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*SCIENTIFIC REVIEW*

# Chemical Constituents of *Verbascum* L. Species

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***Chemical Constituents of Verbascum L. Species***

***Summary***

*Verbascum species (Scrophulariaceae), which are widespread plants in Anatolia, are used as expectorant and mucolytic in folk medicine. In this paper, the chemical constituents of saponins, iridoid and phenylethanoid glycosides, monoterpene glucoside, neolignan glucosides, flavonoids, steroids, spermine alkaloids and other compounds of these species are reviewed.*

***Key words :*** *Verbascum L. species, Scrophulariaceae, mullein.*

***Verbascum Türlerinin Kimyasal Bileşimi***

***Özet***

*Anadolu'da çok yaygın olarak yetişen Verbascum türleri (Scrophulariaceae) halk arasında balgam söktürücü ve göğüs yumuşatıcı olarak kullanılmaktadır. Bu derlemede, türlerin kimyasal bileşiminde yer alan saponinler, iridoit ve feniletanoit glikozitleri, monoterpen glukoziti, neolignan glukozitleri, flavonoitler, steroitler, spermin alkaloitleri ve diğer bileşikler hakkında bilgi verilmiştir.*

***Anahtar Kelimeler:*** *Sığırkuyruğu, Verbascum L. türleri, Scrophulariaceae, mullein.*

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## INTRODUCTION

*Verbascum L.* is the largest genus of the family Scrophulariaceae, with about 2500 species worldwide[1]. This genus, commonly known as "Sığırkuyruğu", is represented by 228 species, of which 185 are endemic in the flora of Turkey[2]. Various preparations of some species of this genus have been used as expectorant and mucolytic, as well as sudorific, sedative, diuretic and constipate in traditional Turkish medicine[3]. *Verbascum* species are also used externally for desiccating wounds, anal fistula and pruritic conditions in urogenital organs[4]. Additionally, in Europe, Asia and Northern America, several *Verbascum* species have been reported as antiseptic, astringent, demulcent, emollient, expectorant, sedative, narcotic, diuretic and antimalarial and as a treatment for tumors, inflammations, migraine, asthma and spasmodic coughs[1].

We present here an exhaustive review of the literature, available as of the end of 2004, on the metabolites from the *Verbascum* species throughout the world.

The compounds in *Verbascum* spec. are classified as eight main groups, such as saponins, iridoid and phenylethanoid glycosides, monoterpene glucoside, neolignan glucosides, flavonoids, steroids and spermine alkaloids. Phenolic acids, fatty acids and some

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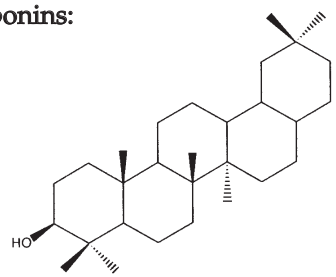
other compounds are included under the title, "Other Compounds".

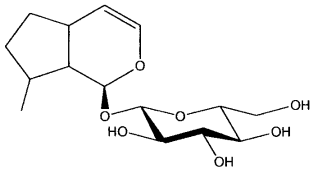
The major skeleton of each main group is given in the relevant section. The structures are represented in the tables from the basic to the complex skeleton, together with distribution in plants in alphabetical order (*Recorded species in the flora of Turkey).

## I. Saponins:



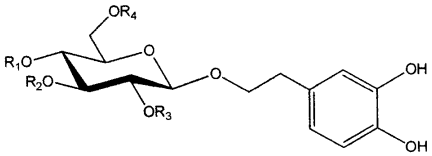

This is one of the major groups in the genus *Verbascum*. The phytochemical studies on these species have revealed the presence of oleanane type triterpene saponins, usually monodesmosidic, and their sugar moieties are attached at C-3 (OH). The saponins in *Verbascum* species are given in Table 1.

## II. Iridoid Glycosides:



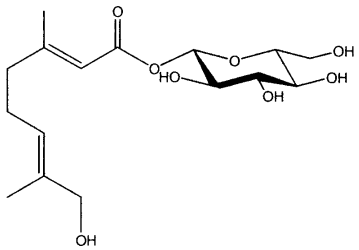

Iridoids, which represent a large group of cyclopentano[*c*]pyran monoterpenoids, are found as natural constituents in a large number of *Verbascum* species. A bicyclic H-5/H-9 *β,β-cis*-fused cyclopentanopyran ring system is the most common structural feature of these substances. They also contain a double bond between C-3 and C-4 including non-substitution at C-4. *Verbascum* species contain especially aucubin and catalpol type iridoids and their acylated derivatives are modified with aliphatic and aromatic acids (e.g. acetic acid, *trans*-cinnamic acid, *trans-p*-coumaric acid, ferulic acid); these glycosides are also varied with the esterification positions. The iridoid glycosides in *Verbascum* species are shown in Table 2.

## III. Phenylethanoid Glycosides:



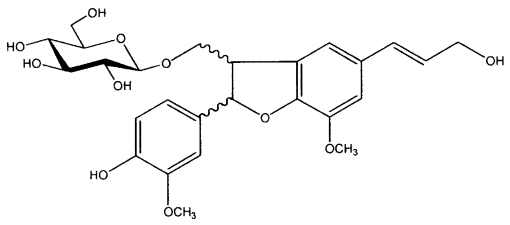

Phenylethanoid glycosides are natural polyphenolic compounds widely seen in many Dicotyledone families, and are also rich in the *Verbascum* genus. Structurally, they are characterized as glycosides of phenylethanol, esterified at $R_1$ position by cinnamic, caffeic and ferulic acid derivatives. Attachment of the increasing number of sugar units (to date, mono, di, tri), the type of the sugar (glucose, rhamnose, arabinose, apiose and xylose), different sequence ($R_2$-$R_4$) and substitutions cause great variations in their structures. The phenylethanoid glycosides in *Verbascum* species are given in Table 3.

## IV. Monoterpene Glucosides:




In a continuation of the phytochemical studies on *Verbascum* species of Turkish origin, a monoterpene glucoside, 1-*β*-glucopyranosyl-8-hydroxy-3,7-dimethyl-2(*E*),6(*E*)-octadienoate, was isolated from the aerial parts of *V. pterocalycinum* var. mutense[9].

## V. Neolignan Glucosides:




Lignans and neolignans belong to an important group of natural products, consisting of two phenylpropane monomers linked through carbon-carbon or carbon-oxygen bonds. The neolignan glucosides

**Table 1.** Saponins of *Verbascum* L. species

| Saponins | Species | References |
|---|---|---|
| Saponin II | *V. nigrum* | 5 |
| Verbascosaponin (= Saponin I) | *V. nigrum* | 5 |
| | *V. phlomoides** | 6 |
| Songarosaponin B | *V. songaricum** | 7 |
| İlwensisaponin C | *V. nigrum* | 8 |
| | *V. pterocalycinum var. mutense** | 9 |
| Thapsuine B | *V. lychnitis* | 10 |
| | *V. thapsus** | 11 |
| Hydroxythapsuine B | *V. thapsus** | 11 |
| Triterpene B | *V. phlomoides** | 6 |
| | *V. thapsus** | 12 |
| Triterpene A | *V. phlomoides** | 6 |
| | *V. thapsus** | 12 |
| Saikogenin A | *V. thapsus** | 12 |
| Songarosaponin A | *V. songaricum** | 7 |
| Songarosaponin E | *V. songaricum** | 13 |
| Songarosaponin F | *V. songaricum** | 13 |
| 3-*O*-*β*-D-fucopyranosylsaikogenin F | *V. roripifolium* | 14 |
| Mulleinsaponin I | *V. sinaiticum* | 14 |
| Saikosaponin A | *V. roripifolium* | 14 |
| | *V. sinaiticum* | |
| Mulleinsaponin II | *V. sinaiticum* | 14 |
| Mulleinsaponin III | *V. roripifolium* | 14 |
| | *V. sinaiticum* | |
| Desrhamnosyl verbascosaponin | *V. phlomoides** | 15 |
| | *V. thapsiforme** | 14 |
| Songarosaponin C | *V. songaricum** | 7 |
| | *V. thapsiforme** | 14 |
| Songarosaponin D | *V. songaricum** | 16 |

| | | |
|---|---|---|
| | *V. thapsiforme** | 14 |
| Buddlejasaponin IV | *V. thapsiforme** | 14 |
| İlwensisaponin A (= Mimengoside A) | *V. pterocalycinum var. mutense** | 9 |
| | *V. roripifolium* | 14 |
| | *V. sinaiticum* | |
| | *V. thapsiforme** | 8 |
| | *V. nigrum* | 14 |
| Buddejasaponin I (= Verbascosaponin B) | *V. fruticulosum* | 14 |
| | *V. roripifolium* | |
| | *V. sinaiticum* | |
| | *V. songaricum** | 13 |
| | *V. thapsiforme** | 14 |
| Mulleinsaponin IV | *V. fruticulosum* | 14 |
| Mulleinsaponin V | *V. fruticulosum* | 14 |
| Mulleinsaponin VI | *V. sinaiticum* | 14 |
| Mulleinsaponin VII | *V. sinaiticum* | 14 |
| 3-O-{[*β*-*D*-glucosyl-(1→2)-*β*-*D*-fucopyranosyl-(1→4)]-*α*-L-rhamnopyranosyl]-(1→2)-*β*-*D*-glucopyranosyl}-13*β*,28-epoxy-olean-11-ene-3*β*,23-diol | *V. lychnits* | |
| 3-*O*-{[*β*-D-glucosyl-(1→2)-*β*-D-fucopyranosyl-(1→4)]-*α*-L-rhamnopyranosyl]-(1→2)-*β*-D-glucopyranosyl}-16*β*-(*β*-D-glucopyranosyloxy)-13*β*,28-epoxy-olean-11-ene-3*β*, 23-diol | *V. lychnitis* | 17 |
| Thapsuine A | *V. lychnitis* | 10 |
| | *V. thapsus** | 11 |
| Hydroxythapsuine A | *V. thapsus** | 11 |
| Niga-ichigoside F1 | *V. wiedemannianum** | 18 |
| Rosmatin | *V. wiedemannianum** | 18 |
| Ursolic acid | *V. lychnitis* | 10 |
| Ancrytosaponin A | *V. ancyritanum** | 19 |

* Recorded species in the flora of Turkey

**Table 2**. Iridoid glycosides of *Verbascum* L. species

| Iridoid glycosides | Species | References |
|---|---|---|
| Aucubin | *V. cheirantifolium** | 20 |
| | *V. georgicum** | 21 |
| | *V. lasianthum** | 22 |
| | *V. laxum* | 23 |
| | *V. lychnitis* | 10 |
| | *V. nigrum* | 24 |
| | *V. phlomoides** | 25 |
| | *V. saccatum** | 26 |
| | *V. sinuatum** | 27 |
| | *V. spinosum* | 28 |
| | *V. thapsiforme** | 24 |
| | *V. thapsus** | 24 |
| | *V. undulatum* | 29 |
| | *V. virgatum* | 30 |
| | *V. wiedemannianum** | 18 |
| 6-*O*-*β*-D-glucopyranosyl aucubin | *V. sinuatum** | 31 |
| Sinuatol | *V. laxum* | 23 |
| | *V. nigrum* | 32 |
| | *V. sinuatum** | 33 |
| | *V. undulatum* | 34 |
| 6-*O*-*β*-D-xylopyranosyl aucubin | *V. sinuatum** | 35 |
| | *V. thapsiforme** | 36 |
| | *V. thapsus** | 27 |
| 6-*O*-*α*-L-sinuatosyl aucubin | *V. sinuatum** | 37 |
| Sinuatoside | *V. sinuatum** | 37 |
| Nigroside II | *V. nigrum* | 32 |
| | *V. undulatum* | 34 |
| Nigroside I | *V. nigrum* | 32 |
| | *V. undulatum* | 29 |
| Nigroside III | *V. nigrum* | 38 |
| | *V. undulatum* | 34 |
| 6-*O*-(3″-*O*-*p*-coumaroyl)-*α*-L-rhamnopyranosyl aucubin | *V. laxum* | 23 |
| | *V. nigrum* | 38 |
| | *V. undulatum* | 29 |
| Unduloside III | *V. lasianthum** | 22 |
| | *V. undulatum* | 39 |
| Unduloside II | *V. undulatum* | 39 |
| 6-*O*-(2″-*O*-*p*-methoxy-*trans*-cinnamoyl, 3″-*O*-asetyl)-*α*-L-rhamnopyranosylaucubin | *V. laxum* | 23 |
| Phlomoidoside | *V. phlomoides** | 15 |
| Unduloside | *V. undulatum* | 34 |
| 6-*O*-(3″-*O*-*trans*- feruloyl)-*α*-L-rhamnopyranosylaucubin | *V. undulatum* | 29 |
| Nigroside V | *V. nigrum* | 38 |
| Nigroside IV | *V. nigrum* | 38 |
| 6-*O*-(*p*-methoxy-cinnamoyl)-aucubin | *V. cheirantifolium** | 20 |
| 6-*O*-(*p*-coumaroyl) aucubin | *V. cheirantifolium** | 20 |
| Aucuboside | *V. chaixii* | 40 |
| | *V. lychnitis* | 41 |

| | | |
|---|---|---|
| | *V. sinuatum** | 27 |
| | *V. phlomoides** | 42 |
| | *V. thapsiforme** | 40 |
| Catalpol | *V. chaixii* | 40 |
| | *V. cheirantifolium** | 20 |
| | *V. cilicicum** | 43 |
| | *V. georgicum** | 21 |
| | *V. laxum* | 23 |
| | *V. lychnitis* | 41 |
| | *V. nigrum* | 24 |
| | *V. phlomoides** | 25 |
| | *V. sinuatum** | 44 |
| | *V. spinosum* | 28 |
| | *V. thapsiforme** | 42 |
| | *V. thapsus** | 24 |
| | *V. wiedemannianum** | 18 |
| Isocatalpol | *V. lychnitis* | 41 |
| | *V. nigrum* | 24 |
| | *V. thapsiforme** | |
| | *V. thapsus** | |
| Methylcatalpol | *V. lychnitis* | 41 |
| | *V. nigrum* | 24 |
| | *V. thapsiforme** | |
| | *V. thapsus** | |
| 6-*O*-α-L-rhamnopyranosylcatalpol | *V. georgicum** | 21 |
| | *V. lasianthum** | 22 |
| | *V. saccatum** | 26 |
| | *V. thapsus** | 45 |
| 6-*O*-β-D-xylopyranosylcatalpol | *V. thapsiforme** | 35 |
| Verbaspinoside | *V. cilicicum** | 43 |
| | *V. spinosum* | 28 |
| 6-*O*-(3″-*O*-*trans*-cinnamoyl)-α-L-rhamnopyranosylcatalpol | *V. cilicicum** | 43 |
| 6-*O*-(4″-*O*-*trans*-cinnamoyl)-α-L-rhamnopyranosylcatalpol | *V. cilicicum** | 43 |
| Saccatoside | *V. cilicicum** | 43 |
| | *V. saccatum** | 26 |
| | *V. thapsus** | 45 |
| | *V. virgatum* | 30 |
| 6-*O*-(3″-*O*-*p*-coumaroyl)-α-L-rhamnopyranosylcatalpol | *V. sinuatum** | 44 |
| | *V. thapsus** | 45 |
| | *V. virgatum* | 30 |
| 6-*O*-(4″-*O*-*p*-coumaroyl)-α-L-rhamnopyranosylcatalpol | *V. thapsus** | 45 |
| 6-*O*-(2″-*O*-(*p*-methoxy-*trans*-cinnamoyl)-α-L-rhamnopyranosylcatalpol | *V. thapsus** | 45 |
| 6-*O*-(3″-*O*-(*p*-methoxy-*trans*-cinnamoyl)-α-L-rhamnopyranosylcatalpol | *V. thapsus** | 45 |
| Verbascoside A | *V. georgicum** | 21 |
| | *V. lasianthum** | 22 |
| | *V. thapsus** | 45 |
| 6-*O*-[2″-*O*-(3,4-dihydroxy-*trans*-cinnamoyl)]-α-L-rhamnopyranosylcatalpol | *V. thapsus** | 45 |
| 6-*O*-[4″-*O*-(3,4-dihydroxy-*trans*-cinnamoyl)]-α-L-rhamnopyranosylcatalpol | *V. thapsus** | 45 |
| 6-*O*-[3″-*O*-(3,4-dimethoxy-*trans*-cinnamoyl)]-α-L- | *V. thapsus** | 45 |

| | | |
|---|---|---|
| rhamnopyranosylcatalpol | | |
| 6-*O*-(2″-*O*-feruloyl)-α-L-rhamnopyranosylcatalpol | *V. thapsus** | 45 |
| 6-*O*-(4″-*O*-feruloyl)-α-L-rhamnopyranosylcatalpol | *V. thapsus** | 45 |
| 6-*O*-(2″-*O*-isoferuloyl)-α-L-rhamnopyranosylcatalpol | *V. thapsus** | 45 |
| 6-*O*-(3″-*O*-isoferuloyl)-α-L-rhamnopyranosylcatalpol | *V. thapsus** | 45 |
| 6-*O*-(4″-*O*-isoferuloyl)-α-L-rhamnopyranosylcatalpol | *V. thapsus** | 45 |
| Pulverulentoside I | *V. lasianthum** | 22 |
| | *V. laxum* | 23 |
| | *V. pulverulentum* | 46 |
| | *V. sinuatum** | 47 |
| | *V. thapsus** | 45 |
| 6-*O*-(2″-*O*-*p*-methoxy-*trans*-cinnamoyl-4″-*O*-asetyl)-α-L-rhamnopyranosylcatalpol | *V. thapsus** | 45 |
| Buddlejoside $A_5$ | *V. lasianthum** | 22 |
| Pulverulentoside II | *V. pulverulentum* | 49 |
| Catalposide | *V. chaixii* | 40 |
| | *V. lychnitis* | 41 |
| 6-*O*-(*p*-coumaroyl) catalpol (= Specioside) | *V. lychnitis* | 48 |
| | *V. phlomoides** | 15 |
| Picroside IV | *V. pterocalycinum var. mutense** | 9 |
| Angeloside | *V. wiedemannianum** | 18 |
| Ajugol | *V. pterocalycinum var. mutense** | 9 |
| | *V. spinosum* | 28 |
| | *V. thapsus** | 45 |
| | *V. undulatum* | 29 |
| | *V. virgatum* | 30 |
| | *V. wiedemannianum** | 18 |
| 6-*O*-benzoyl ajugol | *V. thapsus** | 45 |
| 6-*O*-syringoyl ajugol | *V. thapsus** | 45 |
| 6-*O*-vanilloyl ajugol | *V. lasianthum** | 49 |
| | *V. thapsus** | 45 |
| Harpagide | *V. phlomoides** | 42 |
| | *V. sinuatum** | 27 |
| | *V. thapsiforme** | 42 |
| | *V. thapsus** | 31 |
| | *V. undulatum* | 50 |
| 8-*O*-acetyl harpagide | *V. lasianthum** | 49 |
| | *V. phlomoides** | 42 |
| | *V. thapsiforme** | |
| Verbascoside B | *V. georgicum** | 51 |
| Harpagoside | *V. lasianthum** | 49 |
| | *V. laxum* | 23 |
| | *V. nigrum* | 32 |
| | *V. phlomoides** | 42 |
| | *V. pulverulentum* | 46 |
| | *V. sinuatum** | 47 |
| | *V. thapsiforme** | 42 |
| | *V. thapsus** | 45 |
| | *V. undulatum* | 50 |
| Geniposidic acid | *V. olympicum** | 52 |
| Lychnitoside | *V. lychnitis* | 10 |
| Glutinoside | *V. wiedemannianum** | 18 |
| Rehmaglutin D | *V. wiedemannianum** | 18 |

* Recorded species in the flora of Turkey

**Table 3.** Phenylethanoid glycosides of *Verbascum* L. species

| Phenylethanoid glycosides | Species | References |
|---|---|---|
| Verbascoside (=Acteoside) | *V. cilicicum** | 43 |
| | *V. georgicum** | 53 |
| | *V. lasianthum** | 49 |
| | *V. lychnitis* | 54 |
| | *V. nigrum* | 54 |
| | *V. phlomoides** | 54 |
| | *V. pterocalycinum var. mutense** | 9 |
| | *V. salviifolium** | 55 |
| | *V. sinaiticum* | 56 |
| | *V. sinuatum** | 57 |
| | *V. spinosum* | 28 |
| | *V. thapsiforme** | 54 |
| | *V. undulatum* | 34 |
| | *V. wiedemannianum** | 58 |
| *β*-Hydroxyacteoside | *V. salviifolium** | 55 |
| 2′-*O*-Acetylacteoside | *V. sinaiticum* | 59 |
| Martynoside | *V. salviifolium** | 55 |
| | *V. undulatum* | 29 |
| | V. wiedemannianum* | 58 |
| 6′-*O*-Acetyl-martynoside (= Wiedemannioside A) | *V. undulatum* | 29 |
| | *V. wiedemannianum** | 58 |
| Echinacoside | *V. wiedemannianum** | 58 |
| Poliumoside | *V. blattaria** | 60 |
| | *V. boerhavii* | |
| | *V. chaixii* | |
| | *V. lasianthum** | 49 |
| | *V. phlomoides** | 60 |
| | *V. sinuatum** | |
| | *V. thapsus** | |
| Forsythoside B | *V. lychnitis* | 61 |
| | *V. nigrum* | 61 |
| | *V. phlomoides** | 15 |
| | *V. salviifolium** | 55 |
| | *V. thapsiforme** | 61 |
| | *V. thapsus** | 62 |
| Arenarioside | *V. sinaiticum* | 59 |
| | *V. thapsus** | 62 |
| | *V. undulatum* | 29 |
| Alyssonoside | *V. thapsus** | 62 |
| 1′-*O*-*β*-D-(3,4-dihydroxy-phenyl)-ethyl-*α*-L-rhamnopyranosyl-(1→3′)-*β*-D-xylopyranosyl-(1→6′)-4′-*O*-feruloyl-glucopyranoside | *V. sinaiticum* | 59 |
| | *V. thapsus** | 62 |
| Angoroside A | *V. salviifolium** | 55 |
| | *V. spinosum* | 28 |
| Angoroside C | *V. spinosum* | 28 |
| Leucosceptoside B | *V. thapsus** | 62 |
| | *V. wiedemannianum** | 58 |
| 1′-*O*-*β*-D-(3-hydroxy-4-methoxy-phenyl)-ethyl-*α*-L-rhamnopyranosyl-(1→3′)-*β*-D-xylopyranosyl-(1→6′)-4′-*O*-feruloyl-glucopyranoside | *V. thapsus** | 62 |

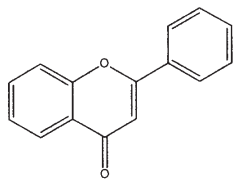
| | | |
|---|---|---|
| Cistanoside B | *V. sinaiticum*<br>*V. thapsus** | 59<br>62 |
| Wiedemannioside B | *V. wiedemannianum** | 58 |
| Wiedemannioside C | *V. wiedemannianum** | 58 |
| Wiedemannioside D | *V. wiedemannianum** | 58 |
| Wiedemannioside E | *V. wiedemannianum** | 58 |
| 1′-*O*-*β*-D-(3,4-dihydroxy-phenyl)-ethyl-*α*-L-rhamnopyranosyl- (1→3′)-3‴-hydroxy-4‴-*O*-*β*-D-glucopyranosyl-cinnamoyl-(1→6′)-glucopyranoside | *V. thapsus** | 62 |

* Recorded species in the flora of Turkey

from *Verbascum* species have dehydrodiconiferyl alcohol skeleton.

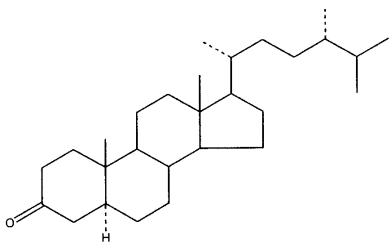
So far, two *Verbascum* species, *Verbascum thapsus*[62] and *V. salviifolium*[55], have been reported to contain neolignan glucosides, such as dehydrodiconiferyl alcohol *9-O-β*-D-glucopyranoside (*7R, 8S*), dehydrodiconiferyl alcohol *9-O-β*-D-glucopyranoside (*7S, 8R*), 5-*O*-methyldehydrodiconiferyl alcohol *9-O-β*-D-glucopyranoside (*7R, 8S*), 5-*O*-methyl-dehydrodiconiferyl alcohol *9-O-β*-D-glucopyranoside (*7S, 8R*), *4-O-β*-D-glucopyranosyl-dehydrodiconiferyl alcohol *9-O-β*-D-glucopyranoside (*7R, 8S*) and dehydrodiconiferyl alcohol *9′-O-β*-D-glucopyranoside.

## VI. Flavonoids:



The flavonoid glycosides are widely distributed in the plant kingdom. They have benzo-*γ*-pyrone skeleton in their structure. To date, many flavonoids have been reported from the *Verbascum* species, in which there was a large variety of flavone and flavonol aglycones, such as apigenin, luteolin, quercetin and kaempherol. Glycosylation was usually at C-7 position of these aglycones. On the other hand, a C-glucoside was found in *V. cherianthifolium*. Isoflavone and flavonolignans from *V. sinaiticum* have also been observed. The flavonoids from *Verbascum* species are seen in Table 4.

## VII. Steroids:



Khuroo and his colleagues determined steroid derivatives in *Verbascum* species[36]. Structually, these compounds usually contain cholestanon skeleton. 24*α*-methyl-5*α*-cholestan-3-on, 24*α*-ethyl-5*α*-cholestan-3-on, 24*α*-ethyl-5*β*-cholestan-3-on, 24*α*-ethyl-5*α*-cholestan-7-en-3-on, 24*α*-ethyl-5*α*-cholestan-22-en-3-on, 24*α*-ethyl-5*β*-cholestan-22-en-3-on, 24*α*-ethyl-5*α*-cholestan-$\Delta^{7,22}$-dien-3-on and *β*-sitosterol were isolated from *V. thapsus*[36]. *β*-sitosterol was also obtained from the aerial parts of *V. lasianthum*[75], *V. phlomoides*[25], *V. pycnostachyum*[376] and *V. thapsiforme*[77]. Morever, sitosterol-3-*O*-*β*-D-glucopyranoside[18] from *V. wiedemannianum*, stigmasterol from *V. pycnostachyum*[76] and *V. phlomoides*[25], phytosterol from *V. phlomoides*[77] and *V. thapsiforme*[77], and phytosterol glucoside from *V. phlomoides*[78] were reported.

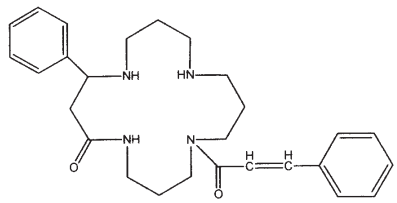
**Table 4.** Flavonoids of *Verbascum* L. species

| Flavonoids | Species | References |
|---|---|---|
| Apigenin | *V. cheiranthifolium** | 63 |
| | *V. eremobium* | 64 |
| | *V. fruticulosum* | 64 |
| | *V. lychnitis* | 41 |
| | *V. phlomoides** | 65 |
| | *V. schimperianum* | 64 |
| | *V. songaricum** | 66 |
| | *V. thapsiforme** | 67 |
| Apigenin-7-glucoside | *V. eremobium* | 64 |
| | *V. fruticulosum* | 64 |
| | *V. letourneuii* | 64 |
| | *V. phlomoides** | 65 |
| | *V. salviifolium** | 55 |
| | *V. schimperianum* | 64 |
| | *V. siniaticum* | 64 |
| | *V. thapsiforme** | 67 |
| Apigenin-7-glucuronide | *V. lychnitis* | 68 |
| | *V. nigrum* | |
| Apigenin-4′-rhamnoside | *V. thapsus subsp. thapsus** | 69 |
| Luteolin | *V. cheiranthifolium** | 63 |
| | *V. lychnitis* | 41 |
| | *V. fruticulosum* | 64 |
| | *V. phlomoides** | 65 |
| | *V. siniaticum* | 70 |
| | *V. songaricum** | 66 |
| | *V. thapsiforme** | 67 |
| | *V. thapsus** | 71 |
| | *V. wiedemannianum** | 18 |
| Luteolin-5-glucoside | *V. lychnitis* | 41 |
| Luteolin-7- glucoside | *V. eremobium* | 64 |
| | *V. fruticulosum* | 64 |
| | *V. letourneuii* | 64 |
| | *V. phlomoides** | 65 |
| | *V. salviifolium** | 55 |
| | *V. scardicolum* | 72 |
| | *V. schimperianum* | 64 |
| | *V. siniaticum* | 64 |
| | *V. songaricum** | 66 |
| | *V. thapsiforme** | 67 |
| Luteolin-3′- glucoside | *V. salviifolium** | 55 |
| Luteolin-7-glucuronide | *V. lychnitis* | 68 |
| | *V. nigrum* | |
| 6-hydroxy-luteolin-7- glucoside | *V. thapsus subsp. thapsus** | 69 |
| 7-methoxy-luteolin | *V. lychnitis* | 41 |
| Verbacoside | *V. thapsus** | 71 |
| Acacetin | *V. lychnitis* | 41 |
| Acacetin-7- glucoside | *V. fruticulosum* | 64 |
| | *V. schimperianum* | |
| | *V. siniaticum* | |
| Acacetin-7-galactoside | *V. fruticulosum* | 64 |
| | *V. schimperianum* | |
| | *V. siniaticum* | |
| Diosmin | *V. phlomoides** | 73 |

| | | |
|---|---|---|
| Hesperidin | *V. phlomoides** | 73 |
| Diosmetin-7-glucuronide | *V. nigrum* | 68 |
| Chrysoeriol | *V. phlomoides** | 65 |
| | *V. siniaticum* | 70 |
| Chrysoeriol-7-glucoside | *V. eremobium* | 64 |
| | *V. fruticulosum* | |
| | *V. salviifolium** | 55 |
| | *V. schimperianum* | 64 |
| | *V. siniaticum* | |
| Chrysoeriol-7-diglucoside | *V. eremobium* | 64 |
| | *V. fruticulosum* | |
| | *V. letourneuii* | |
| | *V. siniaticum* | |
| 7, 4′-dihydroxy flavon-4-rhamnoside | *V. thapsus** | 69 |
| Vitexin | *V. cheiranthifolium** | 63 |
| Swertisin | *V. cheiranthifolium** | 63 |
| Kaemferol | *V. phlomoides** | 65 |
| Quercetin | *V. lychnitis* | 68 |
| | *V. phlomoides** | 65 |
| | *V. songaricum** | 66 |
| Quercetin-7-glucoside | *V. thapsiforme** | 67 |
| Quercetin-7-glucuronide | *V. lychnitis* | 68 |
| | *V. nigrum* | |
| Quercetin-3,7-diglucoside | *V. thapsiforme** | 67 |
| Rutin | *V. phlomoides** | 65 |
| İsorhamnetin | *V. thapsus subsp. thapsus** | 69 |
| Tamarixetin-7-glucoside | *V. phlomoides** | 73 |
| Tamarixetin-7-rutinoside | *V. phlomoides** | 73 |
| 5-hydroxy-6,7-dimethoxyflavone-3-ol | *V. thapsus** | 74 |
| Patuletin | *V. lychnitis* | 41 |
| Orobol | *V.siniaticum* | 56 |
| Orobol-7-glucoside | *V. siniaticum* | 56 |
| 8-methylorobol-7-glucoside | *V. siniaticum* | 56 |
| 3′, 4′-dimethoxy-orobol-7-rhamnoside | *V. siniaticum* | 56 |
| Eriodictiol | *V. phlomoides** | 65 |
| Sinaiticin | *V. sinaiticum* | 70 |
| Hydrocarpin | *V. sinaiticum* | 70 |

* Recorded species in the flora of Turkey

### VIII. Spermine Alkaloids:



The isolation and structural elucidation of the novel 17-membered lactam alkaloids, verbacine and verballocine, were reported from *Verbascum pseudonobile* Stoj. et Stef.[79], together with their corresponding *N,N'*-methylene-bridge derivatives, namely (+)-(*S*)-verbamethine, (+)-(*S*)-isoverbamethine, (-)-verbasitrine, (-)-isoverbasitrine, (+)-verbametrine and (+)- isoverbametrine[80]. Verbaskine was also isolated from this plant, for which evidence of the artificial origin was previously presented[79].

Furthermore, (*S*)-verbasikrin, (*S*)-isoverbasikrin, (*S*)-verbamekrin and (S)-isoverbamekrin were obtained from *V. pseudonobile* and structurally characterized[81]. In the same plant material, the presence of the spermine alkaloids, protoverbine (8*S*)-8-phenyl-1,5,9,13-tetraazacycloheptadecane-6-on, protometin (2*S*)-2-phenyl-1,5,9,14-tetraazabicyclo [12.3.1]-octadecane-4-on[82], verbamedine, isoverbamedine (*Z*) and *N*(13)-formimino-verbacine were reported[83]. Verbacine and verbascenine were also found in *V. nobile*[84]. Verbascenine and verballoscenine were yielded from *V. phoeniceum* L. Verbascenine was also elucidated from the total alkaloid extracts of *V. nigrum* L.[85].

### IX. Other Compounds:

The presence of anabasine and plantagonine alkaloids from the leaves of *V. songaricum* Schrenk was determined[86]. 3$\alpha$-hydroxydrimmanyl-8-methanoate, a sesquiterpene, was reported from *V. thapsus*[36]. Magiatis and his colleagues isolated verbalactone, a macrocyclic dimer lactone, from the roots of *V. undulatum*[50].

*V. phlomoides* contained phenolic acids as dihydroxy cinnamic acid, *para*-coumaric acid, ferulic acid, *para*-hydroxy benzoic acid and vanillic acid[25,87]. However the contents of *para*-coumaric acid, ferulic acid, *para*-hydroxy benzoic acid and vanillic acid in *V. thapsiforme* were two times more than their amounts in *V. phlomoides*[87].

The benzene extract of seed oil of *V. thapsus* contained palmitic, stearic, oleic, linoleic, linolenic, arachidic and behenic acids in the nonsaponifiable fraction[88]. *V. phlomoides* and *V. thapsiforme* were also rich in palmitic and linoleic acids[87].

The water-soluble polysaccharides of mullein flowers (*Verbascum*) were isolated and characterized. The neutral fraction consisted of a xyloglucan and an arabinogalactan[89].

## RESULTS and DISCUSSION

As a result of exhaustive investigations, it is noticed that only 40 species have been studied, 16 of which are recorded in the flora of Turkey.

*Verbascum* species have been used as expectorant, mucolytic and diuretic as well as in the treatment of hemorrhoids.

The isolated compounds from *Verbascum* species were evaluated under eight main groups as: saponins, iridoids, phenylethanoids, monoterpene and neolignan glycosides, flavonoids, steroids and spermine alkaloids. Most of the compounds were isolated from the aerial parts of the plants.

It is considered that iridoid glycosides, flavonoids, phenylethanoid glycosides and saponins, respectively, are obtained in the plants more than the others and that they may be responsible for the biological activities mentioned above.

*V. thapsus*, which has officinal preparations, is also rich in the mentioned compounds. In our ongoing project, developing officinal preparations from some endemic *Verbascum* species will be useful. Morever, the chemical characterization of *Verbascum* species growing in Turkey will be determined.

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