CHAPTER II

HISTORICAL

THE GENUS BIDENS

1. Taxa and Description

The genus *Bidens* Linn. belongs to the subtribe Coreopsidinae (Stuessy, 1977), tribe Heliantheae of the family Compositae, the largest family in the world that contains approximately, 1,100 genera and about 25,000 species

Bidens spp. are characterized by heads solitary or in corymbiform or paniculiform inflorescences, on straight, rigid peduncles, heterogamous and radiate, or homogamous and discoid. Marginal flowers 1-seriate and neuter, or wanting. Disc-flowers numerous. Inferior ovary. Involucre campanulate. Bract 2-3 seriate, connate at the base, outer ones herbaceous, sometimes foliaceous, inner ones with membranous margins and dark nerves; receptacle flat, paleaceous; pale narrow, flat. Corolla in the marginal flowers ligulate with a short tube and a dentate or entire ligule, in the disc-flowers tubular, 5-dentate, usually yellow. Anther with an entire or shallowly sagittate base and acute apex. Style-arms subacute, hairy at the top. Achenes centrifugally decreasing in length, dorsally compressed or 3-4 angular, dark brown, passing into 1-8 apical retrosely blistly awns (In Latin, bidens means 2-toothed). Pappus wanting. Leave opposite. Erect herbs (Backer and Bakuizen, 1965)

2. The Chemistry of the Genus *Bidens*

Chemical constituents isolated from the genus *Bidens* were reported as acetylene, aurones, chalcones and sesquiterpene lactones. List of the compounds found in various parts of *Bidens* spp. is shown in Table 1.

Table 1 Chemical compounds from *Bidens* spp.

Plant and chemical compound	Category	Plant part	Reference
Bidens andicola H.B.K.			
Curcumene	Sesquiterpene	Root	Bohlmann *et al.*, 1983
Curcumene, Gamma:	Sesquiterpene	Root	Bohlmann *et al.*, 1983
Perezone	Sesquiterpene	Root	Bohlmann *et al.*, 1983
Perezone, Dehydroxy:	Sesquiterpene	Root	Bohlmann *et al.*, 1983
Propane-1-iso-butyrate-2-3-oxide,3-(4-iso-butyrate-3-methoxy-phenyl):	Phenylpropanoid	Root	Bohlmann *et al.*, 1983
Thymol iso-butyryl-oxy	Monoterpene	Root	Bohlmann *et al.*, 1983
Thymol methy ether	Monoterpene	Root	Bohlmann *et al.*, 1983
Thymoquinol,di-methyl ether:	Monoterpene	Root	Bohlmann *et al.*, 1983
Trideca-1-11-*trans*-diene-3-5-7-9-tetrayne	Alkenyne	Root	Bohlmann *et al.*, 1983
Trideca-1,11-*trans*-diene-3-5-7-9-tetrayne-13-ol	Alkyne	Leaf	Bohlmann *et al.*, 1983
Trideca-1-ene-3-5-7-9-tetrayne,11-12-epoxy:	Alkenyne	Leaf	Bohlmann *et al.*, 1983
Undeca-1-9-diene-3-5-7-triene,11-acetoxy:	Alkenyne	Leaf	Bohlmann *et al.*, 1983
Bidens aurea (Ait.) Sherff			
Eugenol-iso-butyrate, 1'-(2-acetoxy-2-methyl -propionyl-oxy):	Phenylpropanoid	Root	Bohlmann and Zdero, 1975
Octadec-*cis*-9-*cis*-12-dien-1-ol	Alkene	Root	Bohlmann and Zdero, 1975
		Aerial parts	Bohlmann and Zdero, 1975
Tetradeca-t*rans*-4-t*rans*-6-diene-1-14-diol-1-8-10 -triyne	Alkenyne	Aerial parts	Bohlmann and Zdero, 1975

Table 1 (Continued)

Plant and chemical compound	Category	Plant part	Reference
Trideca-1-*trans*-11-diene-3-5-7-9-tetrayne	Alkenyne	Root	Bohlmann and Zdero, 1975
		Aerial parts	Bohlmann and Zdero, 1975
Trideca-*trans*-1-t*rans*-3-*trans*-5-*trans*-11-tetraene-7-9-diyne	Alkenyne	Aerial parts	Bohlmann and Zdero, 1975
Trideca-*trans*-2-12-diene-4-6-8-10-tetrayn-1-ol	Alkenyne	Root	Bohlmann and Zdero, 1975
Trideca-t*rans*-2-12-diene-4-6-8-10-tetrany-1-ol acetate	Alkenyne	Root	Bohlmann and Zdero, 1975
		Aerial parts	Bohlmann and Zdero, 1975
Trideca-t*rans*-2-12-diene-4-6-8-10-tetrayne,1-oxo:	Alkenyne	Root	Bohlmann and Zdero, 1975
Trideca-t*rans*-2-diene-4-6-8-10-tetraayn-1-ol	Alkenyne	Aerial parts	Bohlmann and Zdero, 1975
Trideca-*trans*-2-*trans*-10-12-triene-4-6-8-triyn-1-ol	Alkenyne	Aerial parts	Bohlmann and Zdero, 1975
Trideca-*trans*-2-t*rans*-10-12-triene-4-6-8-triyn-1-ol acetate	Alkenyne	Aerial parts	Bohlmann and Zdero, 1975
Bidens bipinnata Linn.			
Cadinene, δ:	Sesquiterpene	Essential oil	Craveiro *et al.*, 1968
Cadinene, γ:	Sesquiterpene	Essential oil	Craveiro *et al.*, 1968
Caryophyllene, β:	Sesquiterpene	Essential oil	Craveiro *et al.*, 1968
Cubebene, α:	Sesquiterpene	Essential oil	Craveiro *et al.*, 1968
Elemene, δ:	Sesquiterpene	Essential oil	Craveiro *et al.*, 1968
Elemene, γ:	Sesquiterpene	Essential oil	Craveiro *et al.*, 1968
Humulene, α:	Sesquiterpene	Essential oil	Craveiro *et al.*, 1968
Pinene, α:	Monoterpene	Essential oil	Craveiro *et al.*, 1968

Table 1 (Continued)

Plant and chemical compound	Category	Plant part	Reference
Pinene, beta:	Monoterpene	Essential oil	Craveiro *et al.*, 1968
Thymol	Monoterpene	Essential oil	Craveiro *et al.*, 1968
Thymol methyl ether	Monoterpene	Essential oil	Craveiro *et al.*, 1968
Bidens campylotheca Schulz ssp. *campylotheca*			
Okanin-4-methoxy-4'-O-(6"-O-acetyl-glucoside)	Flavonoid	Aerial parts	Redl, Davis and Bauer, 1993
Okanin-4-methoxy-4'-O-glucoside	Flavonoid	Aerial parts	Redl, Davis and Bauer, 1993
Okanin-4-methoxy-4'-O-primeveroside	Flavonoid	Aerial parts	Redl, Davis and Bauer, 1993
Tridec-*trans*-11-ene-3-5-7-9-tetrayne-1-2-diol 2-O-β-D-glucoside	Alkenyne	Aerial parts	Bauer, Redl and Davis, 1992
Trideca-*trans*-3-*cis*-11-diene-5-7-9-triyne-1-2-diol 2-O-β-D-glucoside	Alkenyne	Aerial parts	Bauer, Redl and Davis, 1992
Trideca-*trans*-3-*trans*-11-diene-5-7-9-triyne-1-2-13-triol 2-O-β–D-glucoside	Alkenyne	Aerial parts	Bauer, Redl and Davis, 1992
Trideca-*trans*-3-t*rans*-11-diene-5-7-9-triyne-1-2-diol 2-O-β–D-glucoside	Alkenyne	Aerial parts	Bauer, Redl and Davis, 1992
Bidens connata Willd.			
Dithiophene, 2-(hexa-1-3-diyn-5-enyl) :	Sulfur compound	Leaf	Bohlmann *et al.*, 1983
Thiophene, 2-(hexa-1-3-dihyn-5-enyl)-5-(prop-1-ynyl) :	Sulfur compound	Root	Bohlmann *et al.*, 1983

Table 1 (Continued)

Plant and chemical compound	Category	Plant part	Reference
Trideca-1-11-*trans*-diene-3-5-7-9-tetrayne	Alkenyne	Root	Bohlmann *et al.*, 1983
Trideca-1-11-*trans*-diene-3-5-7-9-tetrayne,13-acetoxy :	Alkenyne	Leaf	Bohlmann *et al.*, 1983
Undeca-1-9-diene-3-5-7-triene	Alkenyne	Leaf	Bohlmann *et al.*, 1983
Bidens cynapiifolia H.B.K.			
Bicyclogermacrene	Sesquiterpene	Leaf	Bohlmann *et al.*, 1983
Germacrene D	Sesquiterpene	Leaf	Bohlmann *et al.*, 1983
Prop-1-en-3-acetoxy,3-(4-iso-butyrate-3-methoxy-phenyl) :	Phenylpropanoid	Root	Bohlmann *et al.*, 1983
Propane-1-iso-butyrate-2-3-oxide,3-(4-iso-butyrate-3-methoxy-phenyl) :	Phenylpropanoid	Root	Bohlmann *et al.*, 1983
Spathulenol	Sesquiterpene	Leaf	Bohlmann *et al.*, 1983
Bidens frondosa Linn.			
Apigenin	Flavonoid	Leaf	Karikome, Ogawa and Sashida, 1992
Astragalin	Flavonoid	Leaf	Karikome, Ogawa and Sashida, 1992
Cynaroside	Flavonoid	Leaf	Karikome, Ogawa and Sashida, 1992
Luteolin	Flavonoid	Leaf	Karikome, Ogawa and Sashida, 1992
Maritimein,6"-O-*cis*-acetyl :	Flavonoid	Leaf	Karikome, Ogawa and Sashida, 1992
Maritimein,6"-O-*cis*-*p*-coumaroyl :	Flavonoid	Leaf	Karikome, Ogawa and Sashida, 1992
Okanin	Flavonoid	Leaf	Karikome, Ogawa and Sashida, 1992

Table 1 (Continued)

Plant and chemical compound	Category	Plant part	Reference
Okanin,4-O-methyl: 4'-O-(2"-O-acetyl -6"-O-*p*-coumaroyl-β-D-glucopyranoside)	Flavonoid	Leaf	Karikome, Ogawa and Sashida, 1992
Okanin,4-O-methyl: 4'-O-(6"-O-acetyl-β-D-glucopyranoside)	Flavonoid	Leaf	Karikome, Ogawa and Sashida, 1992
Okanin,4-O-methyl: 4'-O-(6"-O-*p*-coumaroyl-β-D-glucopyranoside)	Flavonoid	Leaf	Karikome, Ogawa and Sashida, 1992
Okanin-4'-O-(2"-O-caffeoyl-6"-O-*p*-coumaroyl-β-D-glucopyranoside)	Flavonoid	Leaf	Karikome, Ogawa and Sashida, 1992
Okanin-4'-O-(6"-O-acetyl glucoside)	Flavonoid	Leaf	Karikome, Ogawa and Sashida, 1992
Okanin-4'-O-(6"-O-acetyl-2"-O-caffeoyl-β-D-glucopyranoside)	Flavonoid	Leaf	Karikome, Ogawa and Sashida, 1992
Okanin-4'-O-(6"-O-*p*-coumaroyl-β-D-glucopyranoside)	Flavonoid	Leaf	Karikome, Ogawa and Sashida, 1992
Bidens graveolens Mart.			
Bicyclogermacrene	Sesquiterpene	Root	Bohlmann *et al.*, 1983
Caryophyllene epoxide	Sesquiterpene	Aerial parts	Bohlmann *et al.*, 1983
Cinnamyl acetate	Phenylpropanoid	Root	Bohlmann *et al.*, 1983
Cinnamyl alcohol	Phenylpropanoid	Root	Bohlmann *et al.*, 1983
Germacrene D	Sesquiterpene	Root	Bohlmann *et al.*, 1983
		Aerial parts	Bohlmann *et al.*, 1983
Germacrene D,4-14-dihydro-4-α-hydroxy :	Sesquiterpene	Aerial parts	Bohlmann *et al.*, 1983
Heptadeca-1-*cis*-8-*cis*-15-*trans*-triene-11-13-diyne, 17-aldehyde :	Alkenyne	Aerial parts	Bohlmann *et al.*, 1983

Table 1 (Continued)

Plant and chemical compound	Category	Plant part	Reference
Heptadeca-1-*cis*-8-*cis*-15-*trans*-triene-11-13-diyne-17-ol	Alkenyne	Aerial parts	Bohlmann *et al.*, 1983
Heptadeca-1-*cis*-8-*trans*-15-triene-11-13-diyn-17-ol iso-butyrate	Alkenyne	Aerial parts	Bohlmann *et al.*, 1983
Myrcene,6-7-dihydro : 6-7-dihydroxy- :	Monoterpene	Aerial parts	Bohlmann *et al.*, 1983
Prop-1-en-3-acetoxy,3-(4-iso-butyrate-3-methoxy-phenyl) :	Phenylpropanoid	Root	Bohlmann *et al.*, 1983
Propane-1-iso-butyrate-2-3-oxide,3-(4-iso-butyrate-3-methoxy-phenyl) :	Phenylpropanoid	Root	Bohlmann *et al.*, 1983
Spathulenol	Sesquiterpene	Aerial parts	Bohlmann *et al.*, 1983
Tetradeca-*trans*-6-*trans*-12-diene-8-10-diyn-1-ol,3-oxo : iso-butyrate	Alkenyne	Root	Bohlmann *et al.*, 1983
Trideca-1-11-*trans*-diene-3-5-7-9-tetrayne	Alkenyne	Root	Bohlmann *et al.*, 1983
Bidens maximowicziana Oett.			
Benzene,1-iso-butyroxy-2-methoxy-4-(3-iso-butyr-oxy) :	Phenylpropanoid	Root	Bohlmann and Zdero, 1975
Benzene,1-iso-butyroxy-2-methoxy : 4-(3-acetoxy-1-2-oxido-propane)	Phenylpropanoid	Root	Bohlmann and Zdero, 1975
Eugenol,1'-acetoxy-iso-butyryl :	Phenylpropanoid	Root	Bohlmann and Zdero, 1975
Eugenol,1'-iso-butyroxy-iso-butyryl :	Phenylpropanoid	Root	Bohlmann and Zdero, 1975
Hepta-1-3-diyne-5-ene-1-ol, 1-phenyl :	Benzenoid	Root	Bohlmann and Zdero, 1975

Table 1 (Continued)

Plant and chemical compound	Category	Plant part	Reference
Hepta-1-3-diyne-5-ene-1-ol,1-phenyl acetate	Benzenoid	Root	Bohlmann and Zdero, 1975
Thiophene,2-(but-3-ene-1-yl)-5-(pent-*trans*-3-ene-1-yne) :	Sulfur compound	Aerial parts	Bohlmann and Zdero, 1975
Trideca-1-*trans*-11-diene-3-5-7-9-tetrayne	Alkenyne	Root, Aerial parts	Bohlmann and Zdero, 1975
Trideca-*trans*-2-12-diene-4-6-8-10-tetrayn-1-ol	Alkenyne	Root, Aerial parts	Bohlmann and Zdero, 1975
Trideca-*trans*-2-12-diene-4-6-8-10-tetrayn-1-ol acetate	Alkenyne	Root, Aerial parts	Bohlmann and Zdero, 1975
Bidens nitis (Michx.) Sherff			
Germacrene D	Sesquiterpene	Leaf	Bohlmann *et al.*, 1983
Prop-1-en-3-iso-butyl,3-(4-iso-butyrate-3-methoxy-phenyl) :	Phenylpropanoid	Root	Bohlmann *et al.*, 1983
Propane-1-iso-butyryl-oxy-2-3-oxide,3-(4-iso-butyrate-3-methoxy-phenyl) :	Phenylpropanoid	Leaf	Bohlmann *et al.*, 1983
Propane-1-iso-butyryl-oxy-2-3-oxide,3-(4-iso-butyrate-3-methyl-phenyl) :	Phenylpropanoid	Root	Bohlmann *et al.*, 1983
Trideca-1-11-*trans*-diene-3-5-7-9-tetrayne	Alkenyne	Root	Bohlmann *et al.*, 1983
Trideca-1-11-*trans*-diene-3-5-7-9-tetrayne-13-ol	Alkenyne	Root	Bohlmann *et al.*, 1983
Bidens parviflora Willd.			
Astragalin	Flavonoid	Leaf	Ma, Li, and Yuang, 1991
Coumarin,6-hydroxy :	Coumarin	Aerial parts	De Tommasi *et al.*, 1992

Table 1 (Continued)

Plant and chemical compound	Category	Plant part	Reference
Flavone,2'-5-5'-7-tetrahydroxy :	Flavonoid	Aerial parts	De Tommasi *et al.*, 1992
Jujubasterol-3-O-β-(β-D-glucopyranosyl(1-3)-(alpha-L-deoxytalosyl(1-2))-alpha-L-arabinoside)	Triterpene	Aerial parts	De Tommasi *et al.*, 1992
Maritimein	Flavonoid	Leaf	Ma, Li, and Yuang, 1991
Narirutin	Flavonoid	Aerial parts	De Tommasi *et al.*, 1992
Oleanolic acid	Triterpene	Aerial parts	De Tommasi *et al.*, 1992
Quercetin, iso :	Flavonoid	Leaf	Ma, Li, and Chung, 1991
Rutin	Flavonoid	Aerial parts	De Tommasi *et al.*, 1992
Scopoletin	Coumarin	Aerial parts	De Tommasi *et al.*, 1992
Sulfurein	Flavonoid	Leaf	Ma, Li, and Chung, 1991
Ursolic acid	Triterpene	Aerial parts	De Tommasi *et al.*, 1992
Bidens pilosa Linn.			
Aesculetin	Coumarin	Entire plant	Sang *et al.*, 1991
Amyrin, β :	Triterpene	Entire plant	Sang *et al.*, 1991
Aurone,3'-4'-6-7-tetrahydroxy : *cis* : 6-O-(6-O-acetyl-β-D-glucopyranoside)	Flavonoid	Leaf	Sashida *et al.*, 1991
Aurone,3'-4'-6-7-tetrahydroxy- : *cis* : 6-O-(6-O-*p*-coumaroyl-β-D-glucopyranoside)	Flavonoid	Leaf	Sashida *et al.*, 1991

Table 1 (Continued)

Plant and chemical compound	Category	Plant part	Reference
Aurone,3'-4'-6-7-tetrahydroxy- : *cis* : 6-O-β -D-glucopyranoside	Flavonoid	Leaf	Sashida *et al.*, 1991
Aurone,3'-4'-6-7-tetrahydroxy- : *cis* : 7-O-β -D-glucopyranoside	Flavonoid	Leaf	Sashida *et al.*, 1991
Borneol	Monoterpene	Leaf essential oil	Sakuda, 1988
Cadinol,α :	Sesquiterpene	Leaf essential oil	Sakuda, 1988
Capric acid	Lipid	Entire plant	Sang *et al.*, 1991
Caryophyllene,β:	Sesquiterpene	Leaf essential oil	Sakuda, 1988
Coumaric acid,*p* : 4-O-(2-O-acetyl-6-O-*p*-coumaroyl-β-D-glucopyranoside)	Phenylpropanoid	Leaf	Sashida *et al.*, 1991
Coumaric acid,*p* : 4-O-(6-O-*p*-coumaroyl-β-D-glucopyranoside)	Phenylpropanoid	Leaf	Sashida *et al.*, 1991
Daucosterol	Steroid	Entire plant	Sang *et al.*, 1991
Erythronic acid,2-O-caffeoyl-2-C-methyl-D :	Phenylpropanoid	Leaf	Ogawa and Sashida, 1992
Erythronic acid,2-O-caffeoyl-2-C-methyl-D : methyl ester	Phenylpropanoid	Leaf	Ogawa and Sashida, 1992
Erythronic acid,3-O-caffeoyl-2-C-methyl-D : methyl ester	Phenylpropanoid	Leaf	Ogawa and Sashida, 1992
Erythrono-1-4-lactone,3-O-caffeoyl-2-C-methyl-D :	Phenylpropanoid	Leaf	Ogawa and Sashida, 1992
Friedelan-3-β-ol	Triterpene	Aerial parts	Geissberger and Sequin, 1991

Table 1 (Continued)

Plant and chemical compound	Category	Plant part	Reference
Friedelin	Triterpene	Aerial parts	Geissberger and Sequin, 1991
Germacrene D	Sesquiterpene	Leaf essential oil	Sakuda, 1988
Hepta-1-3-5-triyne,1-phenyl :	Benzenoid	Entire plant	Bondarenko, 1985
Hepta-2-4-6-triyne,7-phenyl :	Benzenoid	Leaf	Graham, Graham and Towers, 1980
Inositol,L:	Carbohydrate	Leaf + Stem	Plouvier, 1964
Lauric acid	Lipid	Entire plant	Sarg *et al.*, 1991
Limonene	Monoterpene	Leaf essential oil	Sakuda, 1988
Linoleic acid	Lipid	Aerial parts	Geissberger and Sequin, 1991
Linolenic acid	Lipid	Aerial parts	Geissberger and Sequin, 1991
Lupeol	Triterpene	Entire plant	Sarg *et al.*, 1991
Lupeol acetate	Triterpene	Entire plant	Sarg *et al.*, 1991
Muurolol,T:	Sesquiterpene	Leaf essential oil	Sakuda, 1988
Myristic acid	Lipid	Entire plant	Sarg *et al.*, 1991
Okanin-3'-4'-diglucoside	Flavonoid	Flowers	Hoffmann and Holzl, 1989
Okanin-3'-glucoside	Flavonoid	Flowers	Hoffmann and Holzl, 1989
Okanin-3'-O-β-D-glucoside	Flavonoid	Leaf	Hoffmannnand and Holzl, 1988a
Okanin-4'-(6"-O-acetyl)-glucoside	Flavonoid	Flowers	Hoffmann and Holzl, 1989
Okanin-4'-diglucoside	Flavonoid	Flowers	Hoffmann and Holzl, 1989
Okanin-4'-glucoside	Flavonoid	Flowers	Hoffmann and Holzl, 1989

Table 1 (Continued)

Plant and chemical compound	Category	Plant part	Reference
Okanin-4'-O-β-D-(2"-4" -6"-triacetyl)-glucoxide	Flavonoid	Leaf	Hoffmann and Holzl, 1988a
Okanin-4'-O-β-D-(2"-4" -diacetyl-6"-*trans-p*-coumaroyl)-glucoside	Flavonoid	Leaf	Hoffmann and Holzl, 1988b
Okanin-4'-O-β-D-(3"-4"-diacetyl-6"-*trans-p* -coumaroyl)-glucoside	Flavonoid	Leaf	Hoffmann and Holzl, 1988b
Okanin-4'-O-β-D-(4"-acetyl-6"-*trans-p*-coumaroyl)-glucoside	Flavonoid	Leaf	Hoffmann and Holzl, 1988b
Okanin-4'-O-β-D-(6"-*trans-p*-coumaroyl) -glucoside	Flavonoid	Leaf	Hoffmann and Holzl, 1988a
Okanin-4'-O-β-D-gluco--pyranoside	Flavonoid	Leaf	Sashida, 1991
Okanin-4-methyl ether 3'-O-β-D-glucoside	Flavonoid	Leaf	Hoffmann and Holzl, 1988c
Palmitic acid	Lipid	Entire plant	Sarg *et al.*, 1991
Palmitoleic acid	Lipid	Entire plant	Sarg *et al.*, 1991
Phenylhepta-1-3-5-triyne	Benzenoid	Flower + Fruit +Leave	N'Dounga, 1983
Phenylheptatriyne	Benzenoid	Aerial parts	Geissberger and Sequin, 1991
		Leaf	Campbell *et al.*, 1982
		Entire plant	Macrae *et al*, 1980
Quercetin-3-O-β-D-glucoside	Flavonoid	Leaf	Sashida, 1991
Tridec-5-ene-7-9-11-triyne-3-ol	Alkenyne	Root	Sarg *et al.*, 1991
Trideca-2-12-diene-4-6-8-10-tetrayn-1-ol	Alkenyne	Root	Sarg *et al.*, 1991

Table 1 (Continued)

Plant and chemical compound	Category	Plant part	Reference
Trideca-3-11-diene-5-7-9 -triyne-1-2-diol	Alkenyne	Root	Sarg *et al.*, 1991
Tridecapentayn-1-ene	Alkenyne	Root	Sarg *et al.*, 1991
Bidens rubifolia H.B.K.			
Coumaric acid methyl ester	Phenylpropanoid	Leaf	Bohlmann *et al.*, 1983
Prop-1-en-3-acetoxy,3-(4-iso-butyrate-3-methoxy-phenyl) :	Phenylpropanoid	Root	Bohlmann *et al.*, 1983
Prop-1-en-3-iso-butyl,3-(4 -iso-butyrate-oxy-3-methoxy-phenyl) :	Phenylpropanoid	Root	Bohlmann *et al.*, 1983
Propane-1-iso-butyrate-2-3-oxide,3-(4-iso-butyrate -3-methoxy-phenyl) :	Phenylpropanoid	Root	Bohlmann *et al.*, 1983
Squalene	Triterpene	Leaf	Bohlmann *et al.*, 1983
Trideca-1-11-diene-3-5-7-9-tetrayne	Alkenyne	Root	Bohlmann *et al.*, 1983
Trideca-1-11-*trans*-diene-3 -5-7-9-tetrayne,13-acetoxy :	Alkenyne	Root	Bohlmann *et al.*, 1983
Bidens squarrosa H.B.K.			
Propane-1-iso-butyryl-oxy-2-3-oxide,3-(4-iso-buty-rate-3-methoxy-phenyl) :	Phenylpropanoid	Root	Bohlmann *et al.*, 1983
Trideca-1-11-diene-3-5-7-9-tetrayne	Alkenyne	Root	Bohlmann *et al.*, 1983
Trideca-1-11-*trans*-diene-3 -5-7-9-tetrayne-13-ol	Alkenyne	Root	Bohlmann *et al.*, 1983
Bidens torta			
Okanin-3-3'-4-4'-tetra-methyl ether	Flavonoid	Leaf	McCormick, Bohm, Ganders, 1984

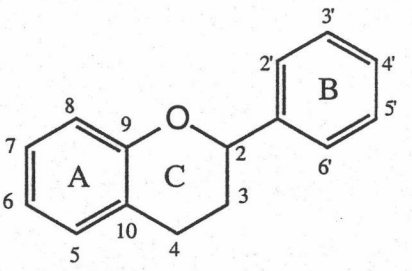
Table 1 (Continued)

Plant and chemical compound	Category	Plant part	Reference
Okanin-3-3'-4-trimethyl ether-4'-O-β-D-glucoside	Flavonoid	Leaf	McCormick, Bohm, Ganders, 1984
Okanin-3-4-dimethyl ether -4'-O-β-D-glucoside	Flavonoid	Leaf	Mccormick, Bolm, Ganders, 1984
Okanin-4-methyl ether-4'-O-β-D-glucoside	Flavonoid	Leaf	McCormick, Bohm, Ganders, 1984
Okanin-4-methyl ether -4'-O-β-D-glucoside monoacetate	Flavonoid	Leaf	McCormick, Bohm, Ganders, 1984
Bidens tripartita Linn.			
Chalcone,2'-hydroxy-4-4'-dimetoxy :	Benzenoid	Flower heads	Christensen, Lam, and Thomasen, 1990
Chalcone,2'-hydroxy-4-4'-dimetoxy :	Flavonoid	Leaf + Stem	Christensen, Lam, and Thomasen, 1990
Coreopsin, iso :	Flavonoid	Entire plant	Serbin *et al.*, 1975
Cosmene	Monoterpene	Flower heads	Christensen, Lam, and Thomasen, 1990
Eugenol	Prenylpropanoid	Flower heads	Christensen, Lam, and Thomasen, 1990
Flavanomerin, (R-2)	Flavonoid	Aerial parts	Serbin *et al.*, 1975
Linoleic acid	Lipid	Leaf + Stem	Christensen, Lam, and Thomasen, 1990
Ocimene, *cis*-β :	Monoterpene	Leaf + Stem	Christensen, Lam, and Thomasen, 1990
		Flower heads	Christensen, Lam, and Thomasen, 1990
Oleanolic acid	Triterpene	Entire plant	Tamai, and Yamahara, 1992

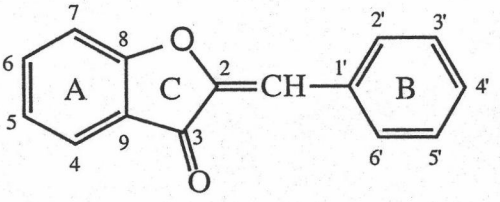
THE AURONES

1 Introduction to Aurones

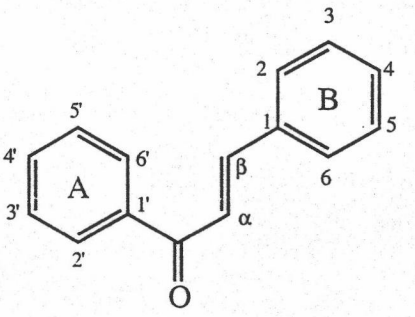
Aurones are hydroxylated 2-benzylidenecoumaranones, classified in flavanoid group. The numbering system is applied from flavonoids, positions on the A ring are identified by unprimed numbers and the B ring positions by primed numbers. Note that in aurones position 4 corresponds biosynthetically to position 5 of other heterocyclic flavonoids. (Bohm, 1982)



Flavans



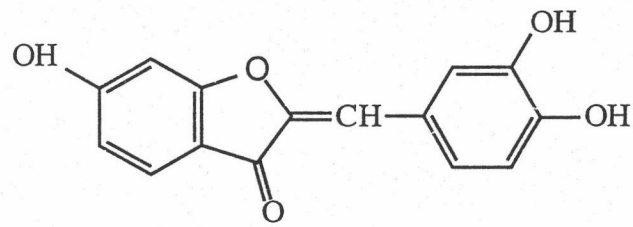
Aurones



Chalcones

These compounds have been known for about 40 years. The name, aurone has been proposed by Bate-Smith and Geissman (1951). This name derives from the fact that they are often golden yellow. Sulfuretin, for example, occurs in the yellow flowers of *Cosmos sulphureus* and *Dahlia variabilis* (Shimokoriyama, 1962). The chalcones, the common intermediates for the biosynthesis of all classes of flavonoids, are found in the yellow flowers like aurones. Aurones and chalcones are detected by the fact that yellow flowers containing them, when fumed with the alkaline vapour of a lighted cigarette, become orange or red as a result. This test is characteristic of both yellow pigments which have been termed "anthochlor" (Shimokoriyama, 1962).

Pairs of structurally related chalcones and aurones occur together in many plants in Compositae, regularly in one group of related taxa centred about *Bidens, Coreopsis* and *Dahlia*. Outside the Compositae aurones occur in : Leguminosae, Plumbaginaceae, Gesneriaceae, Oxalidaceae, Scrophulariaceae and Cyperaceae. (Harborne, 1977)



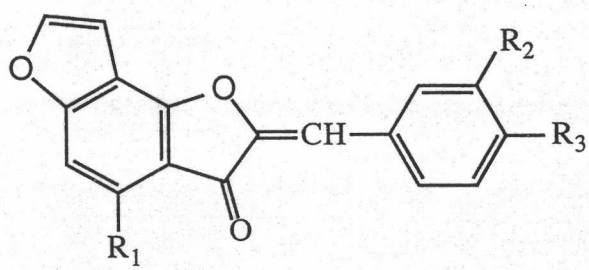
Sulfuretin

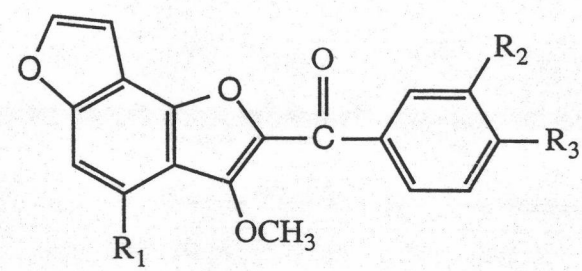
2 Naturally Occurring Aurones

Structures of naturally occurring aurones appear in Table 2. Bohm (1982) has classified aurones into 4 groups

2.1 Aurones Lacking B-Ring Hydroxyl

The first naturally occurring aurones lacking B-ring substitution were isolated from *Derris obtusa* by Do Nascimento *et al.* (1976). The three compound(2), (3) and (4) were accompanied by a methylenedioxy derivative (4a) and by two auronol derivatives (5) and (6).





(1) R_1=R_2=R_3=H

(2) R_1=OH, R_2=R_3=H

(3) R_1=OCH_3, R_2=R_3=H

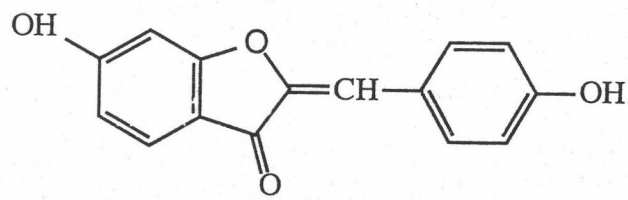
(4) R_1=H, R_2 and R_3=-O-CH_2-O-

(4a) R_1=R_2=H

(5) R_1 and R_2=-O-CH_2-O-

2.2 Aurones Having One B-Ring Hydroxyl

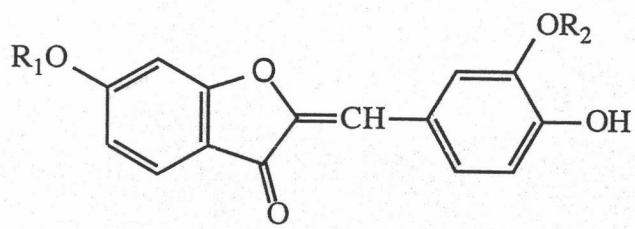
El Sherbeiny and co-workers (1978) reported the presence of the known aurone hispidol (6) and its 6-O-glucoside in seeds of *Lygos raetum* (Leguminosae).



(6)

2.3 Aurones Having Two B-Ring Hydroxyls

Sulfuretin (7), one of the most common aurones, has been reported to occur as the free phenol and as the 6,3'-di-O-glucoside (8) in *Rhus* species (Young, 1979) and in as a series of 6-mono- and di-glycosides in several *Bidens* species , and as the 6-O-glucoside (9) in several *Helianthus* species (Bohm,1982).



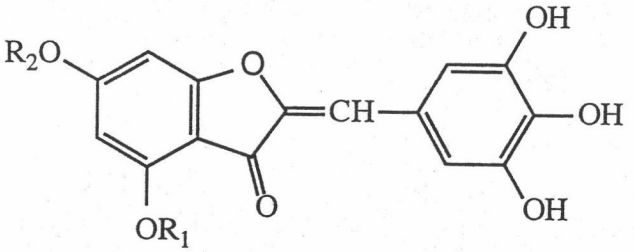
(7) $R_1=R_2=H$

(8) $R_1=R_2=Glc$

(9) $R_1=Glc$, $R_2=H$

2.4 Aurones Having Three B-Ring Hydroxyls

Aurones having this pattern rarely have been found in nature. Bracteatin (10) occurs as the free phenol in the sporophytes, but not in the leaves, of the moss *Funaria hygrometrica* (Weitz and Ikan, 1977) and as the 6-O-glucoside (11) in *Antirrhinum orontium.* (Gilbert, 1975). Subulin, recently isolated from seeds of *Amomum subulatum* (Lakshmi and Chauhan, 1977) was shown to be the novel 6,3',4',5'-tetrahydroxy-4-methoxyaurone 6-O-α-L-rhamnopyranosyl- (1->4)-β-D-glucopyranoside (12)



(10) R_1=R_2=H

(11) R_1=H, R_2=Glc

(12) R_1=CH_3, R_2=Glc-O-Rha

Table 2 Structure of naturally occurring aurones (including auronols)

Substituents			Trivial Name	Source	Reference
OH	OCH_3	Other			
		Furano(2",3",6,7)		*Derris obtusa* (Leguminosae)	Bohm, 1982
4		Furano(2",3",6,7)		*D. obtusa* (Leguminosae)	Bohm, 1982
4		Furano(2",3",6,7)		D. obtusa (Leguminosae)	Bohm, 1982
3		Furano(2",3",6,7); β-carbonyl	Derriobtusone-A	*D. obtusa* (Leguminosae)	Bohm, 1982
6,4'			Hispidol	*Lygos raetum* (Leguminosae)	Bohm, 1982
6,4'		6-O-Glucose	Hispidol glucoside	*L. raetum* (Leguminosae)	Bohm, 1982
6,3',4'			Sulfuretin	*Cosmos sulfureus* (Compositae)	Shimokoriyama and Hattori, 1953
				Rhus spp (Anacardiaceae)	Bohm, 1982
				Amphipterygium adstrigens (Anacardiaceae)	Bohm, 1982
6,3',4'		6-O-Glucose	Sulfurein	*Coreopsis maritima* (Compositae)	Geissman *et al.*., 1956
				C. gigantea (Compositae)	Geissman *et al.*, 1956

Table 2 (Continued)

Subtituents			Trivial Name	Source	Reference
OH	OCH_3	Other			
				Helianthus spp. (Compositae)	Bohm, 1982
				Viguiera laciniata (Compositae)	Bohm, 1982
				Bidens spp. (Compositae)	Bohm, 1982
				Coreopsis bigelovii (Compositae)	Bohm, 1982
				Bidens laevis (Compositae)	Bohm, 1982
6,3',4'		6-O-Glucosyl glucose		*Bidens* spp. (Compositae)	Bohm, 1982
6,3',4'		6,3'-di-O-Glucose		*Rhus* spp. (Anacardiaceae)	Bohm, 1982
				Amphipterygium adstrigens (Anacardiaceae)	Bohm, 1982
6,7,3',4'			Maritimetin	*Bidens pilosa* (Compositae)	Sashida *et al.*, 1991
6,7,3',4'		7-O-β-D Glucose		*B. pilosa* (Compositae)	Sashida *et al.*, 1991
6,7,3',4'		6-O-*p*-Coumaroyl β-D glucose		*B. pilosa* (Compositae)	Sashida *et al.*, 1991
6,7,3',4'		6-O-Acetyl-β-D glucose		*B. pilosa* (Compositae)	Sashida *et al.*, 1991
6,7,3',4'		6-O-Glucose	Maritimein	*B. pilosa* (Compositae)	Sashida *et al.*, 1991
				Coreopsis bigelovii (Compositae)	Bohm, 1982
6,3',4'	7		Leptosidin	*Coreopsis grandiflora* (Compositae)	Geissmann and Moje, 1951

Table 2 (Continued)

Substituents			Trivial Name	Source	Reference
OH	OCH_3	Other			
6,3',4'	7	6-O-Glucose	Leptosin	*C. grandiflora* (Compositae)	Geissmann and Moje, 1951
6,3',4'	7	6-O-Glucose, furano (2",3",6',7'); 3,4-methylenedioxy		*Derris obtusa* (Leguminosae)	Bohm, 1982
6,3',4'	3	Furano (2",3",6', 7');3,4-methylene dioxy; β-carbonyl	Derriobtusone-B	*D. obtusa* (Leguminosae)	Bohm, 1982
4,6,3',4'			Aureusidin	*Melanorrhoea aptera* (Anacardiaceae)	Bohm, 1982
				Oxalis cernua (Oxalidaceae)	Geissmann and Harborne, 1955
4,6,3',4'		6-O-Glucose	Aureusin	*Antirrhinum orontium* (Scrophulariaceae)	Bohm, 1982
4,6,3',4'		6-O-Glucuronic acid		*Marchantia berteroana* (Hepaticae)	Bohm, 1982
				M. polymorpha (Hepaticae)	Bohm, 1982
				Conocephalum supradecompsitum (Hepaticae)	Bohm, 1982
				Carrpos sphaerocarpos (Hepaticae)	Bohm, 1982
4,6,3',4'		4-O-Glucose	Cernuoside	*Oxalis cernua* (Oxalidaceae)	Geissmann and Harborne, 1955
4,6,3',4'		6-O-Rhamnose		*Pterocarpus marsupium* (Leguminosae)	Bohm, 1982

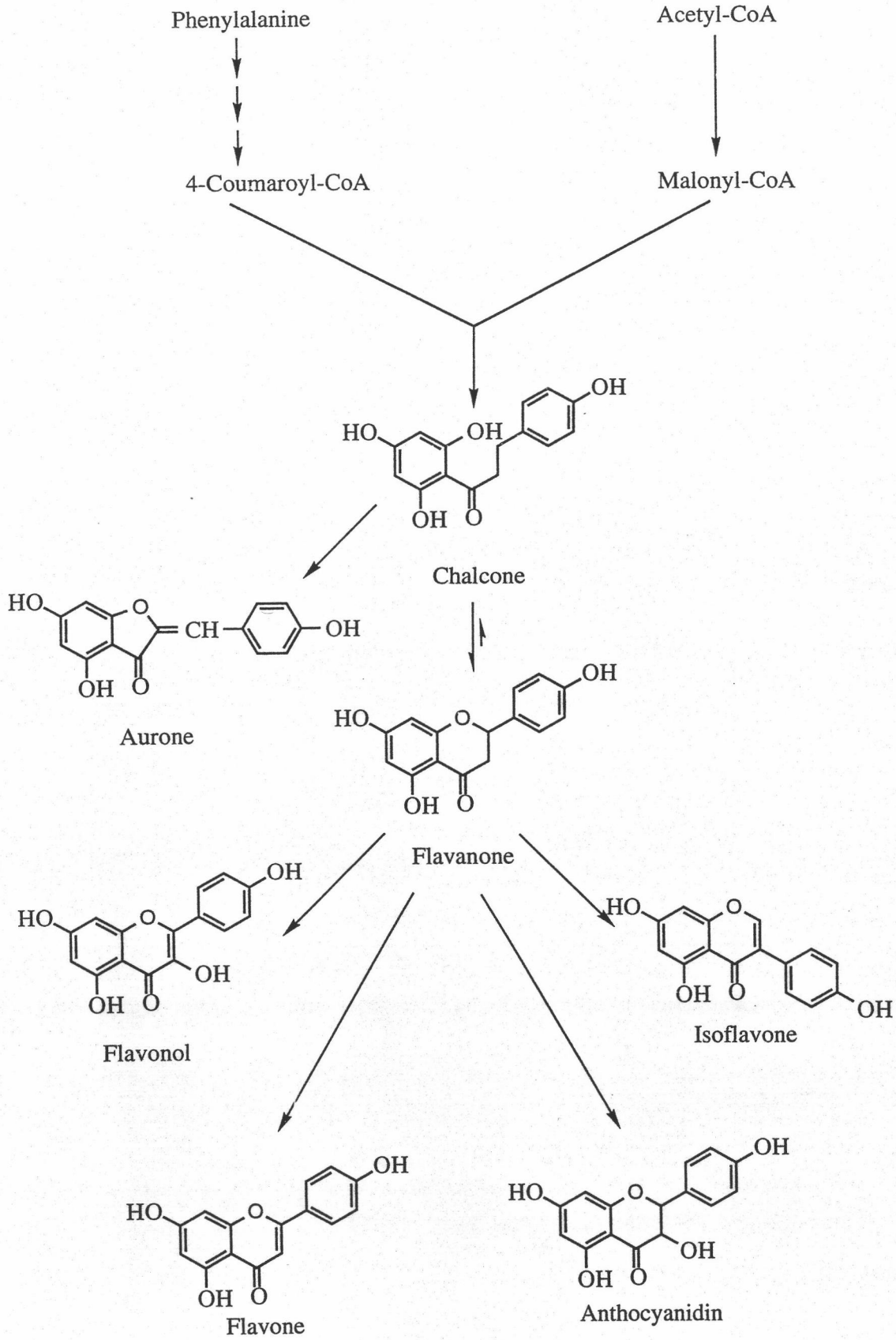
Table 2 (Continued)

Substituents			Trivial Name	Source	Reference
OH	OCH_3	Other			
6,3',4'	4		Rengasin	*Melanorrhoea optera* (Anacardiaceae)	Bohm, 1982
				Rhus spp. (Anacardiaceae)	Bohm, 1982
				Amphipterygium adstrigens (Anacardiaceae)	Bohm, 1982
4,6,3', 4',5'			Bracteatin	*Funaria hygrometrica* (Musci)	Bohm, 1982
4,6,3', 4',5'		6-O-Glucose		*Antirrhinum orontium* (Scrophulariaceae)	Bohm, 1982
4,6,3', 4',5'		4-O-Glucose	Bractein	*Helichrysum bracteatum* (Compositae)	Hansel *et al.*, 1962
6,3',4',5'	4	6-O-Rhamnosyl-glucose	Subulin	*Amomum subulatum* (Zingiberaceae)	Bohm, 1982
5	4,6,4'			*Helianthus annuus* (Compositae)	Alfatafta and Mullin, 1992
4,6,4'				*Asparogus gorocladus* (Liliaceae)	Mandloi and Sant, 1981
6,4'		6-O-Rhamnose, 7-methyl		*Pterocarpus marsupium* (Leguminosae)	Mohan and Joshi, 1989
4,6,4'		6-O-Rhamnose		*P. marsupium* (Leguminosae)	Mohan and Joshi, 1989
4,6,4'		4-O-Rhamnose, 7-methyl		P. marsupium (Leguminosae)	Mohan and Joshi, 1989

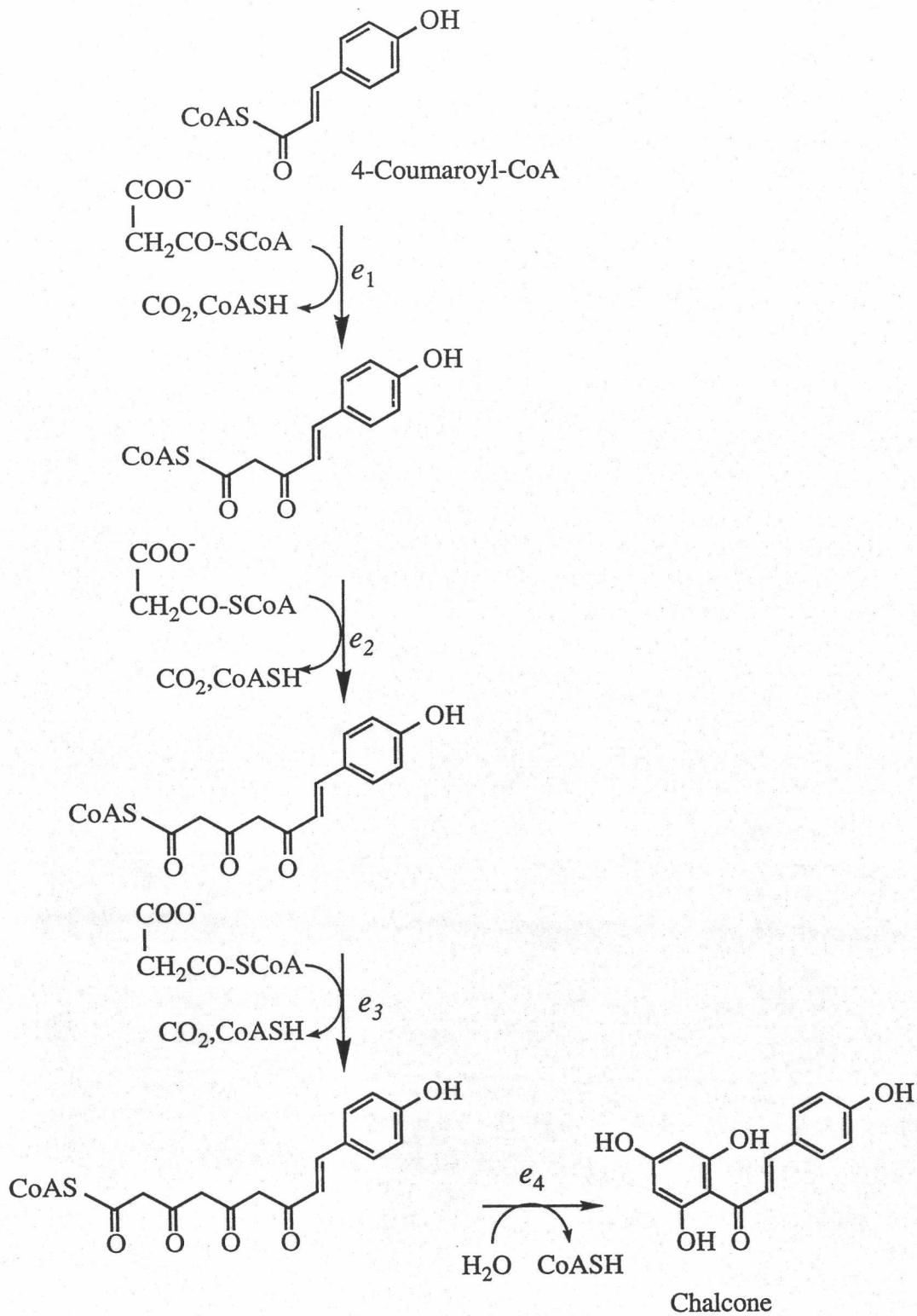
3. Biosynthesis of Aurones

All classes of flavonoids are biosynthetically closely related, with a chalcone being the first common intermediate. The feeding experiments with the radioactively labelled precursors have established that the carbon skeleton is derived from acetate and phenylalanine; ring A is formed by a head-to-tail condensation of three acetate units and ring B as well as carbon 2,3 and 4 of the heterocyclic ring C arise from phenylalanine (Ebel and Hahlbrock, 1982).

The biosynthetic relationships of the flavonoids as concluded mainly from labelling experiments in *vivo* are illustrated in Scheme 1. It is demonstrated that CoA esters of malonic acid and 4-coumaric acid are the best substrates for chalcone synthase which is the first enzyme of the true flavonoid pathway to give chalcone. However, caffeoyl-CoA or feruloyl-CoA could also be accepted to substitute for the latter material. The sequence of reactions are shown in Scheme 2 which was deduced from the occurence of several side products of the chalcone synthase reaction with the patially purified enzymes from parsley and Haploppus (Ebel and Hahlbrock, 1982).

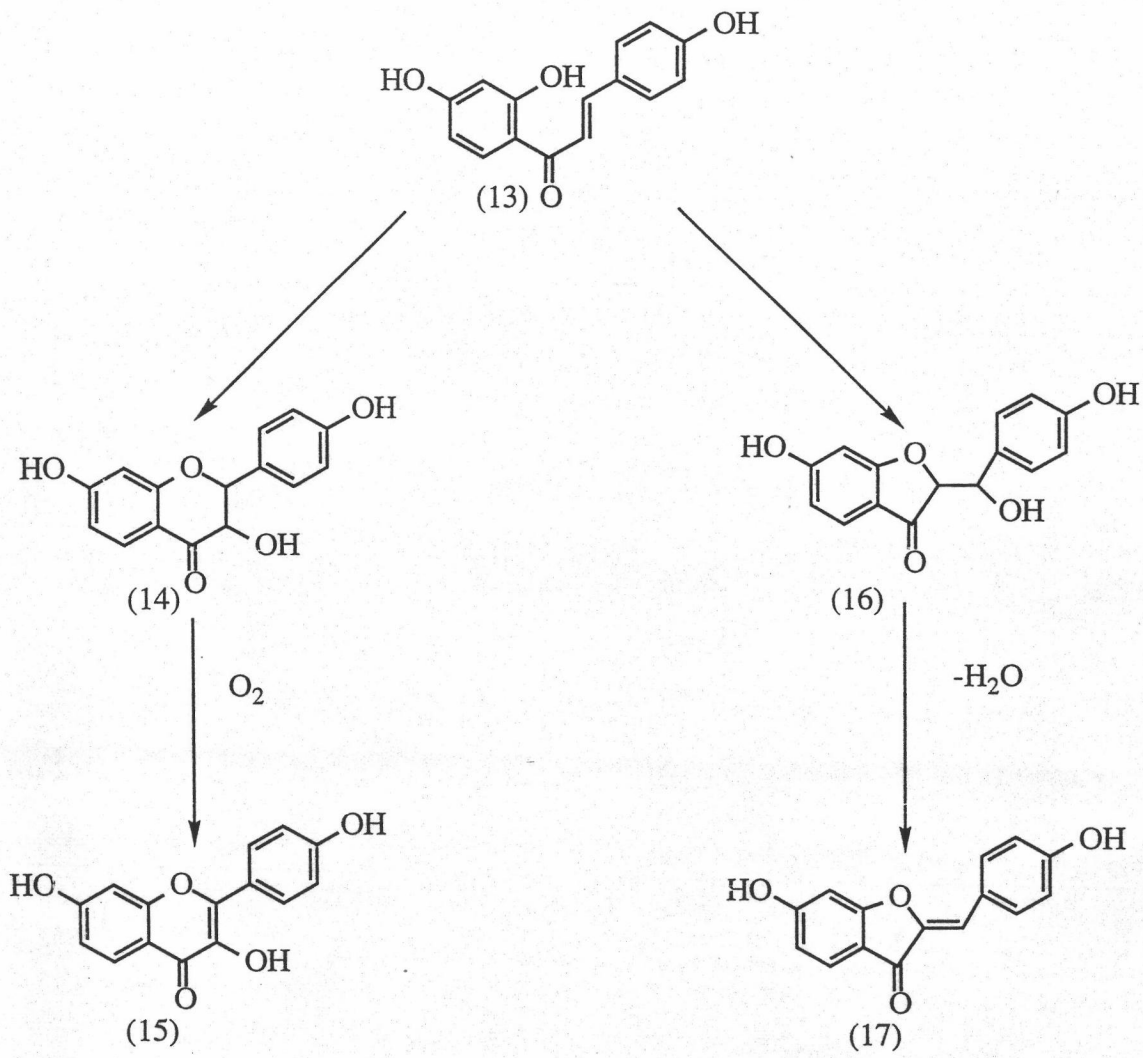


Scheme 1 scheme illustrating the position of the chalcone as the first common intermediate in the biosynthesis of all classes of flavonoids.



Scheme 2 Scheme illustrating the proposed mechanism of action of chalcone synthase from parsley.

Chalcone are precursors of aurones. Wong (1967) reported the conversion of 4,2',4'-trihydroxyl-chalcone (13) to the corresponding 6,4'-dihydroxyaurone, hispidol (17) by cell-free extracts from soya been seedlings, and the isolation of two diastereoisomers of 4',6-dihydroxy-2-(α-hydroxybenzyl) coumaranone (16) which were propose as intermediates in the biosynthesis of aurone. (Scheme 3)



Scheme 3 Conversion of 4,2',4'-trihydroxychalcone (13) to the corresponding flavonol (15) and aurone (17) by cell-fee extract of *Glycine max* or *Cicer arietinum* seedling, *Phaseolus vulgaris* hypocotyls or by horseradish peroxidase

Since the chalcone was also converted to both the corresponding dihydroflavonol (14) and flavonol (15) by cell-free extracts of chick pea and soya been seedlings and to the flavonol (15) and aurone either by extracts of *Phaseolus vulgaris* hypocotyls or by horseradish peroxidase, it is possible that these reactions (Scheme 3) are generally catalysed by peroxidases via free radicals as intermediates. Similar conclusions have been drawn by Pelter et al., (1971) from studies on the oxidation of a chalcone by potassium ferricyanide to the corresponding aurone, flavone, dihydroflavonol, and isoflavone. (Hahlbrock and Grisebach, 1975)