

REVIEW
OF
LITERATURE

2.1 PLANT BIOGEOGRAPHY AND MACROMORPHOLOGY

Tephrosia Pers. is a pantropically distributed genus of pea-flowered legumes comprising of 525 species worldwide (Mabberley, 2008; Schrire, 2005). The diversity centres of this genus are tropical and subtropical regions of the world with highest concentration in Africa–Madagascar (c. 170 spp.), Australia (c. 90 spp.) and Central and tropical North America (c. 45 spp.). In South Asia, the genus is represented with 29 species, two subspecies and one variety (Kumar and Sane, 2003). In India the genus is represented by 27 species and one variety (Sanjappa, 1992), of these six are endemic species (Ahmedullah and Nayar, 1986). In Gujarat it is represented by 13 species namely *T. candida*, *T. strigosa*, *T. jamnagarensis*, *T. villosa*, *T. collina*, *T. tinctoria*, *T. hamiltonii*, *T. purpurea*, *T. pumila*, *T. appollinea*, *T. senticosa*, *T. pauciflora* and *T. uniflora* var. *petrosa* (Shah, 1978). The present work is aimed on the two rare and endemic species namely *T. jamnagarensis* Sant. and *T. collina* Sharma. In-order to initiate the work, it is very important to have proper identification and distribution of these species. Thus extensive review of floras supported by recent records were critically studied and documented. Based on the literature the details of the species are as follows:

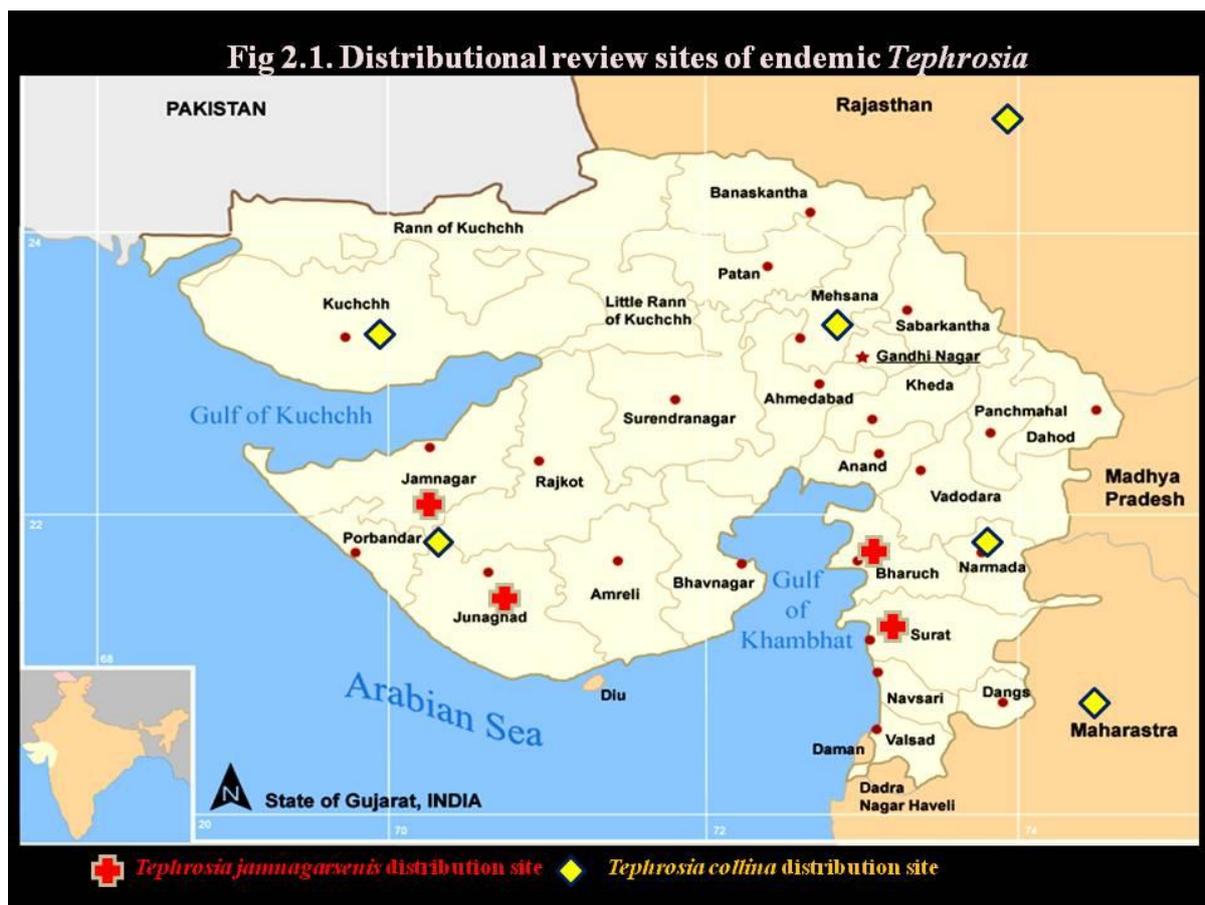
***Tephrosia jamnagarensis* Sant.**

The type specimen of *T. jamnagarensis* was collected from Rozi near Jamnagar in 1945 by Fr. Santapau and was identified as a new species based on the fruit characters (Santapau, 1958 and 1962). Thereafter, the first detailed morphological description of this species with flower was given by Smith and Ahluwalia (1967). However, it was wrongly identifying as a new species '*Tephrosia axillaris*'. The issue was later resolved by Raghava *et al.* (1968) by stating *T. axillaris* as a synonym of *T. jamnagarensis* and reconfirming its identity. Further in 1974, Vyas collected this plant from cultivated field of Saurashtra and Bharuch (Vyas, 1974), which was followed by the collection of J.V. Joshi in 1977 from Wadhana in Surat district (BARO 4.9.69). This species was stated endemic and rare with restricted distribution (Shah, 1978; Shah, 1983). In 1980, other two new distributional sites *i.e.*, Bhad-Bhut and Udhana, of Surat district were reported (Joshi, 1980). Later, Sasikumar (1985) stated it to be a weed in Surat, Southern Gujarat. In 1988, Nayar and Shastri enlisted *T. jamanagernsis* and *T. collina* as a threatened species in Red Data book. Probably on the same basis WCMC and IUCN (1997) gave the status of endemic and rare species (WCMC, 1994; Walter *et al.*, 1997). The factor responsible for rarity of this species were habitat

destruction (Shah, 1978), grazing and other biotic pressures (Nayar and Shastri, 1988). The survey report on Biodiversity by Gujarat ecological commission (GEC) stated this species as rare and Threatened in Gujarat (Anonymous, 2003; Anonymous, 2001). Based on earlier records of *T. jamnagarensis* distribution sites were Jamnagar, Saurashtra, Bhad-bhut, Bharuch and Udhna (Nayar and Sastry, 2003). However, in the same year Khadkhambaliya was reported as a new site for *T. jamnagarensis* on Jamnagar-Samana road by Nagar *et al.*, (2003). The germplasm of *T. jamnagarensis* had been deposited by Junagadh Agriculture University (JAU) at National Seed Gene bank, New Delhi India, for long term conservation. (<http://www.icar.org.in/files/ar0506/cs.pdf>).

***Tephrosia collina* V.S.Sharma**

Tephrosia collina was first discovered by Sharma in 1963 from Ajmer district Rajasthan. Wherein he has described two variants of *Tephrosia collina* i.e., var *collina* and its var. *lanuginocarpa* which can be differentiated by hair, suture of pod and seed size (Sharma, 1963). At present both the variety has been merged into *T. collina* itself (TROPICOS, 2015). In Gujarat, *T.collina* was first time reported by Shah (1978) as a new addition to the Flora of Gujarat from Rajpipla Taluka. Subsequently he state that this species is under threat condition due to restricted distribution (Shah, 1983). Thereafter, Raghavan *et al.* (1981), relocated this species from Kachhchh and two remote localities of Mehsana district Gujarat (BSI, voucher no; 114702). Later, *T. collina* was enlisted as a threatened species under the Intermediate category with the probable locality of its distribution as Rajasthan and Kutch (Gujarat) (WCMC, 1994; Walter *et al.*, 1997). However, after 19 years, this plant was relocated from Rajasthan (Yadav, 2000) and in Maharashtra this plant was discovered from Dhule among the grasses and was stated rare (Singh and Karthikeyan, 2000; Sanjapaa, 1992). Thereafter in Gujarat it was rediscovered from Moti vidi, Jamjodhpur Taluka Jamnagar in 2004 (Nagar, 2007). The threat assessment report for angiosperm biodiversity by Gujarat ecological commission (GEC) stated this species as intermediate (Anonymous, 2003; Anonymous, 2001).



With above reference the geographical distribution of these endemic species showed that *T. jamnagarensis* is distributed in four district of Gujarat namely Junagadh, Jamnagar, Surat and Bharuch whereas, *T. collina* is distributed in two states i.e., Gujarat (Jamnagar, Meshasana, Kutch and Narmada), Maharashtra (Dhule) and Rajasthan (Ajmer) (Fig 2.1). In addition to this, recently in 2014 Conservation Assessment and Management workshop on wild Angiosperm plant of Gujarat gave *T. jamnagarensis* and *T. collina* the status as critically endangered (Anonymous, 2014).

2.1.2 TAXONOMIC AND PHYLOGENETIC STATUS

1. Botanical name: *Tephrosia jamnagarensis* Sant

Synonyms: *Tephrosia axillaris* Smith

Vernacular name: Deshi Sarphankho

English name: Wild Indigo

Classification:

Classification	Bentham & Hooker (1862-1883)	Takhtajan (1997)	APG III (2009)
Division:	Spermatophyta	Plantae	Clade: Eudicots
Sub Division:	Angiospermae	Magnoliophyta	Clades: Core eudicots
Class:	Dicotyledonae	Magnoliopsida	Clade: Fabids (eurosids)
Sub Class:	Polypetalae	Rosidae	
Series:	Calyciflorae	Fabanae	
Order:	Rosales	Fabales	Fabales
Family:	Fabaceae	Fabaceae	Fabaceae
Subfamily:	Papilionoideae	-	Papilionoideae /Faboideae
Tribe:	Millettieae	-	Hedysareae
Genus	<i>Tephrosia</i>	<i>Tephrosia</i>	<i>Tephrosia</i>
Species:	<i>jamnagarensis</i>	<i>jamnagarensis</i>	<i>jamnagarensis</i>

2. Botanical name: *Tephrosia collina* V.S.Sharma

Synonyms: *Tephrosia collina* var. *lanuginocarpa* V.S.Sharma

Vernacular name: Dholo sarphanko

English name: Wild Indigo

Classification:

Classification	Bentham & Hooker (1862-1883)	Takhtajan (1997)	APG III (2009)
Division:	Spermatophyta	Plantae	Clade: Eudicots
Sub Division:	Angiospermae	Magnoliophyta	Clades: Core eudicots
Class:	Dicotyledonae	Magnoliopsida	Clade: Fabids (eurosids)
Sub Class:	Polypetalae	Rosidae	
Series:	Calyciflorae	Fabanae	
Order:	Rosales	Fabales	Fabales
Family:	Fabaceae	Fabaceae	Fabaceae
Subfamily:	Papilionoideae	-	Papilionoideae /Faboideae
Tribe:	Millettieae	-	Hedysareae
Genus	<i>Tephrosia</i>	<i>Tephrosia</i>	<i>Tephrosia</i>

Classification	Bentham & Hooker (1862-1883)	Takhtajan (1997)	APG III (2009)
Species:	<i>collina</i>	<i>collina</i>	<i>collina</i>

After reviewing the status, phylogeny and distribution pattern of these endemic plants parameters like macro-morphology, ecological distribution and its molecular relationship with the other commonly occurring *Tephrosia* species were also studied.

2.2 SEED VIABILITY AND GERMINATION

The germination capacity of medicinal plants is generally low due to the presence of dormancy. Any aberrations or mechanical injury to the seed coat or even any chemical treatment given may release the seed dormancy. Seed germination responses of certain cultivated medicinal plants to various physical and chemical treatments aimed at breaking dormancy and thereby improve the germination percentage (Sriram, 2004).

Dharmalingam *et al.*, (1971) reported that for *Tephrosia purpurea* (kolinji), seed scarification with sand followed by pre-soaking with hot water at 50 °C for five minutes was ideal for improving germination. In contrast, Dharmalingam *et al.* (1973) suggested that seed treatment with concentrated H₂SO₄ for five minutes alone improved the germination in *T. purpurea*.

Babayemi *et al.*, (2003) reported that for three species of *Tephrosia* (*T. bracteolata*, *T. candida* and *T. linearis*) soaking seeds in boiled water for 30 seconds enhanced germination and optimal potential seedling establishment. Even Ruppel *et al.*, (1967) stated that in *T. vogelii* immersion in hot water baths at 50 to 56 °C for 5 to 30 minutes significantly increased the germination percentage of seeds as compared to tapwater soaks and mechanical scarification. In wealth of India, it is stated that pre-treatment with sulphuric acid and hot water is recommended for quick and regular germination in *Tephrosia candida* while hot water and scarification is for *T. purpurea* (Chadha, 1972). In contrast, there are no references available regarding the seed germination of endemic species *T. jamnagarensis* and *T. collina*. Henceforth, the study of the seed germination and phenology of these plants was one of the objectives of present study.

2.3 PHARMACOGNOSY

Crude drugs of vegetable, animal and mineral sources form the subject matter of pharmacognosy. Although pharmacognosy is concerned mainly with naturally occurring substance of medicinal importance, it is not entirely limited to such substances.

In genus *Tephrosia*, the extensive work has been done on the pharmacognosy and anatomical features of *T. purpurea*, *T. villosa* and *T. maxima* stem, root and leaves (Gopalakrishnan *et al.*, 2009; Rajabudeen *et al.*, 2014; Sandhya *et al.*, 2011). The present study aims on pharmacognostic analysis of *T. jamnagarensis* and *T. collina* root, stem and leaves which would be further help full for maintaining the integrity of drug made from it.

2.4. PHYTOCHEMISTRY

In the genus *Tephrosia* various species have been studied more, *esp.* for phytochemical constituents than pharmacological activity. Till date, different kinds of phytoconstituents had been isolated from this genus. The main classes of phytoconstituents in this genus are flavonoids, rotenoids, terpenoids and sterols (Table 2.4.1). From the table we can see that flavonoids are the most abundantly isolated and identified compounds. The class of compound like essential oil and fixed oil are not yet explored.

The chemical constituents till date isolated from this genus are around 168 compounds (Table 2.4.1). This includes 31 flavones (Fig 2.2), 8 Flavonols and 3 Flavanonols (Fig 2.3), 48 Flavans (Fig 2.4), 41 Isoflavones (Fig 2.5), 22 Chalcones (Fig 2.6), 11 other Flavonoids and Terpenoid (Fig 2.7) of which flavonoids and rotenoids (isoflavonoids) are the key phytochemicals.

TABLE 2.4.1 PHYTOCHEMICALS REPORTED IN *TEPHROSIA* GENUS (Chen *et al.*, 2014)

Sr. No.	Compound name
	FLAVONES
1.	Tephroglabrin
2.	Tepurindiol
3.	Glabratephrin
4.	Tachrosin
5.	Staohyoidin
6.	Tephrocin

7.	Semiglabin
8.	Semiglabinol
9.	Tephrostachin
10.	Emoroidone
11.	Tephroapollin C
12.	Tephroapollin D
13.	Tephroapollin E
14.	Tephroapollin F
15.	Tephroapollin G
16.	Multijugin
17.	Multijuninol
18.	Pseudosemiglabrinol
19.	(-)-pseudosemiglabrin
20.	Polystachin
21.	5-methoxy-6,6-dimethylpyrano[2,3:7,6]flavone
22.	Candidin
23.	Hookerianin
24.	Fulvinervin B
25.	Fulvinervin C
26.	Enantiomultijugin
27.	Apollinine
28.	Demethylapollinin 7- <i>O</i> - β -D-glucopyranoside
29.	Tephropurpulin A
30.	Isoglabratephrin
31.	Terpurinflavone
	FLAVONOLS
32.	6-hydroxykaempferol 6-methyl ether 3- <i>O</i> - α -rhamno- pyranosyl(7 \rightarrow 6)- β -galactopyranoside-7- <i>O</i> - α -rhamno-pyranoside
33.	6-hydroxykaempferol 6-methyl ether 3- <i>O</i> - α -rhamno- pyranosyl(1 \rightarrow 2)[α -rhamnopyranosyl(1 \rightarrow 6)- β -galacto- pyranoside
34.	6-hydroxykaempferol 6-methyl ether 3- <i>O</i> - α -rhamno- pyranosyl(1 \rightarrow 2)[α -rhamnopyranosyl(1 \rightarrow 6)]- β -galacto- pyranoside-7- <i>O</i> - α -rhamnopyranoside

35.	6-hydroxykaempferol 6-methyl ether 3- <i>O</i> - α - rhamnopyranosyl (1 \rightarrow 2)[(3- <i>O</i> - <i>E</i> -feruloyl)- α -rhamnopyranosyl(1 \rightarrow 6)]- β -galacto-pyranosides
36.	6-hydroxykaempferol 4'-methyl ether
37.	Candidol
38.	Candirone
39.	7-ethoxy-3,3',4'-trihydroxyflavone
	FLAVANONOLS
40.	(2 <i>R</i> ,3 <i>R</i>)-3-hydroxy-5-methoxy-6'',6''-dimethylpyrano [2'',3'':7,8]flavanone
41.	Lupinifolinol
42.	Lupinifolinol triacetate
	FLAVANS
43.	(2 <i>S</i>)-4'-hydroxy-5-methoxy-6'',6''-dimethylpyrano[2'',3'':7,8]- flavanone
44.	(2 <i>S</i>)-7-hydroxy-5-methoxy-8-prenylflavanone
45.	(2 <i>S</i>)-5-methoxy-6'',6''-dimethyl-4'',5''-dihydrocyclopropa- [4'',5'']furano[2'',3'':7,8]flavanone
46.	(2 <i>S</i>)-5,7-dimethoxy-8-(3-methylbut-1,3-dienyl)flavanone
47.	Tephrocandidin A
48.	Tephrocandidin B
49.	(+)-tephrorin A
50.	(+)-tephrorin B
51.	(2 <i>S</i>)-5-hydroxy-7,4'-di- <i>O</i> -(γ , γ -dimethylallyl)flavanone
52.	6-hydroxy- <i>E</i> -3-(2,5-dimethoxybenzylidene)-2',5'-dimethoxyflavanone
53.	Pumilanol
54.	Emoroidenone
55.	Tephroapollin A
56.	Tephroapollin B
57.	Fulvinervin A
58.	Lupinifolin
59.	5,4'- <i>O</i> , <i>O</i> -dimethyl-lupinifolin
60.	Lupinifolin diacetate
61.	Obovatin
62.	Obovatin methyl-ether

63.	Methylhildardtoll B
64.	Hildgardtol B
65.	Hildgardtene
66.	Methylhildgardtol A
67.	Hildgardtol A
68.	Purpurin
69.	Tephrinone
70.	5,7-dimethoxy-8-prenylflavan
71.	Tephrowatsin A
72.	Tephrowatsin C
73.	Tephrowatsin B
74.	Tephrowatsin D
75.	Tephrowatsin E
76.	Nitenin
77.	Falciformin
78.	Candidone
79.	Quercetol A
80.	Quercetol B
81.	Quercetol C
82.	5,7-dimethoxy-8-(2,3-epoxy-3-methylbutyl)-flavanone
83.	Tephroleocarpin A
84.	Tephroleocarpin B
85.	Spinoflavanone A
86.	Spinoflavanone B
87.	Maxima flavanone A
88.	Tepicanol A
89.	Crassifolin
90.	Astraciceran
91.	(+)-apollineanin
	ISOFLAVONES
92.	(2 <i>S</i>)-5,4'-dihydroxy-7- <i>O</i> -[<i>E</i> -3,7-dimethyl-2,6-octadienyl]flavanone
93.	2 <i>S</i> -5,4'-dihydroxy-7- <i>O</i> -[<i>E</i> -3,7-dimethyl-2,6-octa-dienyl]-8- <i>C</i> -[<i>E</i> -

	3,7-dimethyl-2,6-octadienyl]flavanone
94.	7,4'-dihydroxy-3',5'-dimethoxyisoflavone
95.	Emoroidocarpan
96.	Elongatin
97.	Pumilaisoflavone D
98.	Pumilaisoflavone C
99.	Barbigerone
100.	4'-demethyltoxicarol isoflavone
101.	Maxima isoflavone D
102.	Maxima isoflavone E
103.	Maxima isoflavone F
104.	Maxima isoflavone G
105.	Viridiflorin
106.	Maxima isoflavone J
107.	Pumilaisoflavone A
108.	Pumilaisoflavone B
109.	7- <i>O</i> -geranylbiochanin A
110.	5,7-di- <i>O</i> -prenylbiochanin A
111.	Toxicarol
112.	Villosinol
113.	Villosol
114.	Villosin
115.	Villol
116.	Villosone
117.	Villinol
118.	Dehydrodihydrorotenone
119.	Dihydrostemonal
120.	9-demethyldihydrostemonal
121.	6-acetoxydihydrostemonal
122.	6a,12a-dehydro-2,3,6-trimethoxy-8-(3',3'-dimethylallyl)-9,11-dihydroxyrotenone
123.	12a-dehydro-6-hydroxysumatrol

124.	12a-hydroxyrotenone
125.	12a-hydroxy- β -toxicarol
126.	Tephrosol
127.	Tephrocarpin
128.	Hildecarpin
129.	Hildecarpidin
130.	2-methoxy-3,9-dihydroxy coumestone
131.	3,4:8,9-dimethylenedioxypterocarpan
132.	Tephcalostan
133.	Tephcalostan B
	CHALCONES
134.	Tephcalostan C
135.	Tephcalostan D
136.	Candidachalcone
137.	<i>O</i> -methylpongamol
138.	(+)-tephrosone
139.	(+)-tephropurpurin
140.	2',6'-dimethoxy-4',5'-(2''2''dimethyl)-pyranochalcone
141.	(<i>S</i>)-elatadihydrochalcone
142.	Purpuritenin
143.	Praecansone A
144.	Praecansone B
145.	Obovatachalcone
146.	Spinochalcone C
147.	Crassichalone
148.	Oaxacacin
149.	6'-demethoxypraecansone B
150.	Tephrone
151.	Spinochalcone A
152.	Spinochalcone B
153.	3',5'-diisopentenyl-2',4'-dihydroxychalcone
154.	Tunicatachalcone

155.	Epoxyobovatachalcone
156.	2',6'-dihydroxy-3'-prenyl-4'-methoxy- β -hydroxychalcone
	OTHER FLAVONOIDS
157.	Purpureamethied
158.	Calophione A
159.	Tephrospirolactone
160.	Tephrospiroketone I
161.	Tephrospiroketone II
	TRITERPENOIDS
162.	Oleanolic acid
	SESQUITERPENES
163.	1 β -hydroxy-6,7 α -dihydroxyeudesm-4(15)-ene
164.	Linkitriol
165.	1 β ,6 α ,10 α -guai-4(15)-ene-6,7,10-triol
	Others
166.	2-propenoic acid, 3-(4-(acetyloxy)-3-methoxyphenyl)-3(4-actyloxy)-3-methoxyphenyl)-2-propenyl ester
167.	Cineroside A
168.	(+)-lariciresinol-9'-stearate

PHYTOCHEMICAL STRUCTURE AS PER ABOVE TABLE 2.4.1:

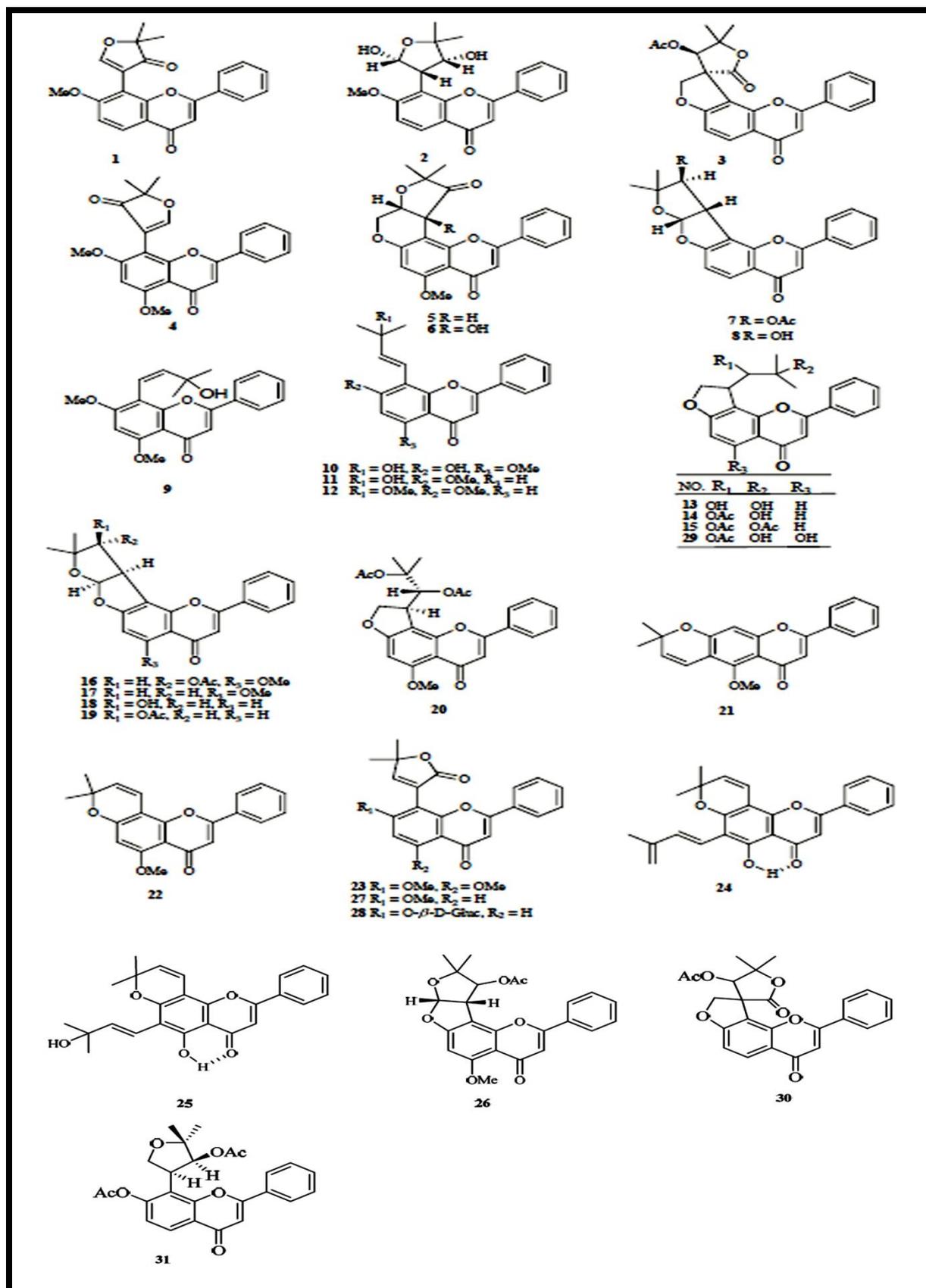


Fig 2.2 Flavones

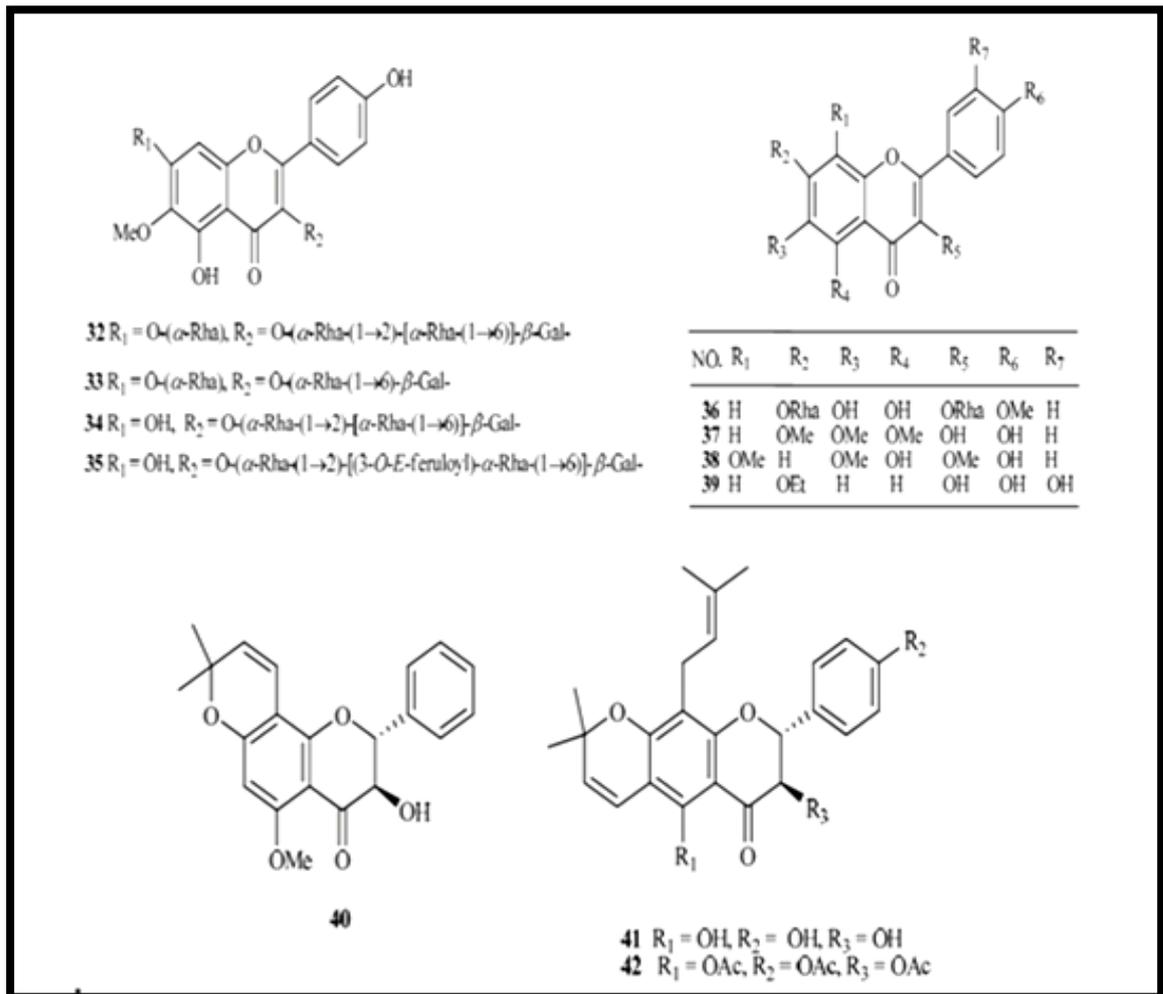


Fig 2.3 Flavonols and Flavanonols

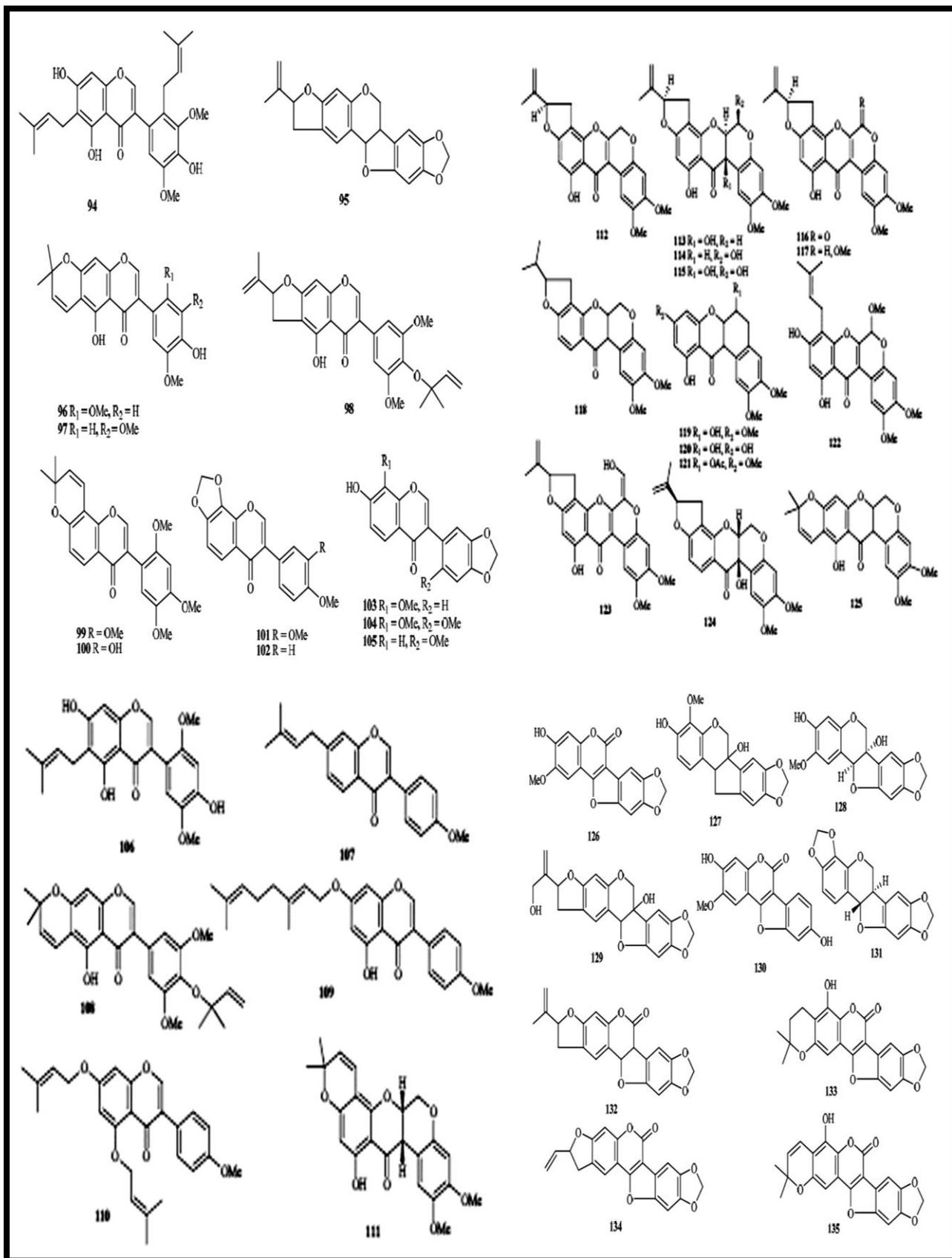


Fig 2.5 Isoflavones

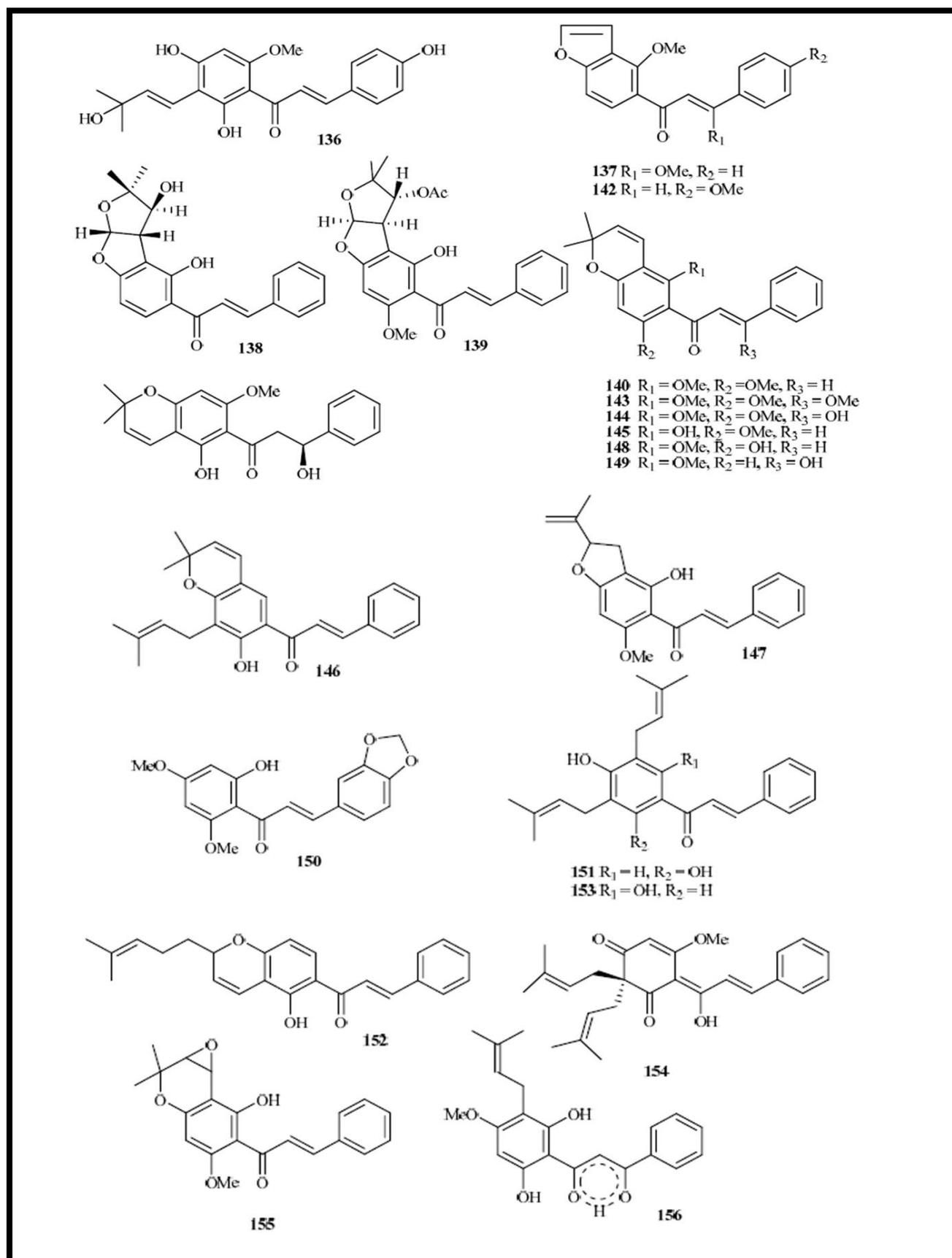


Fig 2.6 Chalcones

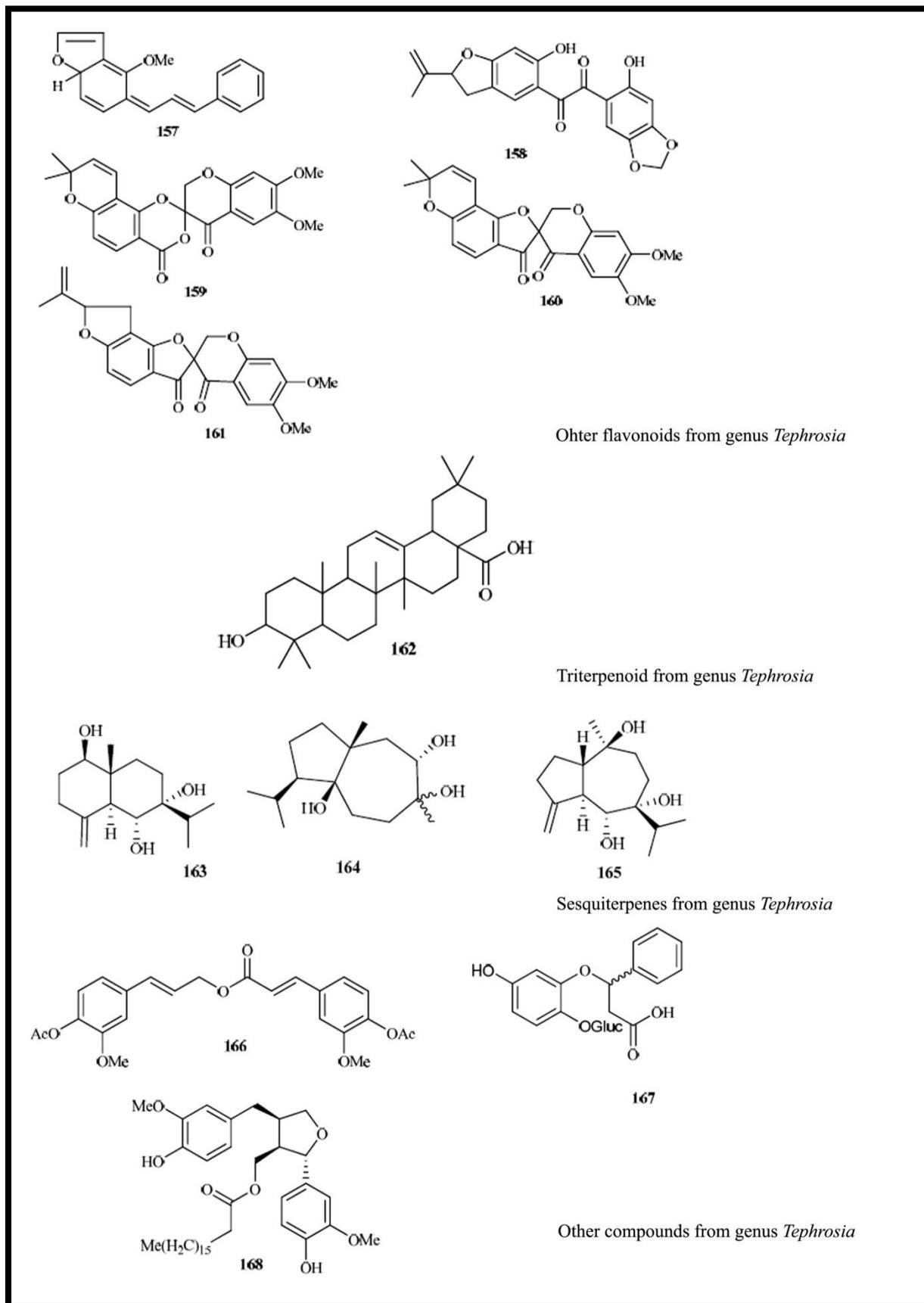


Fig 2.7 Terpenoids and Flavonoids

PYTOCHEMICAL IN VARIOUS SPECIES

Phytochemicals reported in different *Tephrosia* species across the semi arid region of India are critically reviewed (Touqueer *et al*, 2013, Table 2.4.2). Widely exploited species of this genus are *T. purpurea*, *T. candida* and *T. villosa*. Thus both the endemic species *i.e.*, *Tephrosia jamnagarensis* and *T. collina* were compared phytochemically with the corresponding species. Further for analysing their phytochemicals potential.

TABLE: 2.4.2 PHYTOCOMPONENTS FROM THE TEPHROSIA GENUS OF SEMIARID REGION:-

Sr. No.	PLANT NAME	PLANT PART	CLASS	COMPOUNDS	REFERENCE
1	<i>Tephrosia apollinea</i>	Seed and aerial parts	Flavonoid	(-)-semiglabin (-)-pseudosemiglabrin (+)-glabratephrin (+)-glabratephrinol appollinine (7-methoxy-8-[3''-(2'',5''- dihydro-5'',5''-dimethyl-2''-oxofuryl)]- flavones lanceolatin-A (+)-apollineanin (-)-semiglabin (-)-semiglabinol	Waterman and Khalid, 1980 Hisham <i>et al.</i> , 2006
2	<i>Tephrosia candida</i>	Aerial parts and seeds	Flavonoid	Candidol candidone	Dutt and Chibber, 1983
			Chalcone	ovalichalcone dehydrorotenone candidin pongachin flemichapparin	Roy <i>et al.</i> , 1986 Parmar <i>et al.</i> , 1988
			Sterol	β -sitosterol	Roy <i>et al.</i> , 1987
			Acid	caffeic acid	Parmar <i>et al.</i> ,

Sr. No.	PLANT NAME	PLANT PART	CLASS	COMPOUNDS	REFERENCE
	<i>Tephrosia candida</i>	Aerial parts and seeds	Rotenoid	12a-hydroxyrotenone tephrosin amorpholone 6a,12,-dehydodeguelin 12a-hydroxy- β -toxicarol deguelin α -toxicarol 6a,12a-dehydrodeguelin 12a-hydroxy- α -toxicarol, 6a12a-dehydro- α -toxicarol 6a,12a-dehydro- β -toxicarol dehydrodihydrorotenone tephrospirolactone tephrospiroketone I, tephrospiroketone II	1988 Parmar <i>et al.</i> , 1988 Kole <i>et al.</i> , 1992 Parmar <i>et al.</i> , 1988 Andrei <i>et al.</i> , 1997 Roy <i>et al.</i> , 1987 Andrei <i>et al.</i> , 2002
3	<i>Tephrosia collina</i>		NIL	NIL	NIL
4	<i>Tephrosia hamiltonii</i>	Roots	Flavonoids	5, 7-dimethoxy-8-(2, 3-epoxy-3- methylbutyl)-flavanone Pongamol flemichapparin-B flemichapparin-C	Falak and Shoeb 1987
			Coumestone	2-methoxy-3,9-dihydroxy coumestone	Rajani and Sarma, 1988
5	<i>Tephrosia jamnagarensis</i>		NIL	NIL	NIL

Sr. No.	PLANT NAME	PLANT PART	CLASS	COMPOUNDS	REFERENCE
6	<i>Tephrosia pauciflora</i>		No information available	No information available	No information available
7	<i>Tephrosia pumila</i>	seeds	Flavonoid	pumilaisoflavones A pumilaisoflavones B pumilaisoflavones C pumilaisoflavones D pumilanol tephrinone β -hydroxychalcone Praecansone-A.	Yenesew <i>et al.</i> , 1989
			Rotenoid	rotenone	Ganapaty <i>et al.</i> , 2008b
			Triterpene	lupeol	Dagne <i>et al.</i> , 1988
			Sterol	stigmasterol	Ganapaty <i>et al.</i> , 2008b
8	<i>Tephrosia purpurea</i>	Aerial parts Seeds and roots	Flavonoid	tephrosin pongaglabol semiglabin purpuritenin purpureamethide karanjin lanceolatin B	Ahmad <i>et al.</i> , 1999 Sinha <i>et al.</i> , 1982
				(+)-tephrorins A (+)-tephrorins B (+)-tephrosone purpurenone (+)-purpurin (-)-purpurin dehydroisoderricin (-)-maackiain	Sinha <i>et al.</i> , 1982; Chang <i>et al.</i> , 1997 Chang <i>et al.</i> , 2000 Rao and Raju, 1984b Rao and Raju, 1984b; Chang <i>et al.</i> , 1997

Sr. No.	PLANT NAME	PLANT PART	CLASS	COMPOUNDS	REFERENCE
	<i>T.purpurea</i>			pseudosemiglabrin (-)-semiglabrin terpurinflavone Pongamol (-)-isolonchocarpin 7,4'-dihydroxy-3',5'- dimethoxyisoflavone (+)-tephropurpurin (-)-3-hydroxy-4- methoxy- 8,9methylenedioxypteroc arpan(-)-medicarpin 3'-methoxydaidzein desmoxyphyllin B 3,9-dihydroxy-8- methoxycoumestan isoglabratephrin tephropurpulin A quercitin rutin	Juma <i>et al.</i> , 2011 Parmar <i>et al.</i> , 1989; Chang <i>et al.</i> , 1997 Rao and Raju, 1979 Chang <i>et al.</i> , 1997 Hegazy <i>et al.</i> , 2009 Jain <i>et al.</i> , 2009
			Ester	stigmast-5, 22-dien-34, 21diol-34, 21- dihexadecanoate	Sharma <i>et al.</i> , 2008
			Neoflavonoid glycoside	serratin7-O-[β-D- glucopyranosyl-(1→4)- O-β-D-galactopyranoside	Saxena and Choubey, 1997
			Sterol	β-sitosterol spinasterol-α	Chang <i>et al.</i> , 1997; Parmar <i>et al.</i> , 1989
			Acid	ursolic acid	
9	<i>Tephrosia senticosa</i>		Near threated species not	Near threated species not workout for	

Sr. No.	PLANT NAME	PLANT PART	CLASS	COMPOUNDS	REFERENCE	
			workout for phytochemcials	phytochemcials		
10	<i>Tephrosia strigosa</i>	Aerial parts	terpenes	beta-amyrin, n-triacontanol, beta-sitosterol, 3R (-) mucronulatol	Sreenivasulu and Sarma (1998)	
				isoflavan and a pentacyclic triterpene	Rao and Sridhar (1999)	
11	<i>Tephrosia tinctoria</i>	Aerials part	Flavonoid	5,7-di-O-prenylbiochanin 7-O-methylglabranin tephrowatsin C flemichapparin B 2-hydroxy tephrosin tephrinone lupinifolin 7-O-methyl glabranin	Khalivulla <i>et al.</i> , 2008 Ganapaty <i>et al.</i> , 2009	
				Rotenoid	rotenone dehydrodeguelin	Ganapaty <i>et al.</i> , 2010
				Sterols	stigmasterol	
				Acid	betulinic acid	
12	<i>Tephrosia uniflora</i>	Aerial parts	Flavonoid	elongatin	Abreu and Luis, 1996	
			Rotenoid	12a-hydroxyrotenone		
			Sterol	β -sitosterol stigmasterol		
13	<i>Tephrosia villosa</i>	Root Aerial part	Flavonoid	(2S)-5,4'-dihydroxy-7-O-[(E)-3,7-dimethyl-2,6-octadienyl]flavanone (2S)-5,4'-dihydroxy-7-O-[(E)-3,7-dimethyl-2,6-octa-dienyl]-8-C-[(E)-	Madhusudhana <i>et al.</i> , 2010	

Sr. No.	PLANT NAME	PLANT PART	CLASS	COMPOUNDS	REFERENCE
	<i>T. villosa</i>	Root Aerial part		3,7-dimethyl-2,6-octadienyl]flavanone 7-O-methylglabranin tephcalostan 12a-dehydro-6-hydroxysumatrol 7-methylglabranin villosin villosone villol villinol tephrinone	Jayaraman <i>et al.</i> , 1980 David Krupadanam <i>et al.</i> , 1997 Rao and Srimanarayana, 1981
			Triterpenoid	Lupenone Lupeol	Prashant and Krupadanam 1993, Ganapaty <i>et al.</i> , 2008a
			Sterol	stigmasterol	
			Rotenoid	12a-dehydro-6-hydroxysumatrol dehydrorotenone 6a,12a-dehydro,2,3,6-trimethoxy-8-(3',3'-dimethylallyl)-9,11dihydroxy rotenone 12a-hydroxy toxicarol rotenone	Prashant and Krupadanam 1993 Ganapaty <i>et al.</i> , 2008a Prashant and Krupadanam, 1993

The above review of the phytochemical data gives clear cut idea about the lacunae related to phytochemical analysis in *T. jamnagarensis* and *T. collina*. It also highlights the fact that distribution of rotenoids, flavonoids and phenolic component is prominent in aerial and seed part of this genus (Irvine and Freyre, 1959). Henceforth the aerial and seed parts of both these plant along with roots (few analysis) are consider for phytochemistry analysis. However, the sincere efforts are made to overcome this lacuna as the main aim of the present

work is to explore the phytochemical potential of these plants. Furthermore, the analysis for phytoconstituents was carried using the sophisticated technique of modern era.

2.4.1. FATTY ACID IN TEPHROSIA SPECIES

Fatty acid composition of only two *Tephrosia* species have been documented (Table 2.4.3). Both the species are rich in unsaturated fatty acids. The dominating fatty acids in *T. purpurea* the oil was Hexadecanoic acid in stem (69.61%) and root (46.97%) while other common components in the oil were linoleic acid, bulnesol and epiglobulol (Arriaga *et al.*, 2005). Chemo- profiling of these oils showed differences in composition among the studied species although volatile constituents have been previously reported in other species of the *Tephrosia* genus (Arriaga *et al.*, 2005). Caryophyllene oxide was the major component (63.9%) of leaves of *Tephrosia cinerea* (Arriaga *et al.*, 2008) whereas major components of the stem oil of *Tephrosia egregia* were geijerene and pregeijerene (Arriaga *et al.*, 2008). *Tephrosia vogelii* seed consisted more amount of hexadecanoic acid (palmitic acid, 18.70%) along with tetradecanoic acid, pentadecanoic acid, heptanoic acid, stearic acid, oleic acid, linoleic acid, linolenic acid, eicosanoic acid, heneicosanoic acid, docosanoic acid, tricosanoic acid and tetracosanoic acid (Sahayaraj *et al.*, 2014; Xin *et al.*, 2009) .

TABLE 2.4.3.FATTY ACID COMPOSITION

Fatty acid	<i>T. purpurea</i> (Joshi <i>et al.</i> , 1979)	<i>T. villosa</i> (Mukarram <i>et al.</i> , 1987)
Palmitic acid	+	+
Stearic acids	+	-
Tetraenoic acid	-	+
Palmitoleic acid	+	-
Oleic acid	+	+
Linoleic acid	+	+
Linolenic acids	+	-

2.5. PHARMACOLOGY

Among 13 enlisted *Tephrosia* species of Gujarat, *T. purpurea* is extensively worked out for its biological activities. According to Ayurveda this plant is known as ‘Sarwa wranvishapaka’ which means it has the property of healing all types of wounds. It is an important component of some preparations such as Tephroli and Yakrifit used for liver

disorders. The *Tephrosia* plant parts are used in treatment of impotency, asthma, diarrhoea, rheumatism, ulcer and urinary disorders. The plant has been claimed to cure diseases related to kidney, liver, spleen, heart and blood. The pharmacological activity of *T. purpurea* has been depicted in Table 2.5.1 (Mathews *et al.*, 2012).

TABLE 2.5.1 PHARMACOLOGICAL ACTIVITY OF *T. PURPUREA*

Part	Pharmacological Activity	References
Root	<ol style="list-style-type: none"> 1. Anti ulcer activity 2. Anti carcinogenic and antilipid peroxidative 3. Anti microbial 4. Ant-inflammatory and analgesic 5. In-vitro anti oxidant 6. Ameliorates CCl₄ induced hepatic damage 7. Anti-pyretic, anti inflammatory 8. CNS depressant and analgesic 	<p>Deshpande <i>et al.</i>, 2003</p> <p>Manoharan <i>et al.</i>, 2006</p> <p>Kumar <i>et al.</i>, 2007</p> <p>Gopalkrishnan <i>et al.</i>, 2010</p> <p>Sangeetha <i>et al.</i>, 2010</p> <p>Valli <i>et al.</i>, 2011</p> <p>Valli <i>et al.</i>, 2011</p>
Leaves	<ol style="list-style-type: none"> 1. Ameliorates benzoyl peroxide induced cutaneous toxicity 2. Alleviates phorbol ester induced tumour promotion 3. Spasmolytic 4. Hepatoprotective 5. Anti oxidant 6. Anti pyretic 7. Antihyperlipidemic 8. Anthelmentic 	<p>Mohamad <i>et al.</i> 1999</p> <p>Saleem <i>et al.</i>, 2001</p> <p>Soni <i>et al.</i>, 2003</p> <p>Pavan <i>et al.</i>, 2007</p> <p>Patel <i>et al.</i>, 2010</p> <p>Kumar <i>et al.</i>, 2011</p> <p>Sayad, 2012</p> <p>Manjula <i>et al.</i>, 2013</p>
Whole plant	<ol style="list-style-type: none"> 1. Ameliorates diethyl nitrosamine and pot. bromate mediated renal oxidative stress 2. Antileishmania 3. Antiepilepsy 	<p>Khan <i>et al.</i>, 2001</p> <p>Sharma <i>et al.</i>, 2003</p> <p>Asuntha <i>et al.</i>, 2010</p>

Part	Pharmacological Activity	References
	4. A source of beta sitosterol anti carcinogenic and anti hypercholesterolemic. 5. Anxiolytic activity 6. Diuretic activity 7. Anti diarrheal	Kishore and Roy 2011 Kumar <i>et al.</i> 2011 Ashok <i>et al.</i> , 2012 Khalid <i>et al.</i> , 2013
Aerial part	1. Hepato protective 2. Anti cholestatic 3. Inhibition of mast cell degranulation. 4. Immune modulatory 5. Anti asthmatic 6. Wound healing and burns	Murthy <i>et al.</i> , 1993; Mitra <i>et al.</i> , 1999 Mitra <i>et al.</i> , 1999 Gokhle <i>et al.</i> , 2000 Damre <i>et al.</i> , 2003 Gajera <i>et al.</i> , 2011 Satnam <i>et al.</i> , 2006
Seed	1. Tumour protection activity 2. Antihyperlipidemic and antiglycemic. 3. Anti oxidant	Saleem <i>et al.</i> , 2001 Sethupathy <i>et al.</i> , 2006 Kumar <i>et al.</i> , 2011
Flower	1. Anti viral and anti bacterial	Kokila and Patel, 2010

In other, *Tephrosia* species chemical constituents have been shown to exhibit various bioactivities, such as estrogenic, antitumor, antimicrobial, antiprotozoal, antifeedant activities (Hegazy *et al.*, 2011; Belmain *et al.*, 2012). The estrogenic activity was exhibited by chemical constituent candidachalcone isolated from *T. candida* with IC₅₀ value of 80 µM, compared with 18 µM for the natural steroid 17 β-estradiol (Hegazy *et al.*, 2011). (+)-Tephrorins A and B and (+)-tephrosone isolated from *T. purpurea* were evaluated for their potential cancer chemopreventive properties using a cell-based quinone reductase induction assay (Chen *et al.*, 2014; Chang *et al.*, 2000). Along with these other active components like 7,4'-dihydroxy-3',5'-dimethoxyisoflavone and (+)-tephropurpurin were obtained from *T. purpurea*, were effective bioassay against based cell line cultured Hepa 1c1c7 mouse hepatoma cells (Chang *et al.*, 1997). The chalcone 2',6'-Dimethoxy-4',5'-(2'',2''-dimethyl)-pyranochalcone from *T. pulcherrima* showed significant antimicrobial activity when tested

against a series of micro-organisms (Ganapaty *et al.*, 2008). Terpurinflavone (31) isolated from *T. purpurea* showed antiplasmodial activity against the chloroquine-sensitive (D6) and chloroquine-resistant (W2) strains of *Plasmodium falciparum* with IC50 values of 3.12 ± 0.28 μ M (D6) and 6.26 ± 2.66 μ M (W2) (Juma *et al.*, 2011).

Today in herbal market 14 products are made from *T.purpurea* marketed, of which nine herbal products, 9 are used for treating diseases related to liver and kidney (Table 2.5.2). With reference to above context, *T. jamnagarensis* and *T.collina* are study for its hepatoprotective activity on HepG2 cell line and Lymphocyte activity.

TABLE 2.5.2 SOME OF THE MARKET PRODUCT MADE FROM *T. PURPUREA*

PRODUCT	MANUFACTURED BY	USES
G-LIV-D.S	Morpheme Remedies Syrup	Liver corrective and restorative
Stimuliv	FrancoIndia	Limited For supportive treatment in viral hepatitis, drug induced and alcoholic hepatitis
Dilapsin	Solumiks	Digestive, improves appetite, relieves flatulence
Safi	Hamdard Laboratories	Skin diseases like acne vulgaris ,skin rashes and blemishes , boils
Vi mliv Fortified syrup	Solumiks herbaceutical products	Comprehensive liver tonic
Vasuliv syrup	Vasu pharmaceuticals	Liver corrective and protective
Hibril oil	Vital care Pvt. Ltd.	Relieves stress and provides cooling effect. Induces sleep
Janduna capsules	Ajmera Pharmaceuticals Pvt. Ltd.	UT infection expels urinary stones. Relieves burning micturition.UT anti-infective
Livina syrup (Darbar <i>et al.</i> , 2010)	Deys Medical Stores (Mfg.) Ltd.	Hepatitis due to virus, jaundice
Stomyne capsules	Eisen Pharmaceutical Co. Pvt. Ltd.	UT infection,UT anti- infective
Tefroliv	Ttk Healthcare Ltd.	Acute and chronic hepatitis, liver

PRODUCT	MANUFACTURED BY	USES
		cirrhosis
NewLivfit (Gupta <i>et al.</i> , 2004)	NLF	Management of hepatitis B in end stage renal disease
Livex	Ban	Liver corrective, protective and regenerative
Hepjaun	S.G Phytopharma Pvt. Ltd.	Hepatitis and jaundice

2.6 Review summary

The literature review state that both this endemic Tephrosia species shows huge lacunae related to seed germination, population ecology, pharmacognosy, phytochemistry and pharmacology.