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Natural flavans and flavanones with antioxidant activities: An overview

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Abstract
In the recent research, plant derived natural compound become the hot point of study for the safe and effective drug. Flavonoids are one of the important secondary plant metabolites. Flavan and flavanone are the major class of flavonoids, important biologically active natural compounds. So search of new natural flavans and flavanones, having radical scavenging activity is of major attention to the chemists now. The present resume describes 41 new examples of naturally occurring flavans and flavanones having antioxidant potential reported during the period of 2005 to 2017. These flavan and flavanones are found either as aglycones or as glycosides, comprising flavans, flavanones, flavanols, isoflavans and isoflavanones and miscellaneous flavanones (Homoisoflavan and bi-flavanones). The main topics addressed are source, structure, antioxidant activity. The review cites 66 references.

Keywords: Natural flavans and flavanones, antioxidant, radical scavenging

Introduction
Our Nature is an infinite source of biologically active chemical entities [1]. Plant-derived natural compounds are showing us different paths for discovering different drugs for the treatment of various diseases [2-3]. Thus, natural Compounds, derived from nature, are now proved themselves as important sources for pharmacologically active agents and so these are being employed in drug design [4-7]. Plants are the major source of all these. So, more and more attentions are being given to compounds derived from plants [8-16]. Biological activities of all these chemical compounds from the nature are one of the key points of the recent research.
Among the natural compounds, flavonoids are of much interest of the chemists for their wide distribution in the plant kingdom and immense biological activities [17-19]. One of such important activities is their antioxidant activities [20-21].
Flavans and Flavanones are two major sub-classes of flavonoids. Flavans, a class of benzopyran derivatives show diverse biological activities [22-23]. One of them is antioxidant activity. Flavanones are the other class of flavonoids which are important antioxidants [24-25]. The present review describes new naturally occurring flavans and flavanones with antioxidant activities reported during the period of 2005 to 2017. The review focuses on the sources, structures and antioxidant activities of the reported flavans and flavanones.

2. Chemical Structures: Flavans and Flavanones are major class of flavonoids which contain mainly aryl substituted benzopyran group. This resume describes new natural flavans and flavanones having antioxidant potentials reported during the mentioned period. Based on the chemical structures of the reported flavans and flavanones, all the compounds are broadly classified into flavans, flavanones, flavanols, isoflavans and isoflavanones and miscellaneous flavans and flavanone.
2.1 Flavans: Flavans are class of compounds which contain benzopyran group having an phenyl moiety at 2 position. Here structure nos 1-4 represent this group. Here all the flavans are glycosides. This group is represented by Fig.1 and Table-2.
2.2 Flavanones: Flavones, when dehydrogenated at 2,3 positions, are called flavanones. Structure no 5-27 represents this group. In this group, 17- 18 and 20-23 are glycosides of flavanone and other group members are substituted flavanones. Chemical structures of this group are given in Fig.2 and the names are tabulated in Table-3
2.3 Flavanols: When flavanone contains hydroxyl group is at 3 position, the compound is refer to as flavanols. Structure nos 28-34 represent this group. Here, structure no 28-29 are glycosides of flavanols. The structures are given in Fig 3 and names are listed in Table-4
2.4 Isoflavans and Isoflavanones: If the flavans or flavanones contains the aryl group at 3 position instead of 2-position, the compounds are called isoflavans or isoflavanones.structure nos 35 – 39 refers to this group. Structure 35-36 are isoflavanones and rest are isoflavans.

Only structure 36 is glycoside of flavanone. The structures are given in Fig. 4 and compounds are listed in Tabla-5.

2.5 Miscellaneous Flavan and Flavanone: dimer and homoflavonoids are included in this group. Only two members are there. Structure no 40 is dimer of flavan and 41 represent homoisoflavanone. Fig.5 represents the chemical structures and Table-6 represents the names of this group members.

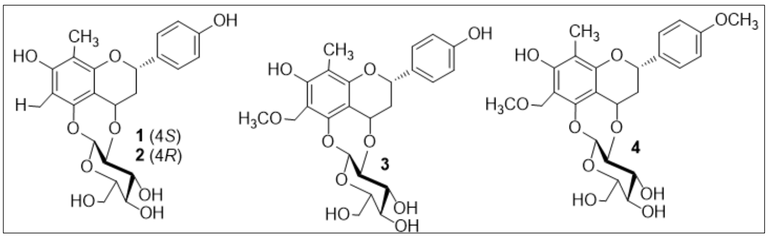

Fig 1: Chemical structures of Flavans

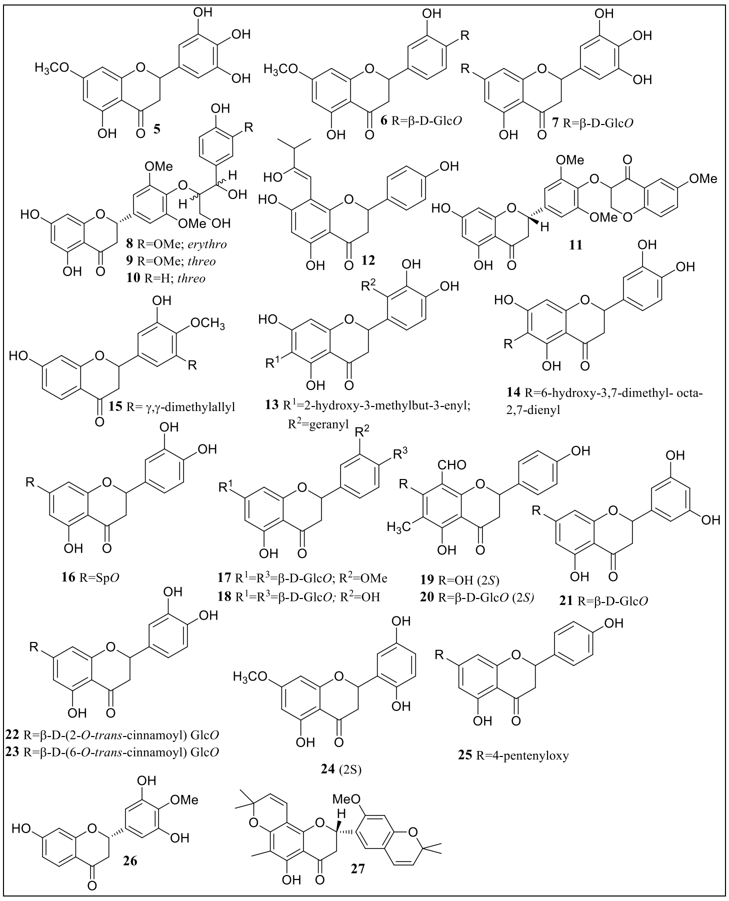

Fig 2: Chemical structures of Flavanones

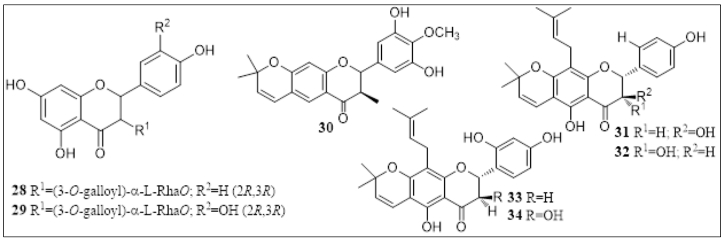

Fig 3: Chemical Structures of Flavanols

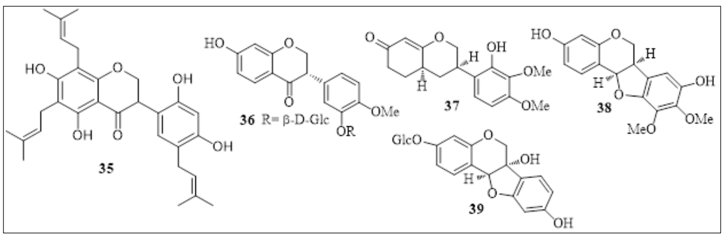

Fig 4: Chemical Structures of Isoflavans and Isoflavanones

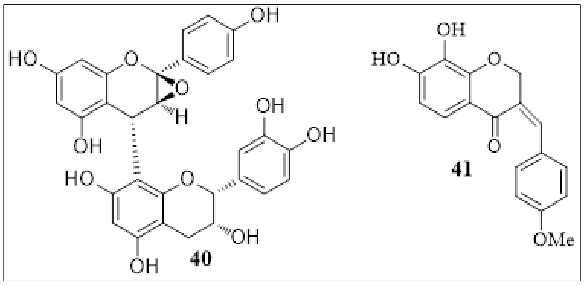

Fig 5: Chemical Structures of Miscellaneous Flavan and Flavanone

3. Antioxidant Activity of the reported Flavans and Flavanones: Antioxidants are defined by any substance that delays, prevents or removes oxidative damage to a target molecule as described by Halliwell and Gutteridge [26]. Main role of this substance is to prevent the damage to cellular components arising as a consequence of chemical reactions involving free radicals [27, 28]. So in living system, generation of any free radicals is a matter of considerable concern. In all living systems, reactive free radicals attack various biological molecules. So, many diseases are developed in the body depending upon the path of the reaction of the free radicals generated. Natural products are found to show antioxidant activities mainly due to their redox properties. These natural antioxidants quench singlet and triplet oxygen, or decompose peroxides. The plants produce such phenolic compounds such as flavonoids as a defense against adverse conditions. Naturally occurring flavonoids have been known to possess significant antioxidant efficacy; the antioxidant effect of the compounds can reside in their both radical-scavenging activity and metal-chelating properties, of which the former may dominate [29, 30]. The antioxidant capabilities of natural many flavonoids are stronger than Vitamin C or E [31]. Flavans and Flavanones are important class of flavonoids having these antioxidant properties.

Flavans and flavanones can prevent the injury resulted by free radicals by the different mechanisms. These are direct scavenging of reactive oxygen species (ROS), activation of antioxidant enzymes [32], metal chelating activity [33], reduction of α-tocopheryl radicals [34, 35], inhibition of oxidases [35, 36] etc.

Here, antioxidant activities of the reported flavans and flavanones are discussed. Antioxidant properties are evaluated with DPPH, Cytochrome C reductase NBT assay etc.

3.1 Activities of Flavans

The four flavan-4-ol glycosides, abacopterins E–H (1-4) isolated from a fern *Abacopteris penangiana* exhibited antioxidant activity against $ABTS^{\cdot +}$ in Trolox equivalent antioxidant capacity (TEAC) assay with TEAC values of 1.03–1.44 mM [37]. The comparatively lower TEAC value of 4 is due to methylation of -OH function at 4′-position as revealed from the structure-activity relationships described by Zhao *et al*. [37].

3.2 Activities of Flavanones

Three flavonoid compounds 5-7 isolated from *Areva persica* exhibited profound antioxidative activities in both DPPH and Cytochrome-*c*-reduction assays using the HL-60 cell culture system with respective IC_{50} values of 16.9 and 16.5 mg/mL for compound 5, 18.1 and 17.6 mg/mL for compound 6 and 14.4 and 14.0 mg/mL for compound 7 [38].

Five bioactive flavonoids (8-11), isolated from *Calamus quiquesetinervius*, were evaluated for their radical scavenging ability of the hydroxyl radical ($^{\cdot}OH$) and superoxide anion ($^{\cdot}O_2^-$) using an ultra-weak CL assay. Three of the tested new flavanones were found to have significant scavenging activities against the hydroxyl radical with IC_{50} value in the range of 0.56–8.74 mg/mL except for compound 11 which resulted IC_{50}> 20 mg/mL. Compound 8 and 9 were reported to exhibit IC_{50} value as 0.56 and 0.60 mg/mL, respectively, against the hydroxyl radical while compound 10 and 11 exhibited 8.74 and 29.9 mg/mL, respectively. However, they showed a moderate or weak scavenging efficiency on the superoxide anion as compared with the reference Trolox. Against the superoxide anion, the flavanones 8 and 9 were found to have IC_{50} values 119.03 and 153.8 mg/mL, respectively while the values for other two compounds (10-11) were >200 mg/ML [39].

The isolated flavonoids 12 from *Eriophorum scheuchzeri* were found to have antioxidant activity against DPPH assay [40]. The Flavanone 14, isolated from *Macaranga tanarius*, exhibited radical scavenging properties against DPPH assay with IC_{50} value of 20 mM and was stronger than the Flavanone 13 of the same plant, which showed IC_{50} value of 33 mM [41]. All the isolated compounds along with flavanone 15 from *Erythrina latissima* were evaluated for radical scavenging activity using DPPH assay having Ascorbic acid as the reference. Compound 15 showed weak radical scavenging properties towards DPPH assay with IC_{50} value 700 mg/mL [42]. The flavonoid constituents along with compound 16 of *Globularia alypum* were found to have potent antioxidant properties against DPPH radical. Methanol was taken as negative control and BHT was taken as positive control in this experiment. The flavanone 16 was reported to result very low IC_{50} value of 8.0 mM as compared to the value of positive control, BHT as 40.0 mM indicating, thereby, their high ability to scavenge free radicals [43].

Yao *et al.* isolated two flavanone glycosides 17 and 18 from branches and leaves of *Viscum coloratum*, and the isolates were found to show antioxidative activities against both hydroxy radical and superoxide anion radical. The results suggested that a hydroxyl or methoxyl substitution at C-3′ might have increased their antioxidative activities [44]. Four flavonoid compounds 19, 20, from *Cleistocalyx operculatus* were tested for their *in vitro* antioxidant activity using a 1,1-diphenyl-2-picrylhydrazyl (DPPH) radical scavenging assay. Compounds 19 exhibited DPPH radical scavenging activity with IC_{50} values of 22.8, while compounds 20 exhibited weak activity with IC_{50} values of 117.2 as reported by Min and his group [45]. Compound 21 along with all the isolated compounds were evaluated antioxidant activity using DPPH assay taking Ascvorbic acid as the reference. Compound 21 was found to show radical scavenging activity against DPPH with EC_{50} value 2.00 mg/mL. So the compound (21) reported as strong antioxidant as it resulted lower EC_{50} value than that of reference Ascorbic acid (3.32 mg/mL) [46].

Kuo and his group (2010) isolated two flavonone glycosides visartiside A (22) andvisartiside B (23) from *Viscumar ticulatum*, the flavanone derivatives 22 and 23 were evaluated to have possess radical-scavenging activity with ED_{50} values of 37.6, and 34.1 μM, respectively [47]. Both the flavanones possess a 3′,4′-dihydroxyphenyl moiety in the B ring that might play a crucial role in radical-scavenging activity [47]. Flavanone (24) was reported to be moderately antioxidant [48]. Compound 25 along with other isolated flavones were tested for radical scavenging activity against DPPH assay using Propyl gallate as the standard. Compound 25 was found antioxidant against the DPPH with 6.85% of radical scavenging activity [49] although the compound was reported as weak radical scavenging activity as compared to standard (90.31%), the new compound was found as antioxidant [49]. It is well-known that 1,1-Diphenyl-2-picryl-hydrazyl (DPPH) is an ideal agent to suppress radical species and it has been used for evaluation of free radical scavenging activity of isolated compounds [50]. The antioxidant activity of the isolated compounds was evaluated using this DPPH. Dioclin A (26), isolated from *Dioclea reflexa*, was reported to show radical scavenging activity with IC_{50} value of 58.14 mM using Butylated hydroxylanisole (BHA) as standard with corresponding IC_{50} value 44.2 mM [51]. Superoxide anion scavenging activity of the isolated flavanone (27) along with other isolates was evaluated with NBT (Nitro Blue Tetrazolium) method using Trolox C, a water soluble Vit-C analogue, as the reference. Among the isolated compounds, the flavanone (27) had the strongest antioxidant activity. It showed 95.79% antioxidant activity in NBT while the value was 70.02% for the reference, Trolox C. From the plot of radical inhibiting activity with the concentration of the compound, IC_{50} value was calculated as 0.14 mg/ml for the compound (27) [52]. Since the scavenging effect of flavanone (27) could not be explained simply by unusual H abstraction [53] or electron and/or proton transfer [54-55], a theoretical analysis of possible pathway through transient-states was discussed by the author [52].

3.3 Activities of Flavanols:

Compound 28 and 29 were evaluated the antioxidant activity using ORAC and HOSC to measure the absorbing capacity against peroxy radical and scavengingcapacity of hydroxyl radical, respectively. The ORAC value of compound 28 was found less than that of compound 29 and in HOSC test the same result was followed. Both the results confirmed that the antioxidant activity of compound 28 was less because of the less number of hydroxyl group present in the molecule [56-57]. The scavenging effect of the new flavanone (30) isolated from the roots of *Lannea alata*, on the stable free radical DPPH was examined by Koorbanally *et al.* and the activity was compared with that of the standard antioxidant ascorbic acid. It was shown that the compound 30 exhibited strong antioxidant activities exhibited good radical scavenging activity. Both the flavonoids 30 exhibited dose dependent radical-scavenging activity in the presence of the DPPH radical. At concentrations 6.25, 12.50, 25, 50 and 100 mg/mL, the percentage of radical scavenging were reported as 46.07, 53.36, 72.36, 80.37 and 87.36, respectively. Subsequently, the mean value was deduced as 68.77% while the value foe reference, Ascorbic acid, was 95.52%. The percentage radical scavenging activity for the isolated flavonol glycosides and ascorbic acid revealed that the compound (30) was moderately antioxidant [58]. Compounds (31-34) were isolated from roots of *Eriosema chinense*. Sutthivaiyakit *et al.*, tested for their DPPH radical scavenging properties; it was observed that four compounds showed antioxidant activity. The respective IC_{50} values of the flavanones (31-34) are given in the Table- 1 [59].

Table 1: IC_{50} values (μM) of Compounds (31-34) from *E. chinense*

Structure No of Compounds	31	32	33	34
IC_{50}	1.768	0.538	0.681	0.252

3.4 Activities of isoFlavans and iso Flavanones

Ormosinol (35), a rare naturally-occurring polyprenylated isoflavanone constituent of the root bark of *Ormosia henryi* Prain, showed significant anti-oxidation activity against DPPH radicals (IC_{50} 28.5 μM) and cancer cell line (A549, LAC, and HepG2) growth inhibitory activity with IC_{50} ranging from 4.25 to 7.09 μM [60].

Antioxidant activity of the isolated compound (36) was assayed using DPPH, BCB and FRAP tests. Compound (36) was less active among the other isolated compound as reported by Mezrag *et al*. The compound was less active due the loss of free OH group in aromatic ring. The absence of double bond in the compound (36) was also responsible for decreased antioxidant activity as described by the author [61].

The isolated flavonoids (37-38) were evaluated for free radical scavenging activity using Vitamin E (VE) as the reference. Compound (38) was found significantly antioxidant with IC_{50} value 3.8 mM. Compound (37) was reported to lack the antioxidant activity resulting IC_{50} value 50 mM while the IC_{50} value of reference VE was 7.6 mM [62].

The antioxidant activities of compound 39 along with all other isolated compounds were investigated in terms of their peroxyl radical-scavenging and reducing capacity. It was investigated that the radical scavenging activity of the compound (39) against peroxy radical was dose dependent at 1-10 mM. Compound (39) showed potent antioxidant activity over 20 Trolox Equivalent (TE) at 10 mM [63].

3.5 Activities of Miscellaneous Flavans and Flavanones:

Antioxidant activity of the compounds isolated from the fruits of *Prunus mume* were evaluated in terms of peroxyl radical scavenging and reducing capacities. It was reported that the scavenging activity of the dimeric flavan (40) on peroxyl radical generated from AAPH was significant and dose dependent at concentration 1-10 mM. At 1 mM, the compound (40) was found to show scavenging activity with Trolox Equivalent (TE) value of 5.42 mM [64]. In order to determine whether the peroxyl radical-scavenging activity of compounds 1 is related to their reduction capacity, it was found that the flavan dimer (40) had showed potent reducing capacity of 29.90 mM [64].

Antioxidant activity of the compound (41) along with other isolated compound and extracts were evaluated using DPPH, ABTS radical scavenging assays. Isointricatinol (41) was found to exhibit mild to moderate antioxidant activity against both the radicals with IC_{50} values 85.50 and 44.13 mM, respectively. Compound was reported to inhibit 62.12 and 79.95%, respectively, at 100 mM concentration against the DPPH and ABTS radicals [65].

4. List of Flavans and Flavanones: All the new flavans and flavanones will antioxidant potentials reported during the time are given here in tabular form for easy look. The plant sources of the isolated compounds are also given. The compounds are tabulated according to the classification mentioned earlier.

Table-2: Names and source of flavans

Sl. No	Compound (Structure No.)	Source Plant (Family)	Reference
1	Abacopterin E (1)	*Abacopteris penangiana* (Thelypteridaceae)	[37]
2	Abacopterin F (2)	*Abacopteris penangiana* (Thelypteridaceae)	[37]
3	Abacopterin G (3)	*Abacopteris penangiana* (Thelypteridaceae)	[37]
4	Abacopterin H (4)	*Abacopteris penangiana* (Thelypteridaceae)	[37]

Table-3: Names and source of flavanones

Sl. No	Compound (Structure No.)	Source Plant (Family)	Reference
1	Persinol (5)	*Aerva persica* (Amaranthaceae)	[38]
2	Persinoside A (6)	*Aerva persica* (Amaranthaceae)	[38]
3	Persinoside B (7)	*Aerva persica* (Amaranthaceae)	[38]
4	Calquiquelignan A (8)	*Calamus quiquesetinervius* (Arecaceae)	[39]
5	Calquiquelignan B (9)	*Calamus quiquesetinervius* (Arecaceae)	[39]
6	Calquiquelignan C (10)	*Calamus quiquesetinervius* (Arecaceae)	[39]
7	Calquiquelignan F (11)	*Calamus quiquesetinervius* (Arecaceae)	[39]
8	5,7,4¢-Trihydroxy-8-(2-hydroxy-3-methyl-butenyl) flavanone (12)	*Eriophorum scheuchzeri* (Cyperaceae)	[40]
9	Tanariflavanone C (13)	*Macaranga tanarius* (Euphorbiaceae)	[41]
10	Tanariflavanone D (14)	*Macaranga tanarius* (Euphorbiaceae)	[41]
11	(−)-7,3′-dihydroxy-4′-methoxy-5′-(γ,γ-dimethyl-allyl) flavanone [Erylatissin C] (15)	*Erythrina latissima* (Fabaceae)	[42]
12	Eriodictyol 7-*O*-sophoroside(16)	*Globularia alypum* (Globulariaceae)	[43]
13	(2*S*)-homoeriodictyol 7,4′-di-*O*-b-D-gluco-pyranoside (17)	*Viscum coloratum* (Leguminosae)	[44]
14	(2*R*)- eriodictyol 7,4′-di-*O*-b-D-glucopyranoside (18)	*Viscum coloratum* (Leguminosae)	[44]
15	(2*S*)-8-formyl-6-methyl naringenin (19)	*Cleistocalyx operculatus* (Myrtaceae)	[45]
16	(2S)-8-formyl-6-methylnaringenin 7-*O*-b-D-glucopyranoside (20)	*Cleistocalyx operculatus* (Myrtaceae)	[45]
17	(2*S*)-5,7,3′,5′-tetra-hydroxyflavanone 7-*O*-b-D-glucopyranoside (21)	*Jasminum lanceolarium* (Oleaceae)	[46]
18	Visartiside A (22)	*Viscum articulatum* (Viscaceae)	[47]
19	Visartiside B (23)	*Viscum articulatum* (Viscaceae)	[47]
20	(2*S*)-5,2′,5′-trihydroxy-7-methoxy flavanone (24)	*Abacopteris penangiana* (Thelypteridaceae)	[48]
21	[Lawsonaringenin] (25)	*Lawsonia alba* (Lythraceae)	[49]
22	Dioclin A (26)	*Dioclea reflexa* (Fabaceae)	[51]
23	5-hydroxy-6-methyl-2′-methoxy-[6″,6″-dimethylpyrano(2″,3″:7,8)] [6‴,6‴-dimethyl pyrano (2‴,3‴:4′,5′)]-(2S) flavonone (27)	*Lespedeza virgata* (Thunb.) DC (Fabaceae)	[52]

Table 4: Names and source of flavanols

Sl. No	Compound (Structure No.)	Source Plant (Family)	Reference
1	(2*R*, 3*R*)-3, 5, 7, 4′-tetrahydroxy-flavanonol-3-*O*-(3″-*O*-galloyl)-α-L-rhamnopyranoside (28)	*Engelhardia roxburghiana* (Juglandaceae)	[56]
2	(2*R*, 3*R*)-3, 5, 7, 3′, 4′-pentahydroxy-flavanonol-3-*O*-(3″-*O*-galloyl)-α-L-rhamnopyranoside (29)	*Engelhardia roxburghiana* (Juglandaceae)	[56]
3	(2*R*, 3*R*)-3, 5, 3′, 5′-tetrahydroxy-4′-methoxy-6,7-(2″,2″-dimethyl-chromene)-dihydroflavonol (30)	*Lannea alata* (Anacardiaceae)	[58]
4	Lupinifolinol (31)	*Eriosema chinense* (Leguminosae)	[59]
5	Flemichin D (32)	*Eriosema chinense* (Leguminosae)	[59]
6	3-epi-lupinifolinol (33)	*Eriosema chinense* (Leguminosae)	[59]
7	2-hydroxylupinifolinol (34)	*Eriosema chinense* (Leguminosae)	[59]

Table 5: Names and source of isoflavans and isoflavanones

Sl. No	Compound (Structure No.)	Source Plant (Family)	Reference
1	Ormosinol (35)	*Ormosia henryi* (Leguminosae)	[60]
2	(3*S*)-7-Hydroxy-4-methoxy isoflavanone-3′-β-D-glucopyranoside (36)	*Ononis angustissima* L (Leguminosae)	[61]
3	Oxytropisoflavan B (37)	*Oxytropis falcate* (Leguminosae)	[62]
4	(6a*R*,11a*R*)-3,8-Dihydroxy-9,10-dimethoxypterocarpan (38)	*Oxytropis falcate* (Leguminosae)	[62]
5	Glycinol-3-*O*-b-D-glucopyranoside (39)	*Ducrosia ismaelis* (Apiaceae)	[63]

Table 6: Names and source of miscellaneous flavans and flavanones

Sl. No	Compound (Structure No.)	Source Plant (Family)	Reference
1	2b,3b-epoxy-5,7,4′-trihydroxy flavan-(4a→8)-epicatechin (40)	*Prunus mume* (Rosaceae)	[64]
2	Isointricatinol (41)	*Caesalpinia digyna* Rottler (Fabaceae)	[65]

5. Structure –Activity Relationship (SAR): The biological activity of any natural products depends upon structure of the molecule. Flavonoids having diversified substitution pattern in the structural skeleton are thus biologically active molecules. So, the antioxidant activity of the flavones and flavonols also depends upon the structural pattern of these molecule. These molecule, being polyphenolic, shows different activity according to the extent of conjugation present in the molecule and position and freeness of the hydroxyl groups.

Ahmed *et al.* described that the substitution patterns in the B ring markedly affect the antioxidant potencies of the flavonoids. Very particularly the di-OH substitution at C-3' and C-4' seemed to be particularly important to the oxygen radical absorbing activity of the flavonoids [38].

From the structure-activity relationship, it might be argued that the tricin-type analogues 8 and 9 possess more antioxidant capacities against the hydroxyl radical rather than superoxide anion. Comparisons of the hydroxyl radical scavenging activities of the compounds showed that 8 and 9 are more potent than the others, thereby suggesting that the C_2–C_3 bond in C-ring of tricin-type of derivatives enhances antioxidant activity. Other isolated flavonoids were found to show moderate radical scavenging activity due to lack of *ortho*-methyl group on the aromatic ring of the flavonoid derivatives [39].

The results suggested that a hydroxyl or methoxyl substitution at C-3′ might have increased their antioxidative activities [44]. It was also noticed that the steric effect of the 7-substituted group decreased the antioxidant activity of the compound [46]. Both the flavanones 22 and 23 possess a 3′,4′-

dihydroxyphenyl moiety in the B ring that might play a crucial role in radical-scavenging activity [47]. It was concluded from the results that the antioxidant activity of compound 28 was less because of the less number of hydroxyl group present in the molecule [56-57].

The presence of a hydroxyl group at 8-position of homoisoflavonoid nucleus significantly increased the antioxidant activity. A drastic decrease in the activity was observed when 8-hydroxyl was converted to 8-methoxy [65, 66].

6. Conclusion: The protective effect of natural flavonoids in biological system is attributed to their antioxidant activities. Since free radical generated in the biological system can damage several biological pathways so compounds with scavenging activity of these free radicals are of much interest. Natural flavans anf flavanones being polyphenol has the properties to quench the free radicals and thus they are very good antioxidant. Again, natural flavans and flavanones are metabolized as such and removed from the body. These flavans and flavanones are, thus, important for the medicinal chemists to search for natural antioxidants. So, search of new natural flavans and flavanones with antioxidant properties becomes attractive for scientists. Although the *in vivo* study of the antioxidant activity of the flavans and flavanones are very poor and this topic should be studied further, summing up of new natural flavans and flavanones can help all scientists to search for new natural antioxidants. This resume will surely assist the research on antioxidant flavonoids.

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Abbreviations

Glc = glucopyranosyl; Rha = rhamnopyranosyl; Gal = galloyl; Sp =sophorosyl; Galloyl = 3, 4, 5-trihydroxybenzoyl; Sophorosyl = b-D-Glc(1→3)-b-D-Glc;

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