusillus* Medik. Biochemical Systematics and Ecology. 45:12-15.

Harney PM, Grant WF. 1964. A chromatographic study of the phenolics of species of Lotus closely related to L. corniculatus and their taxonomic significance. American Journal of Botany.621-627.

Ingham JL. 1977. Isoflavan phytoalexins from *Anthyllis*, *lotus* and *Tetragonolobus*. Phytochemistry. 16(8):1279-1282.

Ingham JL, Dewick PM. 1979. A new isoflavan phytoalexin from leaflets of *Lotus hispidus*. Phytochemistry. 18(10):1711-1714.

Ingham JL, Dewick PM. 1980. Isolation of a new isoflavan phytoalexin from two *Lotus* species. Phytochemistry. 19(12):2799-2800.

Jay M, Hasan A, Voirin B, Viricel M-R. 1978. Les flavonoides du *Lotus corniculatus*. Phytochemistry. 17(4):827-829.

Jay M, Ibrahim RK. 1986. Biosynthesis of 8-substituted flavonols in relation to ontogeny of flower colour in *Lotus corniculatus*. Biochemie und Physiologie der Pflanzen. 181(3):199-206.

Kadry H, Shoala S, El Gindy O, Kassem M. 2007. Two triglycoside flavonols from *Lotus corniculatus*. Egypt J Pharm Sci. 48:17-25.

Kasem MES. 2001. Flavonoids of Some Plant Belonging to the Family Leguminosae. Faculty of Pharmacy: Cairo University.

Koelzer J, Pereira DA, Dalmarco JB, Pizzolatti MG, Fröde TS. 2009. Evaluation of the anti-inflammatory efficacy of *Lotus corniculatus*. Food chemistry. 117(3):444-450.

Mahasneh AM. 2002. Screening of some indigenous Qatari medicinal plants for antimicrobial activity. Phytotherapy research. 16(8):751-753.

Mahmoud ZF, Amer ME, Kader MSA, Abdel-Salam NA. 1990. A coumestan from *Lotus creticus*. Phytochemistry. 29(1):355-356.

Morris P, Lanot A. 2005. Elicitation of isoflavan phytoalexins in *Lotus japonicus*. Lotus japonicus Handbook.355-361.

Nielsen JG. 1970. Isolation and structure of the 3-galactoside of a new flavonol 5, 7, 3′, 4′-tetrahydroxy-8-methoxy-flavonol (corniculatusin) from *lotus corniculatus*. Tetrahedron Letters. 11(11):803-804.

Osman SM, Alazzouni AS, Koheil MA, Khalek SMA, Saad AM. 2013. Phytochemical screening and hepatoprotective activity of the aerial parts of *Lotus polyphyllos* ED Clarke family Fabaceae growing in Egypt. Life Science Journal. 10(3).

Pereira DA, Dalmarco JB, Wisniewski Jr A, Simionatto EL, Pizzolatti MG, Fröde TnS. 2011. *Lotus corniculatus* regulates the inflammation induced by bradykinin in a murine model of pleurisy. Journal of agricultural and food chemistry. 59(6):2291-2298.

Rafiq S, Majeed R, Qazi AK, Ganai BA, Wani I, Rakhshanda S, Qurishi Y, Sharma P, Hamid A, Masood A. 2013. Isolation and antiproliferative activity of *Lotus corniculatus* lectin towards human tumour cell lines. Phytomedicine. 21(1):30-38.

Reynaud J, Jay M, Raynaud J. 1982. Flavonoid glycosides of *Lotus corniculatus* (Leguminosae). Phytochemistry. 21(10):2604-2605.

Reynaud J, Lussignol M. 2005. The flavonoids of *Lotus corniculatus*. Lotus Newsletter. 35(1):75-82.

Sandhar HK, Kumar B, Prasher S, Tiwari P, Salhan M, Sharma P. 2011. A review of phytochemistry and pharmacology of flavonoids. Internationale Pharmaceutica Sciencia. 1(1):25-41.

Sarelli L, Tuori M, Saastamoinen I, Syrjälä-qvist L, Saloniemi H. 2003. Phytoestrogen content of birdsfoot trefoil and red clover: effects of growth stage and ensiling method. Acta Agriculturae Scandinavica, Section A-Animal Science. 53(1):58-63.

Shimada N, Akashi T, Aoki T, Ayabe S-i. 2000. Induction of isoflavonoid pathway in the model legume *Lotus japonicus*: molecular characterization of enzymes involved in phytoalexin biosynthesis. Plant Science. 160(1):37-47.

Strittmatter CD, Wagner ML, Kade M, Gurni AA. 1992. Identification of *Lotus tenuis* (Waldst et Kit.) flavonoids. Biochemical systematics and ecology. 20(7):685-687.

Täckholm V. 1974. Students' Flora of Egypt. 2nd Edition ed. Beirut: Cooperative Printing Company.

Trouillas P, Calliste C-A, Allais D-P, Simon A, Marfak A, Delage C, Duroux J-L. 2003. Antioxidant, anti-inflammatory and antiproliferative properties of sixteen water plant extracts used in the Limousin countryside as herbal teas. Food Chemistry. 80(3):399-407.

Tselepi M, Papachristou E, Emmanouilidi A, Angelis A, Aligiannis N, Skaltsounis A-L, Kouretas

D, Liadaki K. 2011. Catalytic inhibition of eukaryotic topoisomerases I and II by flavonol glycosides extracted from Vicia faba and Lotus edulis. Journal of natural products. 74(11):2362-2370.

Walter E. 1961. Isolation of oleanolic and and saponin from trefoil (*Lotus corniculatus*, var. viking). Journal of pharmaceutical sciences. 50(2):173-173.

Yamaguchi F, Ariga T, Yoshimura Y, Nakazawa H. 2000. Antioxidative and anti-glycation activity of garcinol from *Garcinia indica* fruit rind. Journal of agricultural and food chemistry. 48(2):180-185.

Yang SS, Gao F, Mabry TJ, Amer M, Abdel-Kader M, Mahmoud Z, Abdel-Salam N. 1989. Flavonoids from *Lotus creticus*. Phytochemistry. 28(6):1749-1750.