Journal of
Microbial & Biochemical Technology

Abdelgawad, J Microb Biochem Technol 2017, 9:1
DOI: 10.4172/1948-5948.1000340

Review Article Open Access

Tamarix nilotica (Ehrenb) Bunge: A Review of Phytochemistry and Pharmacology

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Abstract

Tamarix nilotica (Ehrenb.) Bunge is known as Nile Tamarisk belonging to the Tamaricaceae family. This plant has diverse and potential medicinal uses in traditional herbal medicine for treating relieve headache, draw out inflammation, and as an antiseptic agent in Egypt. *Tamarix nilotica* have been occurs in Lebanon, Palestine, Egypt, Sudan, Somalia, Ethiopia and Kenya. Phytochemical investigation revealed that the major chemical constituents of *Tamarix nilotica* are flavonoids, tannins and phenolics. The hydro-alcoholic extracts of the leaves of *T. nilotica* exhibited significant antioxidant, anti-tumor, hepatoprotective and antiviral activities.

Keywords: *Tamarix nilotica*; Nile Tamarisk; Ellagitannins; Flavonoids; Antioxidant; Antitumor; Antiviral; Hepatoprotective; Antimicrobial; Antidiabetic

Introduction

Tamaricaceae is relatively a small family of 4 genera and 120 species [1]. Members of the family are chiefly temperate and sub-tropical, growing in maritime or sandy habitats in addition to halophytes or xerophytes that are distributed from the Mediterranean, North Africa and south-western Africa through Arabian Peninsula to Central and South Asia [2].

The genus Tamarix (tamarisk, salt cedar) is composed of about 50–60 species of flowering plants in the family Tamaricaceae, native to drier areas of Eurasia and Africa. Tamarix is represented in Egypt with two indigenous species which are *T. aphylla* (L.) H. Karst and *T. nilotica* (Ehrenb.) Bunge while, it is represented by 8 species in Saudi Arabia, namely: *T. mascatensis* Bunge.; *T. ramosissima Leded., T. nilotica (Ehrenb.)* Bunge., *T. aphylla L., T. tetragyna* Ehrenb., *T. aucheriana* Decne., *T. pyconocarpa* DC and *T. passerinoides* Del [2-4]. Another species of Tamarix include *T. arabica, T. aralensis, T. boveana, T. chinensis, T. hohenackeri, T. karelinii, T. kotschyi, T. leptopetala, T. laxa* var. *araratica, T. laxa* var. *subspicata, T. mannifera* var. *persica, T. pycnocarpa, T. hampeana, T. mascatensis, T. bengalensis, T. gallica* var. *arborea, T. mannifera* var. *purpurascens, T. passerinoides* var. *macrocarpa* and *T. pallasii* var. *macrostemon* [5].

Several species of plants belonging to the genus Tamarix have been employed in traditional medicine. The common traditional uses shown in various reports for some plant species of the genus are as a diaphoretic, diuretic and hepatotonic and to treat liver disorders, relieve headache, ease prolonged or difficult labor, and cure sores and wounds besides being an astringent and employed for tanning and dyeing purposes [6-10].

Among Tamarix plants, *Tamarix nilotica* (Ehrenb.) Bunge is a native plant in Egypt with a long history. Its leaves and young branches were used for reducing spleen edema, and it is mixed with ginger for uterus infections, while an aqueous decoction of its bark with vinegar is used as a licicidal lotion [9]. The aim of this review is to compile and document information on different aspects of *Tamarix nilotica* and highlight the need for research and development.

Botanical Description

Tamarix nilotica (Ehrenb.) Bunge is described as shrubs or trees of 2-5 m; multiform, glabrous, glaucescent or green, leaves with free distinct blade, ovate or deltoid-cordate, acute, half-clasping. Foliage is variable: green or grayish, dotted or not, sometimes covered with salt crystals. Racemes are loose, also much variable in size and shape. Pedicel is shorter than the calyx; petals are obovate-oblong; stamens 4-5; styles 3; capsule opening by 3 valves [11]. Seeds are numerous, elliptic with a tuft of hairs at the tip [3].

Taxonomy

The taxonomic classification of *Tamarix nilotica* is illustrated bellow [12,13]:

Kingdom: Plantae

Subkingdom: Tracheobionta

Division: Magnoliophyta

Class: Magnoliopsida

Order: Violales

Family: Tamaricaceae

Genus: *Tamarix*

Species: *nilotica*

Vernacular Names

The generic name originated in Latin: *Tamarix* may have referred to the Tamaris River in Hispania Tarraconensis (Spain) and *nilotica*, referred to the valley of the Nile. *T. nilotica* was known locally: in Egypt as Tarfa or Abal or Nile tamarisk; in Saudi Arabia and Palestine as Athel in Kenya as Uvari or Zizinda [14,15].

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Received January 16, 2017; **Accepted** February 01, 2017; **Published** February 08, 2017

Citation: Abdelgawad AAM (2017) *Tamarix nilotica* (Ehrenb) Bunge: A Review of Phytochemistry and Pharmacology. J Microb Biochem Technol 9: 544-553. doi: 10.4172/1948-5948.1000340

Geographical Distribution

T. nilotica widespread in Egypt, growing in saline sandy soils, on the edges of salt marshes, coastal and inland sandy plains, and Nile banks [4,16]. *T. nilotica* occurs in Lebanon, Palestine, Egypt, Sudan, Somalia, Ethiopia and Kenya [15,17].

Traditional Uses

Tamarix nilotica has been known since pharaonic times and has been mentioned in medical papyri to expel fever, relieve headache, to draw out inflammation, and as an aphrodisiac aperient, sudorific, ulcer, expectorant, carminative, astringent, diuretic [9,18]. In Egyptian traditional medicine, it has been used as an antiseptic agent [19]. Different parts of *T. nilotica* are used; the leaves and young branches are cooked for oedema of spleen and mixed with ginger for uterus infections, while the bark, when boiled in water with vinegar is used as lotion against lice. The bark used to treat eyes sore from a scratch or blow, also it is used for hemorrhoid [20,21]. The wood yields a locally made charcoal, also used as a fuel, said to be good firewood; the timber is sometimes used for inferior carpentry. *Tamarix nilotica* can help stabilize sand and may form nabkhas as part of the dune forming process [22].

Phytochemical Constituents

T. nilotica is a rich source of different classes of natural products with varying structural patterns. Many compounds have been isolated from *T. nilotica* including carbohydrates, phenols, flavonoids, terpenoids, steroids, tannins, and cardiac glycosides. Total phenolic and flavonoid contents in their chemical equivalents (gallic acid and quercetin, respectively) of the different extracts of the flowers of *T. nilotica* collected from Ismailia road, Egypt, in October, 2011were reported as in Table 1 [9].

Phenolics

Many phenolic compounds include Nilocitin, Ellagic acid, Gallic acid and some derivatives were isolated from leaves, flowers, roots and the aerial parts of *T. nilotica* [8,19,23-27]. All the chemical constituents that have been reported in the literature from *T. nilotica* were listed in Table 2 (Figure 1).

Flavonoids

Flavonoids are common constituents of numerous plants world-

Fraction	Total phenolic (mg/g GAE)	Total flavonoid (mg/g QE)
Chloroform	21.67 ± 2.1	0.79 ± 2.4
Ethyl acetate	20.6 ± 1	1.75 ± 1.5
Butanol	22.12 ± 2.4	0.58 ± 2.3
Aqueous	17.2 ± 1.4	-
Total	119.63 ± 0.09	2.55 ± 0.19

Table 1: Phenolic and flavonoid contents in *T. nilotica* flowers.

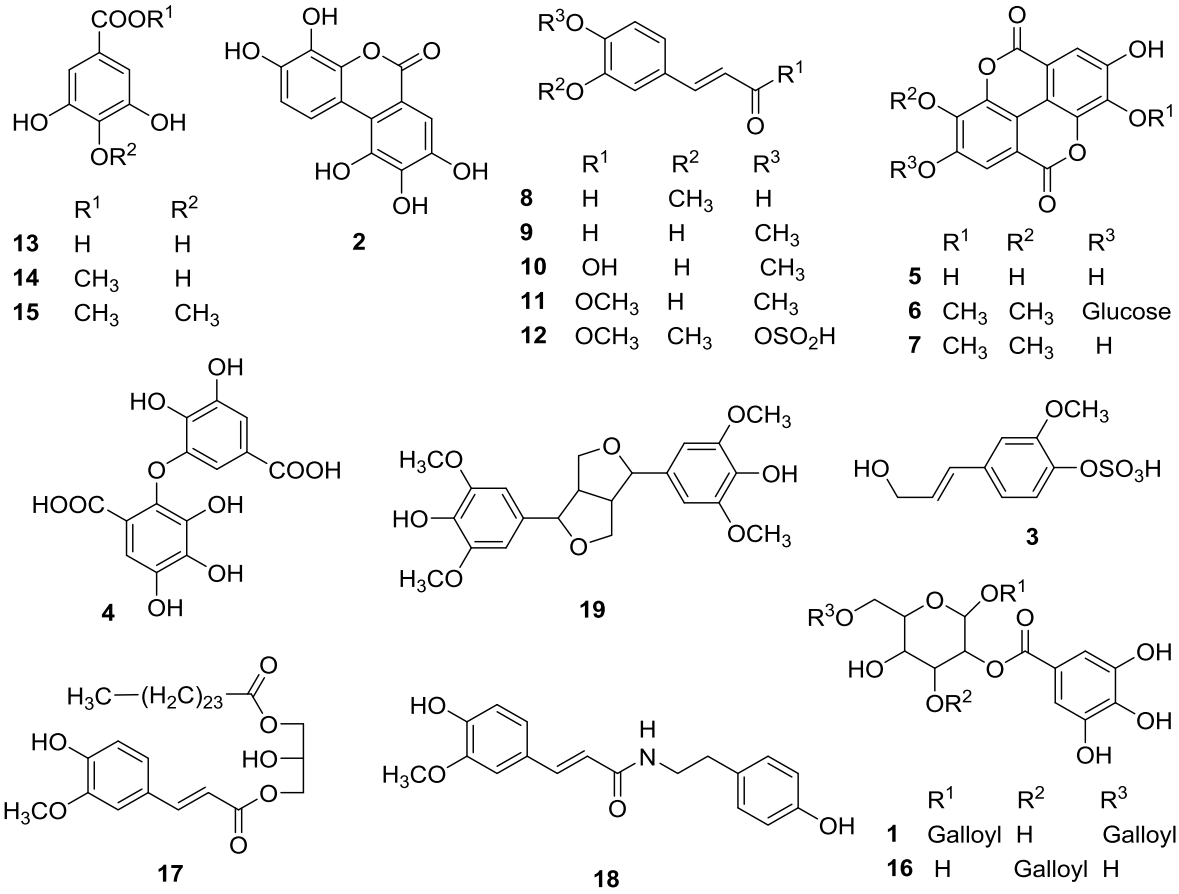


Figure 1: The structure of phenolic compounds isolated from *T. nilotica*.

	Isolated compounds	Extract/Fraction	Plant part	References
Phenolics				
1	1,2,6-Tri-*O*-galloyl-*β*-D-glucose	Aq Ac	LP	[35]
2	3,4,8,9,10-pentahydroxy-dibenzo-[*b*,*d*]pyran-6-one	Aq Ac	FP	[23,24]
3	Coniferyl alcohol 4-*O*-sulphate	*n*-Bu	LP	[26]
4	Dehydrodigallic acid	Et Ac	RP	[19]
5	Ellagic acid	Aq Ac	FP	[23,24]
6	Ellagic acid 3,3′-dimethyl ether 4-*O*-*β*-D-glucopyranoside	Et Ac	RP	[19]
7	Ellagic acid-3-methyl ether	Et	AP	[8]
8	Ferulaldehyde (4-hydroxy-3-methoxycinnamaldehyde)	Pet Eth	RP	[25]
9	Isoferulaldehyde (3-hydroxy-4-methoxycinnamaldehyde)	Pet Eth	RP	[25]
10	Isoferulic acid	Bn	RP	[19]
11	Isoferulic acid methyl ester	Et	AP	[8]
12	Methyl ferulate 3-*O*-sulphate	*n*-Bu	LP	[26]
13	Gallic acid	Et Ac	RP	[19]
14	Methyl gallate	Aq Ac	FP	[23,24]
15	Methyl gallate 4-methylether	Aq Ac	FP	[23,24]
16	Nilocitin (2,3-digalloyl-D-glucopyranose)	Aq Ac	FP	[23,24]
17	Niloticol (l-ferulloyl-3-pentacosanoylglycerol)	Pet Eth	RP	[25]
18	*N-trans*-Feruloyltyramine	Et	AP	[8]
19	Syringaresinol	Bn	RP	[19]
Flavonoids				
20	5,7,4'-trihydroxy-5'-methoxylflavone	Bu	LP	[30]
21	Flavone	Bu	LP	[31]
22	Clematine	Et	AP	[8]
23	Dihydroflavonol	Bu	LP	[31]
24	Dillenetin	Et	AP	[8]
25	Kaempferide	Et	AP	[8]
26	Kaempferol	*n*-Bu	LP	[26]
		Et	LP	[28]
27	Kaempferol-3-glucoside (Astragalin)	Aq Ac	FP	[29]
		Et	LP	[28]
28	Kaempferol 3-*O*-sulphate-7,4′-dimethyl ether	Aq Ac	FP	[29]
29	Kaempferol 3-*O*-*β*-D-glucuronide 6"-ethyl ester	Aq Ac	FP	[29]
30	Kaempferol-4', 7-dimethyl ether	Aq Ac	FP	[29]
		Et	LP	[28]
		Et	AP	[8]
31	Kaempferol-4', 7-dimethyl ether-3-glucoside	Et	LP	[28]
32	Naringenin	Et	AP	[8]
33	Quercetin	Aq Ac	FP	[29]

34	Quercetin 3-*O*-*β* -D-glucupyranuronide	*n*-Bu	LP	[26]
35	Quercetin 3-*O*-*β*-D-glucuronide 6"-ethyl ester	Aq Ac	FP	[29]
36	Quercetin 3-*O*-*β*-D-glucuronide 6"-methyl ester	Aq Ac	FP	[29]
37	Quercetin-3-glucoside (Isoquercitrin)	Et	LP	[28]
38	Tamarixetin	*n*-Bu	LP	[26]
39	Tamarixin (tamarixetin-3-glucoside)	Et	LP	[28]
	Ellagitannins			
40	1,3-Di-*O*-galloyl-4,6-*O*-(*S*)-hexahydroxydiphenoyl-*β*-D-glucose	Aq Ac	LP	[34]
41	Gemin D	Aq Ac	LP	[34]
42	Hippomanin A	Aq Ac	LP	[34]
43	Hirtellin A	Aq Ac	LP	[34]
44	Hirtellin B	Aq Ac	LP	[35]
45	Hirtellin C	Aq Ac	LP	[35]
46	Hirtellin D	Aq Ac	LP	[37]
47	Hirtellin F	Aq Ac	LP	[35]
48	Hirtellin T1	Aq Ac	LP	[10]
49	Hirtellin T2	Aq Ac	LP	[37]
50	Hirtellin T3	Aq Ac	LP	[10]
51	Isohirtellin C	Aq Ac	LP	[35]
52	Nilotinin D1	Aq Ac	LP	[34]
53	Nilotinin D2	Aq Ac	LP	[34]
54	Nilotinin D3	Aq Ac	LP	[34]
55	Nilotinin D4	Aq Ac	LP	[36]
56	Nilotinin D5	Aq Ac	LP	[36]
57	Nilotinin D6	Aq Ac	LP	[36]
58	Nilotinin D7	Aq Ac	LP	[35]
59	Nilotinin D8	Aq Ac	LP	[35]
60	Nilotinin D9	Aq Ac	LP	[35]
61	Nilotinin D10	Aq Ac	LP	[37]
62	Nilotinin M1	Aq Ac	LP	[34]
63	Nilotinin M2	Aq Ac	LP	[36]
64	Nilotinin M3	Aq Ac	LP	[36]
65	Nilotinin M4	Aq Ac	LP	[35]
66	Nilotinin M5	Aq Ac	LP	[37]
67	Nilotinin M6	Aq Ac	LP	[37]
68	Nilotinin M7	Aq Ac	LP	[37]
69	Nilotinin Q1	Aq Ac	LP	[10]
70	Nilotinin T1	Aq Ac	LP	[37]
71	Nilotinin T2	Aq Ac	LP	[10]
72	Nilotinin T3	Aq Ac	LP	[10]
73	Remurin A	Aq Ac	LP	[34]
74	Remurin B	Aq Ac	LP	[34]
75	Tamarixinin A	Aq Ac	LP	[35]
76	Tamarixinin B	Aq Ac	LP	[37]

77	Tamarixinin C	Aq Ac	LP	[37]
78	Tellimagrandin I	Aq Ac	LP	[35]
79	Tellimagrandin II	Aq Ac	LP	[35]
Terpenoids				
80	3-*O*-*trans*-caffeoylisomyricadiol	Et	AP	[8]
81	3α-(3",4"-dihydroxy-*trans*-cinnamoyloxy)-D-friedoolean-14-en-28-oic acid	*n*-Hn	LP	[26,27]
Steroids				
82	*β*-Sitosterol	Et	AP	[8]

Table 2: Isolated compounds from the different parts of *T. nilotica*.

LP: Leaves Parts; FL: Flowers Parts; RP: Roots Parts; AP: Aerial Parts; Aq Ac: Aqueous Acetone; Pet Eth: Petroleum Ether; Bn: Benzene; *n*-Bu: *n*-Butanol; *n*-Hn: *n*-Hexane; Et Ac: Ethyl Acetate; Et: Ethanol; Bu: Butanol

wide. The flavonoids isolated from the aerial parts of *T. nilotica* include kaempferol, tamarixetin, quercetin, isoquercitrin, flavone, naringenin, dillenetin and its derivatives *T. nilotica* [8,26,28-31]. Flavonoids are the mostly biological active compounds found in plants, they are widely used in a variety of nutraceutical, cosmetic and pharmaceutical applications [32] (Figure 2).

Ellagitannins

The tamaricaceous plants produce a unique class of ellagitannins with diverse structures [33]. The review of literature reported the isolation of monomeric (Isohirtellin C, Remurin A-B, Gemin D, Nilotinin, Nilotinin M2-7, Hippomanin A, and Tellimagrandin I-II), dimeric (Nilotinins D1-D10, Tamarixinin A-C and Hirtellin A-D and F), trimeric (Nilotinin T1-T2, Hirtellin T1-T3) and tetrameric ellagitannins (Nilotinin Q1) from the aqueous acetone extracts of leaves of *T. nilotica* growing in Egypt [10,34-37]. Interest in the ellagitannin constituents due to their marked antiviral, antimicrobial, immunomodulatory, antitumor, and hepatic protective activities, which are largely dependent on the tannin structures [38] (Figure 3).

Terpenoids and steroids

To date, two terpenoids and one steroid compounds from *T. nilotica* have been reported. In 2009, 3α-(3",4"-dihydroxy-*trans*-cinnamoyloxy)-D-friedoolean-14-en-28-oic acid, was isolated from the leaves of *T. nilotica* growing in Egypt [26]. Furthermore, 3-*O*-*trans*-caffeoylisomyricadiol and *β*-sitosterol were isolated from the ethanolic extract of the aerial parts of *T. nilotica* growing in Saudi Arabia [8] (Figure 4).

Pharmacological Activities

Scientific studies on *T. niloyica* indicate that it has wide-reaching pharmacological activities, including the effects as anti-tumor, antioxidant, antidiabetic, antiviral, antimicrobial and hepatoprotective activity.

Antioxidant activity

Free radicals are involved in a number of pathological conditions such as inflammatory diseases, atherosclerosis, cerebral ischemia, AIDS, and cancer [39]. The free radicals are produced in the human body due to environmental pollutants, chemicals, physical stress, radiations, etc. Catalase and hydroperoxidase enzymes are among the important antioxidants produced by the immune system. Consumption of antioxidants or free radical scavengers is necessary to compensate depletion of antioxidants of the immune system.

In 2008, AbouZid et al., reported that, the aqueous alcoholic extracts of leaves and flowers of *Tamarix nilotica* grown in Egypt had a significant antioxidant activity (73-96%) [7]. The *in vitro* antioxidant assays used in this study were 1,1-diphenyl-2-picryl hydrazyl (DPPH) radical scavenging activity, superoxide anion scavenging activity and iron chelating activity [26,40].

DPPH free radical scavenging activity of different *T. nilotica* sub-extracts has been screened at 100 µg/ml. EtOAc (100%), BuOH (93%) and total extract (90%) exhibited potential antioxidant activity while CHCl3 exhibited the lowest effect (26%). Comparing the IC50 of promising subextracts (>90%) with ascorbic acid as positive control (IC50 4.8 ± 0.54 µg/ml), EtOAc showed the best effect (7.25 ± 0.86 µg/ml), with lower IC50 followed by BuOH (8.25 ± 0.65µg/ml) and total extract (45 ± 0.73µg/ml) [9]. When antioxidant assay was performed by TLC using DPPH, a significant antioxidant activity was related to butanol fractions of *Tamarix nilotica* grown in Sudan [31].

Cytotoxic and anti-angiogenic activity

Ellagitannins from the leaves of *T. nilotica* grown in Egypt were reported to exhibit significant host-mediated antitumor activities against sarcoma-180 in mice and strong cytotoxic effects with higher tumor specificity against four tumor cell lines [35,37]. *T. nilotica* showed a selective cytotoxic potential against liver (HUH-7), colon (HCT-116), lung and breast (MCF-7) carcinoma cell, while being non-toxic to other cancer cells [9,40].

A considerable number of cancers have been reported to be dependent on angiogenesis and respond well to anti-angiogenic therapies. These include cancers of the colon, breast, lung, and bladder as well as renal cell carcinoma and non-small cell lung cancer (NSCLC). Anti-angiogenic therapies target angiogenesis by two major mechanisms: blocking the receptor tyrosine kinases intracellularly or neutralizing angiogenic factors such as VEGF or its receptors [41].

The results indicated that the leaves extract of *Tamarix nilotica* grown in Sudan exhibited remarkable anti-angiogenic activity by inhibiting the sprouting of micro-vessels more than 60% by using *ex vivo* rat aortic ring assay [42].

Hepatoprotective activity

Hepatoprotective activity of *T. nilotica* grown in Egypt was assessed using carbon tetrachloride- induced hepatic injury in rats by monitoring biochemical parameters. Aqueous ethanol extract of flowers of *T. nilotica* ameliorated the adverse effects of carbon tetrachloride and returned the altered levels of biochemical markers near to the normal levels [40]. In this study, carbon tetrachloride was used to induce liver damage and hence enhancing the levels of SGOT, SGPT and ALP. Carbon tetrachloride is biotransformed by liver enzymes to a highly reactive free radical. This free radical can lead to lipid peroxidation, disruption of Ca^{2+} homeostasis, elevation of hepatic enzymes, and finally results in cell death [43]. Carbon tetrachloride has been used in animal models to investigate chemical toxininduced liver damage. The extent of hepatic damage is assessed by the increased level of cytoplasmic enzymes (SGOT, SGPT and ALP).

Antidiabetic activity

The leaves aqueous extracts of *T. nilotica* were used effectively to reduce the serum glucose level as the experimental period progressed and demonstrated a marked hypolipidemic effect evidenced by the lower serum triglyceride and total cholesterol levels. The overall effect of the plant extracts was significantly better than the synthetic drug, metformin in terms of antihyperglycemia and antihyper triacylglycerolaemia. Also, the results suggest that the plant extract are potential phytotherpeutic agents which could be used for the management of diabetes type 2 and dyslipidemia associated with it [44]. The hypoglycemic activity may result from both pancreatic and extrapancreatic mechanisms, on the other hand, enhanced by high antioxidant capacity [45]. The actual role of these interesting compounds in the antidiabetic properties of *T. nilotica* still requires elucidation. These polyphenolic compounds act as monomers or oligomers, responsible for in *vitro* insulin enhancing activity in epididymal fat cells and shown *in vitro* to have insulin-like activity as well as an antioxidant effect.

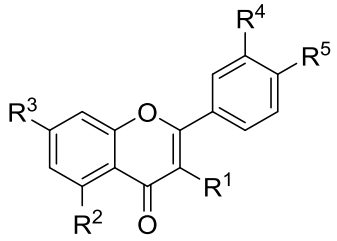
Antiviral effect

Infectious viral diseases are still major threat to public health and remain as an important problem due to viruses have resisted prophylaxis or therapy longer than any other form of life [46]. Egyptian medicinal plants have diverse uses in traditional folk medicine to cure various ailments including infectious diseases.

The Hydro-alcoholic extracts of the aerial parts of *Tamarix nilotica* are found to have virucidal effect against herpes simplex-1 virus (HSV) at concentration of 1000 µg/ml with Rf 10^4 [47]. The antiviral bioassay is carried out by the end point titration technique (EPTT) that builds on the ability of plant extract dilutions to inhibit the produced cytopathogenic effect (CPE) and expressed as reduction factor (Rf) of the viral titer.

Antimicrobial activity

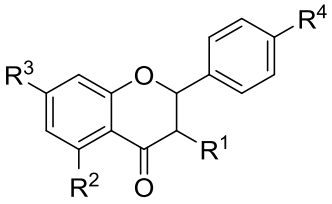
A significant antibacterial and antifungal activity was related to



	R^1	R^2	R^3	R^4	R^5
22	H	OH	OH	OH	OCH_3
23	H	H	H	H	H
25	OH	OH	OH	OCH_3	OCH_3
26	OH	OH	OH	H	OCH_3
27	OH	OH	OH	H	OH
28	OG	OH	OH	H	OH
29	OSO_3H	OH	OCH_3	H	OCH_3
30	OGREE	OH	OH	H	OH
31	OH	OH	OCH_3	H	OCH_3
32	OG	OH	OCH_3	H	OCH_3
34	OH	OH	OH	OH	OH

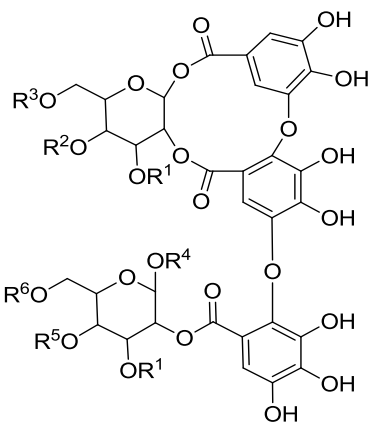
	R^1	R^2	R^3	R^4	R^5
35	OGP	OH	OH	OH	OH
36	OGREE	OH	OH	OH	OH
37	OGRME	OH	OH	OH	OH
38	OG	OH	OH	OH	OH
39	OH	OH	OH	OH	OCH_3
40	OG	OH	OH	OH	OCH_3

where: G = glucoside;
GP = -β-D-glucupyranuronide;
GREE = -β-D-glucuronide 6"-ethyl ester;
GRME = -β-D-glucuronide 6"-methyl ester

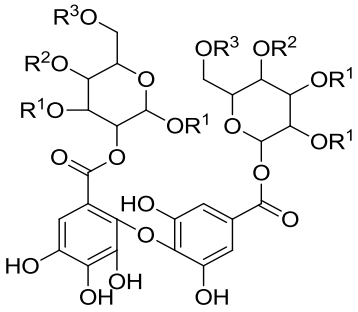


	R^1	R^2	R^3	R^4
24	OH	H	H	H
33	H	OH	OH	OH

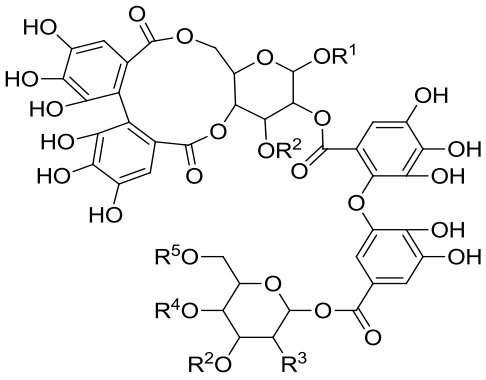
Figure 2: The structure of flavonoid compounds isolated from *T. nilotica*.



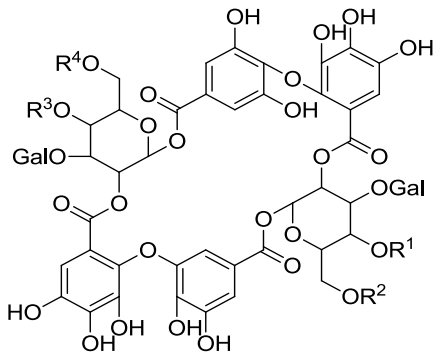
	R^1	R^2	R^3	R^4	R^5	R^6
44	Gal	$R^2 + R^3$ = HHDP		Gal	$R^6 + R^7$ = HHDP	
58	Gal	H	Gal	Gal	$R^6 + R^7$ = HHDP	
59	Gal	H	H	Gal	$R^6 + R^7$ = HHDP	
75	Gal	$R^2 + R^3$ = HHDP		H	$R^6 + R^7$ = HHDP	



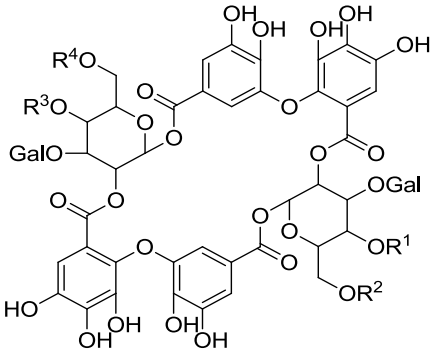
77 R^1 = Gal, $R^2 + R^3$ = HHDP



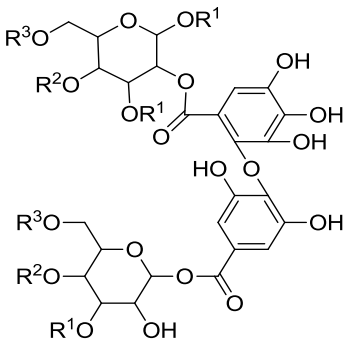
	R^1	R^2	R^3	R^4	R^5
43	Gal	Gal	Gal	$R^4 + R^5$= HHDP	
52	Gal	Gal	H	$R^4 + R^5$= HHDP	
53	H	Gal	H	$R^4 + R^5$= HHDP	
54	H	Gal	Gal	$R^4 + R^5$= HHDP	
57	Gal	Gal	Gal	H	H
61	Gal	Gal	DHDG	H	H



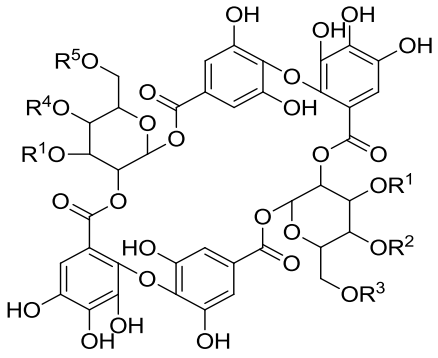
45 $R^1 + R^2$ = HHDP, $R^3 + R^4$ = HHDP
47 R^1 = H, R^2 = H, $R^3 + R^4$ = HHDP
60 $R^1 + R^2$ = HHDP, R^3 = H, R^4 = H



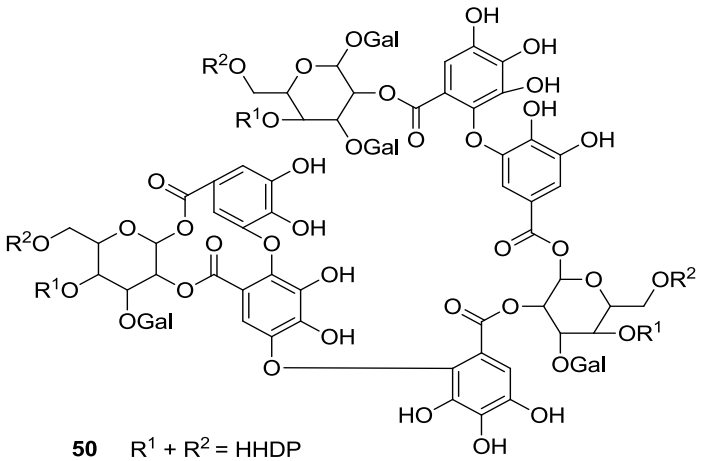
	R^1	R^2	R^3	R^4
46	H	H	$R^3 + R^4$ = HHDP	
51	$R^1 + R^2$ = HHDP		$R^3 + R^4$ = HHDP	



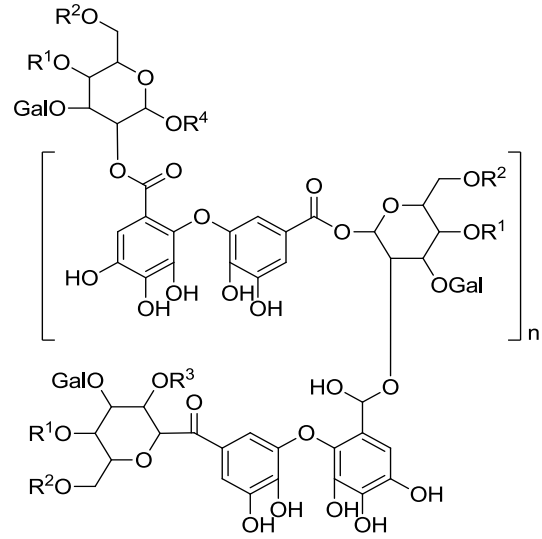
55 R^1 = Gal, $R^2 + R^3$ = HHDP

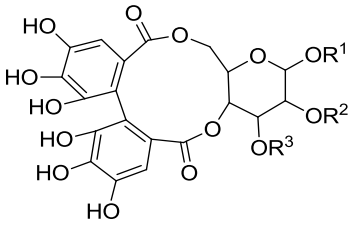


	R^1	R^2	R^3	R^4	R^5
56	Gal	H	H	$R^3 + R^4$ = HHDP	
76	Gal	$R^2 + R^3$ = HHDP		$R^3 + R^4$ = HHDP	



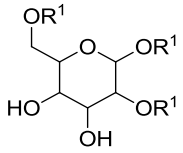
50 $R^1 + R^2$ = HHDP



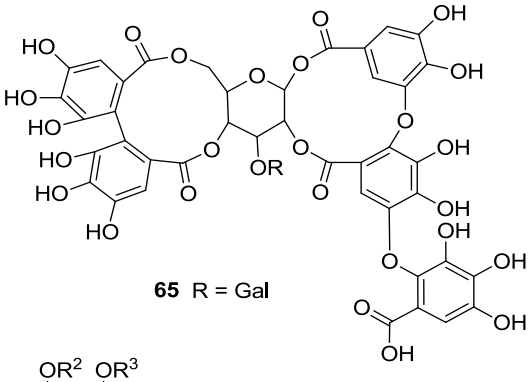


	R^1	R^2	R^3		R^1	R^2	R^3
40	Gal	H	Gal	**67**	isoDHDG	isoDHDG	Gal
41	H	H	Gal	**68**	Gal	isoDHDG	Gal
42	H	Gal	H	**73**	Gal	DHDG	Gal
62	H	isoDHDG	Gal	**74**	H	DHDG	Gal
63	CH_3	DHDG	Gal	**78**	H	Gal	Gal
64	isoDHDG	H	Gal	**79**	H	Gal	Gal
66	isoDHDG	DHDG	Gal				

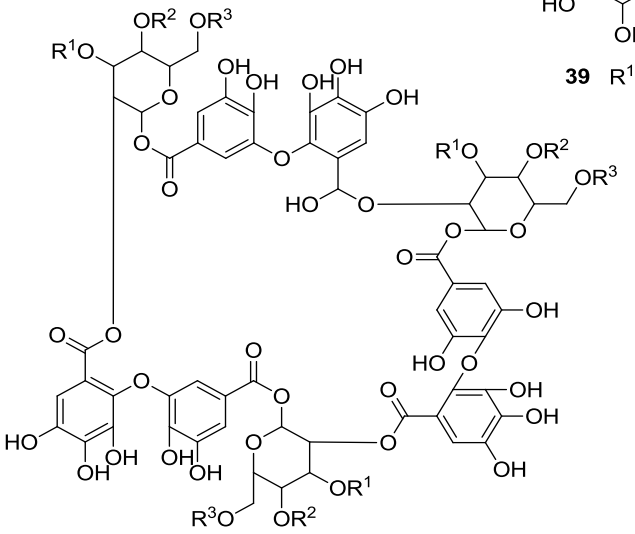
48, n =1, R^1+R^2 = HHDP, R^3 = Gal, R^4 = Gal
71, n =1, R^1+R^2 = HHDP, R^3 = H, R^4 = Gal
69, n =2, R^1+R^2 = HHDP, R^3 = H, R^4 = Gal
72, n =1, R^1+R^2 = HHDP, R^3 = Gal, R^4 = H



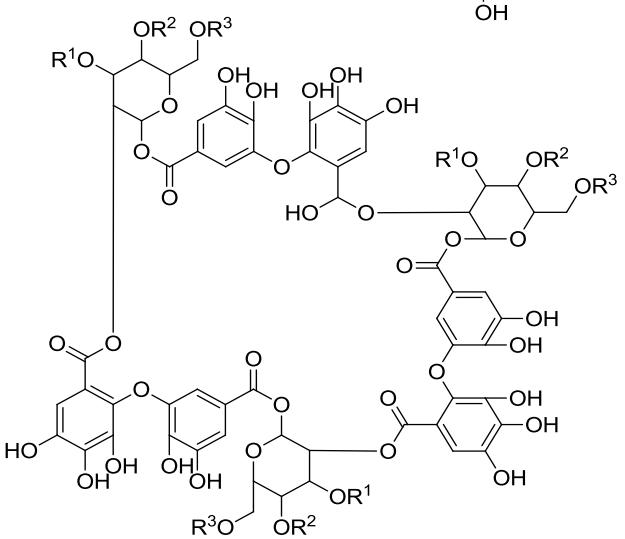
39 R^1 = Gal



65 R = Gal

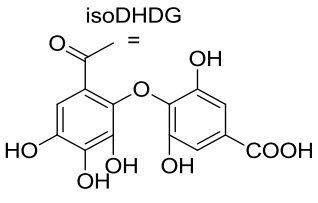


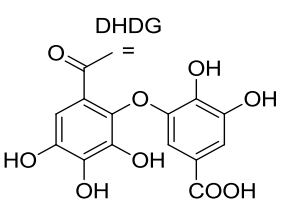
70 R^1 = Gal, R^2 + R^3 = HHDP

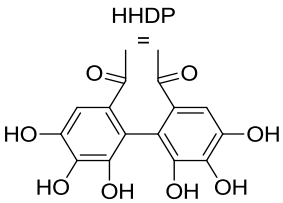


49 R^1 = Gal, R^2 + R^3 = HHDP

Where:







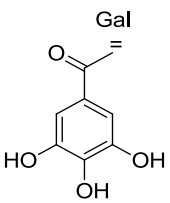


Figure 3: The structure of ellagitannins isolated from *T. nilotica*.

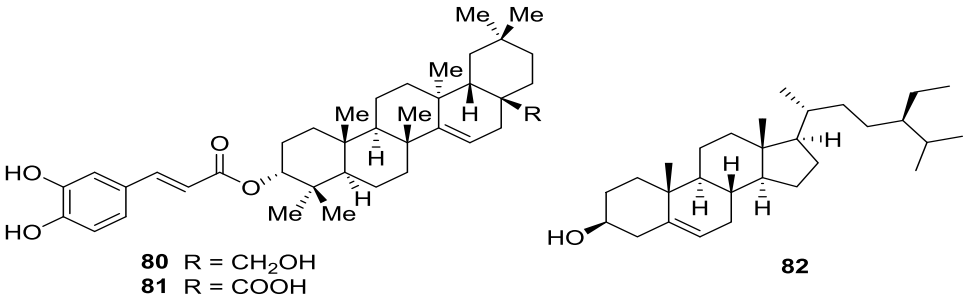


Figure 4: Structures of terpenoids and steroids isolated from *T. nilotica*.

butanol extract from Tamarix nilotic growing in Sudan. The other extracts showed moderate to weak inhibition on fungi (*Aspergillus niger* and *Candidas albicans*). The pure compounds (flavone and dihydroflavonol) isolated from butanol extract of *Tamarix nilotica* also revealed significant antibacterial activity and antifungal activity. This study demonstrated that the butanol fraction of *Tamarix nilotica* is potential candidate for antimicrobial activity and deserves further optimization [31]. Evaluation of the antimicrobial activities of different extracts and isolated compounds was carried out by the disc diffusion method, measured by the diameter of the zone of inhibition.

Endophytic fungi, which have been reported in numerous plant species, are important components of the forest community and contribute significantly to the diversity of natural ecosystems. *Tamarix nilotica* grown in Saudi Arabia showed the highest endophytic diversity with a relative frequency of 27.27%, the most frequently isolated species was *Penicillium chrysogenum* with an overall colonization rate of 98.57% [48].

Conclusion

T. nilotica could be considered as promising candidates for the discovery of novel chemopreventive or chemotherapeutic formulations with reduced side effects. The literature endorses further investigations on this plant to determine the active principles and their mode of action.

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