



A review of phytochemical studies of *Digitalis* species

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Abstract

A review of phytoconstituents and biological activities of *Digitalis* species has been presented. Despite the fact that there are about 24 species of this genus spread around the world, the present survey revealed that only 17 species have been studied phytochemically. Hence an attempt is made to present a review on the phytochemical studies of *Digitalis* species which would possibly serve as a source for much potent cardioactive molecules.

Keywords: *Digitalis* species, phytochemical, biological activity.

1. Introduction

The exclusively important genus *Digitalis* (Foxglove Leaves) belong to the family Scrophulariaceae and is distributed through out UK and most parts of the European continent. This genus comprises of 24 species [1]. Interestingly, two species among them, namely *D. purpurea* and *D. lanata* have been cultivated as medicinally important plants through out the world [2].

Although the literature reveals that the physicians at Welsch as early as in the 15th century have used the leaves of *Digitalis* for external application, it was Fuchs in 1542 who

first came up with the name *Digitalis*. It was after the inclusion of *Digitalis* in the London Pharmacopoeia in 1650 that William Withering, a physician and botanist from Birmingham, England, published the clinical importance of *Digitalis* in 1785.

During the late 18th century many researchers like Nativelle (1868), Killani (1891) and Stoll (1938) actively engaged themselves and revealed the chemistry of *Digitalis*. The chemistry of this genus suggested the presence of cardiac glycosides, flavonoids, anthraquinones and also triterpenes. But the most important of the

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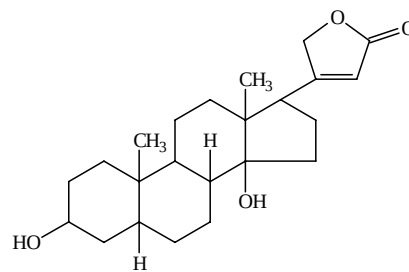
phytoconstituents contributed by this genus is the striking presence of numerous cardiac glycosides that has proven to be the most important drugs in treating congestive heart failures.

Sir James Mackenzie in 1911 demonstrated for the very first time the actions of *Digitalis* on electrically induced auricular fibrillation [3]. *Digitalis purpurea* popularly known as *Digitalis* is well known for its cardiac glycosides that has even today retained its place as a powerful cardio active drug. The genin (aglycone) containing a five membered lactone ring attached to the steroidal nucleus at C-17 is classified as a cardenolide.

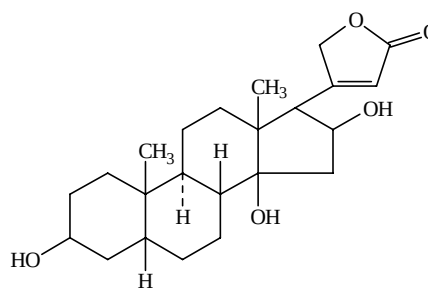
The *Digitalis* species still pose as promising plant members with potential medicinal properties that could be explored extensively. Prompted by these findings and the magnitude at which this genus has gained her place in the therapeutic armamentarium, we felt it worthwhile to present a phytochemical review of all the constituents reported so far from *Digitalis* species along with their sources. This data is prescribed in Table-1.

2. Biological Activity

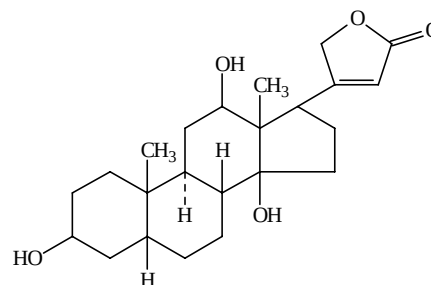
The glycosides of *Digitalis* species are considered to possess cardiac stimulant, wound healing, diuretic and virucidal properties [4, 5]. Many of the *Digitalis* glycosides exhibit slowing ventricular rate in atrial fibrillation, atrial flutter, supraventricular tachycardia and premature extra systoles. Two species of *Digitalis*, *D. purpurea* and *D. lanata* have been reported to possess increasing of coagulability of blood and antagonise the anticoagulant action of heparin in the body [4]. The cardenolides of *Digitalis* increases the force of systolic contractions due to blocking of the Na^+ , K^+ -ATPase pump of the cardiac muscle and increased intracellular $[\text{Na}^+]$, which inturn exchanges with extracellular Ca^{+2} leads to increased intracellular Ca^{+2} levels [6].



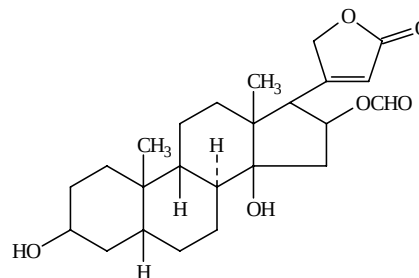
Digitoxigenin



Gitoxigenin



Digoxigenin



Gitaloxigenin

Table 1.
List of compounds isolated from digitalis species

Species	Constituents Isolated	Ref.
<i>D. grandiflora</i>	Lugrandoside (a)	7
(or) <i>D. ambigua</i>	Lugrandoside decaacetate (a)	7
	Lanatosides – A (a)	8, 9, 10, 11
	Lanatosides – B (a)	8, 9, 11
	Lanatosides – C (a)	9, 11
	Glucoevatromonoside (a)	10
	Odorobioside – G (a)	10
	Neo odorobioside – G (a)	10
	4-hydroxy-1, 2-dimethoxy-3-methyl anthraquinone (b) (or) (4-hydroxy-digitolutein-2-methylether)	12, 13
	Digitolutein (b)	12
	Tigogenin	14
	Gitogenin	14
	Digalogenin	14
	Digitogenin	14
	Apigenol (a)	15
	Luteolol (a)	15
	Chrysoeriol (a)	15
	Luteol-7-glucoside (d)	15
	Kaempferol heterobioside (d)	15
	Luteolin-7-yl-D-glucoside (d)	16
<i>D. cariensis</i>	Digitalinum verum (a) (c)	10, 17
	Glucogitoroside (a) (c)	17
	Glucoevatromonoside (a) (c)	17
	Glucoverodoxin (c)	17
	Gitorocellobioside (c)	17
	Gitostin (c)	17
	Neogitostin (c)	17
	Glucodigifucoside (c) (a)	10
	Glucolanadoxine (c)	17
	Glucodigitofucoside (a) (c)	10
	Glucodigitoroside (a)	10
	Glucodigitoxigenin-glucomethyloside (c)	17
	3-0-acetyl glucoevatromonoside (c)	17
	Gitoxigenin-3-0-β-D-glucosyl-β-D-glucomethylosyl- β-D-bis-digitoxoside (a)	17
	Gitoxigenin-3-0-β-D-glucosyl-β-D-glucomethylosyl- β-D-digitoxoside (a)	17
	Gitoxigenin-3-0-β-D-glucosyl-β-D- glucomethyloside (a)	17
	3-0-acetylated digitoxosides (α-form & β-form) (a)	17
	Digitoxigenin-3-0-β-D-glucosyl-(1→4)-3'-0-acetyl-β-D-digitoxoside (c)	17
	Neoglucodigifucoside (a)	10
	Glucogitofucoside (a)	10
	Neodigitalinum verum (a)	10
	Digitoemodin (a)	18
	Ziganein-1-methylether (a)	18

Species	Constituents Isolated	Ref.
<i>D. ciliata</i>	Lanatoside – A (a)	20, 19
	Lanatoside – B (a)	19
	Lanatoside – C (a)	19
	Digitoxin (a)	20
	Acetyldigitoxin- α (a)	20
	Digitalinum verum (a)	20, 19
	Acetyl digoxin (a)	21
	Gitaloxin (a)	22
	Gitoxin (a)	23, 24
	Acetyl- α -gitoxin	23, 24
	Deacetyl lanatoside – A	25, 26
	Deacetyl lanatoside – C	21
	Digiproside (a)	26
	Evatromonoside (a)	26
	Glucoside evatromonoside (a)	26
	Odoroside – H (a)	26
	Odorobioside – G (a)	27
	Digitoxigenin- β -D-glucoside (a)	21
	Digitoxigenin-3-O-bis-digitoxoside (a)	24
	Acetyl digitoxin- α -3-O-monodigitaloside (a)	24
	Digitoside – A (a)	28, 29
	Digitoside – B (a)	28, 29
	Digicitrin (a)	30
	Jaceoside (a)	30
	Apigenin (a)	31, 32
	Luteolin (a)	31, 32, 33
	Luteolin-3'-D-glucoside (Dracocephaloside) (a)	31, 32
	Luteolin-7-D-glucoside (Cynaroside) (a)	31, 34
	β -carotene (a)	35
	Cryptoxanthin (a)	35
	Zeaxanthin (a)	35
	Lutein (a)	35
	Flavoxanthin (a)	35
	β -sitosterol (c)	36
	Stigmasterol (c)	36
	Cholesterol (c)	36
	Glycerol (c)	36
	Butane di-1, 2-ol (c)	36
<i>D. davisiana</i>	1-OH, 2-hydroxymethyl-8-methoxy anthraquinone (b)	37
<i>D. ferruginea</i>	Lanatoside – A (a)	10, 38, 39
	Glucodigifucoside (a)	10, 38
	Neoglucodigifucoside (a)	10, 38
	Lanatoside – B (a)	38, 39
	Lanatoside – C (a)	38, 39
	Digitoxin (a)	38, 39

	Gitoxin (a)	38, 39
	Digoxin (a)	38, 39
	Caffeicacid (a) (b)	40, 41
	P-coumaricacid (a) (b)	40, 41
	Ferrulicacid (a) (b)	40, 41
	Chlorgenicacid (a, b)	41
	Tigogenin (a) (c)	38, 42
	Gitogenin (a) (c)	38, 42
	Digitogenin (a) (c)	38, 42
	Kaempferol (a)	40
	Quercetin (a)	40
	Luteolin (a) (d)	40, 43
	Apigenin (a)	40
	Diosmetin (d)	40
	Hispidulin (a)	43
	Scutellarein dimethylether (a)	43
	Cirsimaritin (a)	43
	3', 5, 7-trihydroxy-6'-methoxy flavone (a)	40
	5, 7-dihydro-4', 6'-dimethoxy flavone (a)	40
	Auranetin (a)	40
	Digiferrol (a)	44, 45
	Ferruginol (a)	44
	Digiferruginol (a)	45
<i>D. lanata</i>	Lanatoside – A (a)	6, 10, 46, 47, 48
	Lanatoside – B (a)	6, 46, 47, 48
	Lanatoside – C (a)	6, 46, 47, 48
	Lanatoside – D (a)	6, 47, 48
	Lanatoside – E (a)	6, 47, 48
	Acetyl digitoxin(α & β forms) (a)	6, 48
	Digitoxin (a)	6, 48
	Glucoevatromonoside (a)	6, 48
	Digitoxigenin-o-glucosyl-6-deoxyglucoside (a)	46
	Glucodigifucoside (a)	6, 10, 48
	Glucogitoroside (a)	6, 48
	Digitalinum verum (a)	6, 10, 48
	Acetyl digoxin (α , β & γ forms) (a)	6, 48
	Deacetyl lanatoside – C (a)	6, 48
	Digoxin (a)	6, 48, 49
	Digoxigenin-glucosyl-bis-digitoxoside (a)	6, 48
	Glucolanadoxin (a)	6, 48
	Glucoverodoxin (a)	6, 48
	Neoglucodigifucoside (a)	6, 10
	Glucodigitaloside (a)	10
	Neodigitalinum verum (a)	10
	Glucodigoxoside (a)	50
	Digitoxigenin-3-O- β -D-digitoxosido- β -D-digitoxosido- β -D-2, 6-dideoxyglucoside (a)	50

Species	Constituents Isolated	Ref.
<i>D. lutea</i>	Digitoxigenin-3-0- β -D-digitoxosido- β -D-xyloside (a)	51
	Digitoxigenin-3- β -D-digitoxosido- β -D-digitoxosido- β -D-xyloside (a)	51
	Digoxigenin-3-0- β -D-digitaloside (a)	52
	Digoxigenin-3-0- β -D-digitoxosido- β -D-2, 6- dideoxyglucoside (a)	52
	Digitoxigenin-bis-digitoxoside (a)	53, 54
	Gitoxigenin-bis-digitoxoside (a)	53, 54
	Digoxigenin-bis-digitoxoside (a)	53, 54
	Digitoxigenin-monodigitaloside (a)	55
	Tigogenin (c)	14
	Gitogenin (c)	14
	Digalogenin (c)	14
	Digitogenin (c)	14
	Pectolarigenin (a) (d)	56, 59
	Hispidulin (a) (d)	56, 57, 58
	Jaceosidin (a) (d)	56, 57, 58
	Chrysoeriol (a) (d)	56, 57
	Diosmetin (a) (d)	56, 57
	Nepetin (a) (d)	56, 57, 58
	Luteolin-7-o- β -monoglucopyranoside (a)	41, 58
	Desmethoxy centaureidin (a)	59
	Apigenin (a)	41, 59
	1-methoxy-2-methyl anthraquinone (a)	48
	3-methoxy-2-methyl anthraquinone (a)	48
	Digitolutein (a)	48
	3-methyl alizarin (a)	48
	1, 4, 8-trihydroxy-2-methyl anthraquinone (a)	48
	Caffeicacid (d)	41
	Ferrulicacid (d)	41
	P-coumaricacid (d)	41
	Chlorgenicacid (d)	41
	Lanatoside – A (a)	8
	Lanatoside – B (a)	8
	Lugrandoside (a)	7
	Lugrandoside decaacetate (a)	7
	Tigogenin	14
	Digitogenin	14
	Gitogenin	14
	Cholesterol (a)	60
	Campesterol (a)	60
	Stigmasterol (a)	60
	Sitosterol (a)	60
	Cycloartenol (a)	60
	24-methylenecycloartenol (a)	60
	Luteolol (a)	61
	6-hydroxy luteolol (a)	61

	Apigenol (a)	61
	Caffeicacid (d)	41
	Ferrulicacid (d)	41
	P-coumaricacid (d)	41
	Cholrgenicacid (d)	41
<i>D. mertonensis</i>	Digitoxin (a)	62
	Tigogenin (a)	14
	Gitogenin (a)	14
	Digitogenin (a)	14
<i>D. orientalis</i>	Digitoxin (a)	63
	Lanatoside – A (a)	63
	Ziganein (b)	64
	Pachybasin (b)	64
	Isochrysophanol (b)	64
	5-hydroxydigitolutein (b)	64
	Digitolutein (b)	64
	Madeirina (b)	64
	Digitoemodin (b)	64
	α -monohydroxy- β -hydroxymethyl anthraquinone (b)	64
	1-hydroxy anthraquinone-3-carboxylicacid (b)	64
	Apigenin	65
	Luteolin	65
	Chrysoeriol	65
	Dinatin	65
	Jaceosidin	65
	Scutellarein	65
	Betuletol-3-methylether	65
<i>D. parviflora</i>	Caffeicacid	66
	Ferrulicacid	66
	P-coumaricacid	66
	4-hydroxy benzoicacid	66
	Vanillicacid	66
	Chlorogenicacid	66
<i>D. purpurea</i>	Purpurea glycoside – A (a)	48, 6
	Digitoxin (a)	48, 6
	Glucododoroside – H (a)	48
	Oodoroside – H (a)	48
	Purlanoside – A (a)	48
	Purpurea glycoside – B (a)	48, 6
	Gitoxin (a)	48, 6
	Digitalinum verum (a) (c)	48, 6
	Strospeside (a)	48, 6
	Acetyl glucogitoroside (a)	48
	Acetyl digitalinum verum (a)	48
	Purlanoside – B (a)	48
	Glucogitaloxin (a)	48, 6

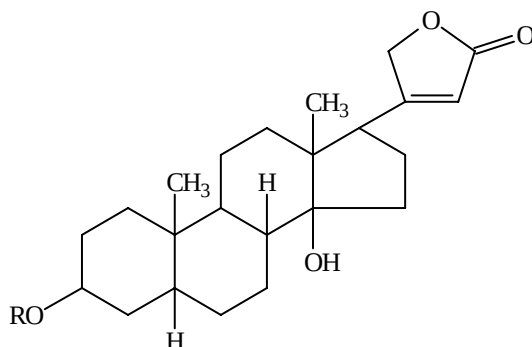
Species	Constituents Isolated	Ref.
	Gitaloxin (a)	48, 6, 67
	Glucoverodoxin (a)	48, 6
	Verodoxin (a)	48, 6
	Glucodigitoxigenin-bisdigitoxoside (a)	6
	Glucoevatromonoside (a)	6
	Glucogitoroside (a)	6
	Glucogitaloxigenin-bisdigitoxoside (a)	6
	Glucolanadoxin (a)	6
	Digitalin (c)	68
	Glucodigifucoside (c)	68
	Glucodigiproside (c)	68
	Digitogenin (a)	14, 60
	Gitogenin (a)	14, 60
	Tigogenin (a)	14, 60
	β -sitosterol (c)	5, 60
	Cholesterol (c)	5, 60
	Campesterol (c)	5, 60
	Stigmasterol (c)	5, 60
	Cycloartenol (c)	60
	24-methylene cycloartenol (c)	60
	Apigenin (a)	41
	Dinatin (a)	69
	Chrysoeriol (a)	69
	Nepetin (a)	69
	Luteolin (a)	41
	1-methoxy-2-methyl anthraquinone (a)	48
	3-methoxy-2-methyl anthraquinone (a)	48
	Digitolutein (a)	48
	3-methyl alizarin (a)	48
	1, 4, 8-trihydroxy-2-methyl anthraquinone (a)	48
	Caffeicacid (d)	41
	Ferrulicacid (d)	41
	P-coumaricacid (d)	41
	Chlorgenicacid (d)	41
<i>D. schischkinii</i>	Digitoxin (a)	70
	α -acetyldigitoxin (a)	70, 71
	β -acetyldigitoxin (a)	70, 71
	Acetylgitaloxin (a)	70
	α -acetylgitoxin (a)	70
	β -acetylgitoxin (a)	70
	Acetyldigoxoside (a)	70
	α -acetyldigoxin (a)	70, 71
	β -acetyldigoxin (a)	70, 71
	Gitoxin (a)	70
	α -acetyldiginatin (a)	70
	β -acetyldiginatin (a)	70

Digoxin (a)	70
Gitoroside (a)	70
Digoxigenin bis-digitoxoside (a)	70
Digoxigenin monodigitoxoside (a)	70
Diginatin (a)	70
Diginatigenin bis-digitoxoside (a)	70
Diginatigenin monodigitoxoside (a)	70
Lanatoside – A (a)	70, 71
Lanatoside – B (a)	70, 71
Lanatoside – C (a)	70, 71
Lanatoside – D (a)	70, 71
Lanatoside – E (a)	70, 71
Desacetyl lanatoside – A (a)	70
Desacetyl lanatoside – B (a)	70
Desacetyl lanatoside – C (a)	70
Neolanatoside – C (a)	70
Glucodigitoxigenin bis-digitoxoside (a)	70
Glucoacetyldigoxoside (a)	70, 72
Glucoevatromonoside (a)	70
Glucogitaloxigenin bis-digitoxoside (a)	70
Glucolanadoxin (a)	70
Glucodigoxoside (a)	70, 72
Glucogitoroside (a)	70
Glucodigitoxigenin glucomethylside (a)	70
Glucodigoxigenin bis-digitoxoside (a)	70
Glucodigoxigenin monodigitoxoside (a)	70
Digitalinum verum (a)	70
Neodigitalinum verum (a)	70
Odoroside – G (a)	70
Neoodorobioside – G (a)	70
Glucodiginatigenin monodigitoxoside (a)	70
Diginatigenin-digilanidobioside (a)	70
Luteolin (a)	73
Dinatin (a)	73
Apigenin (a)	73
Pectolinarigenin (a)	73
6-methoxy luteolin (a)	73
Ziganein (a) (b)	73, 74
Ziganein-1-methylether (a) (b)	74
Digitopurpone (a) (b)	73
3-methyl quinizarin (a) (b)	73
4-hydroxy digitolutein (a) (b)	73
5-hydroxy digitolutein (a) (b)	73
4, 5-dihydroxy digitolutein (a) (b)	73
Digitopurpone-1-methylether (a) (b)	73
Digitoemodin (a) (b)	73

Species	Constituents Isolated	Ref.
<i>D. subalpina</i>	Subalpinoside (a)	75, 76
	Lanatoside – A (a)	76
	Lanatoside – B (a)	76
	Evatromonoside (a)	76
	Gitoroside (a)	76
	Digitalinum verum (a)	76
	Strospeside (a)	76
	Glucogitoroside (a)	76
	Neoglucogitoroside (a)	76
	Neodorobioside – G (a)	76
	Glucoevatromonoside (a)	76
	Digitoxigenin glucomethyloside (a)	76
	Lanadoxin (a)	76
	Digitoxin (a)	76
	Purpurea glycoside – B (a)	76
<i>D. toletana</i>	Caffeicacid	66
	Ferrulicacid	66
	P-coumaricacid	66
	4-hydroxybenzoicacid	66
	Vanillicacid	66
	Chlorgenicacid	66
	Chrysoeriol (a)	77
	Jaceosidin (a)	77
	Luteolin (a)	77
<i>D. thapsi</i>	Digithapsin – A (a)	78
	Digithapsin – B (a)	78
	Digitoxin (a)	78
	Gitoxin (a)	78
	Diginin (a)	78
	Calycopterin (a)	79
	3' -methoxy calycopterin (a)	78, 79
	Penduletin (a)	79
	Cirsimaritin (a)	79
	Polycladin (a)	79
	3, 3' , 7-trimethyl quercetin (a)	79
	Jaranol (a)	79
	2-phenyl ethanol (a)	78
	P-hydroxypropiophenone (a)	78
	Linalool (a)	78
<i>D. trojana</i>	Gitogenin (a)	78
	Digitopurpone-1-methylether (b)	80
	Pachybasin (b)	80
	Ziganein-1-methyl ether (b)	80
	Apigenin	65
	Luteolin	65

<i>D. viridiflora</i>	Chrysoeriol	65
	Dinatin	65
	Pectolinarigenin	65
	Jaceosidin	65
	Scutellarein	65
	Digitoxin (a)	81
	Gitoxin (a)	81
	Glucoevatromonoside (a)	81
	Lanatoside – A (a)	11, 81, 82
	Lanatoside – B (a)	11, 81, 82
	Lanatoside – C (a)	11, 81
	Glucolanadoxin (a)	81
	Strospeside (a)	81, 82
	Purpurea glycoside – B (a)	81
	Acetyl digitoxin- α (a)	81, 83
	Glucogitoroside (a)	83
	Desacetyl lanatoside – C (a)	81
	Digitalinum verum (a)	81, 83
	Diginigenin glycoside (a)	82
	Kaempferol-3, 7, 4' -trimethylether (a)	65
	5-hydroxy auranetin (a)	65
	Luteolin (a)	65, 84
	Chrysoeriol (a)	65, 84
	Dinatin (a)	65
	Pectolinarigenin (a)	65
	Jaceosidin (a)	65
	Scutellarein (a)	65
	Apigenin (a)	65
	Betuletol-3-methylether (a)	65
	Digitoemodin (a)	84, 85
	2-hydroxy-1,6-dimethoxy-3-methyl anthraquinone (a)	86
	Digitolutein (a)	84, 87
	Isochrysophanol-8-methylether (a)	87
	5-hydroxy digitolutein (a)	87

Leaf (a); root (b); seed (c); flower (d)



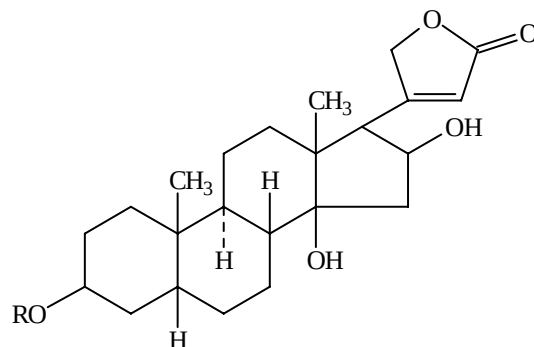
Digitoxigenin R = H

Glycoside

Digitoxin
 Purpurea glycoside – A
 Purlanoside – A
 Gluco-odoroside – H
 Odoroside – H
 Lanatoside – A
 Acetyl digitoxin
 Glucoevatromonoside
 Glucodigifucoside
 Digitoxigenin – 0 – glucosyl – 6-deoxy glucoside
 Digitoxigenin – bis digitoxoside
 Digitoxigenin-3-0-β-D-digitoxosido--β-D-xyloside
 Acetyl gluco evatromonoside
 Glucodigitoxigenin – bis digitoxoside
 Digitoxigenin-β-D-glucoside
 Evatromonoside
 Neo-gluco – digifucose
 Acetyl digitoxin-α-3-0-mono digitaloside
 Digitonin
 Digitoxigenin – glucomethyloside

R

(Digitoxose)₃ –
 Glucose – (digitoxose)₃ –
 Glucose – (digitoxose)₂ – acetyldigitoxose –
 Glucose – digitalose –
 Digitalose –
 Glucose – acetyldigitoxose – (digitoxose)₂ –
 Acetyldigitoxose – (digitoxose)₂ –
 Glucose – digitoxose –
 Glucose – fucose –
 Glucose – glucomethylose –
 (Digitoxose)₂ –
 Xylose – digitoxose –
 Glucose – (acetyl digitoxose) –
 Glucose – (digitoxose)₂ –
 Glucose –
 Digitoxose
 Fucose – glucose –
 Acetyldigitoxose – (digitoxose)₂ – digitalose –
 (glucose)₂ – (galactose)₂ – Xylose –
 Glucomethylose –



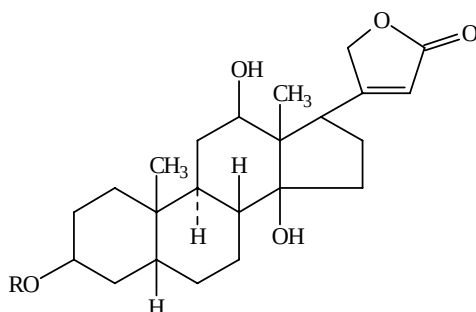
Gitoxigenin R = H

Glycoside

Purpurea glycoside – B
 Gitoxin
 Digitalinum verum
 Stros peside
 Lanatoside – B
 Glucogitoroside
 Acetyl glucogitoroside
 Acetyl digitalinum verum
 Purlanoside – B
 Gitoxigenin-3-0-β-D-glucosyl-β-D-glucomethylosyl-β-D-bis digitoxoside
 Gitoxigenin-3-0-β-D-glucosyl-β-D-glucomethylosyl-β-D-digitoxoside.
 Gitoxigenin-3-0-β-D-glucosyl-β-D-Glucomethyloside.
 Gitoroside
 Gitoxigenin – bis – digitoxoside
 Gluco gitofucoside
 Gitostin
 Neogitostin
 Acetyl gitoxin
 Gitorocellobioside
 Gitonin
 Neodigitalinum verum
 Neoglucogitoroside

R

Glucose – (Digitoxose)₃ –
 (Digitoxose)₃ –
 Glucose – Digitalose –
 Digitalose –
 Glucose – acetyldigitoxose – (digitoxose)₂ –
 Glucose – digitoxose –
 Glucose – acetyldigitoxose –
 Glucose – acetyl digitalose –
 Glucose – (digitoxose)₂ – acetyldigitoxose –
 (Digitoxose)₂ – (glucosmethylose) – glucose –
 Digitoxose – glucosmethylose – glucose –
 Glucosmethylose – glucose –
 Digitoxose –
 (Digitoxose)₂ –
 Glucose – Fucose –
 Cellobiose – Digitalose
 Gentiobiose – Digitalose –
 Acetyldigitoxose – (digitoxose)₂ –
 Cellobiose – (digitoxose) –
 Glucose – (galactose)₂ – (Xylose) –
 Digitalose – glucose –
 Digitoxose – glucose –



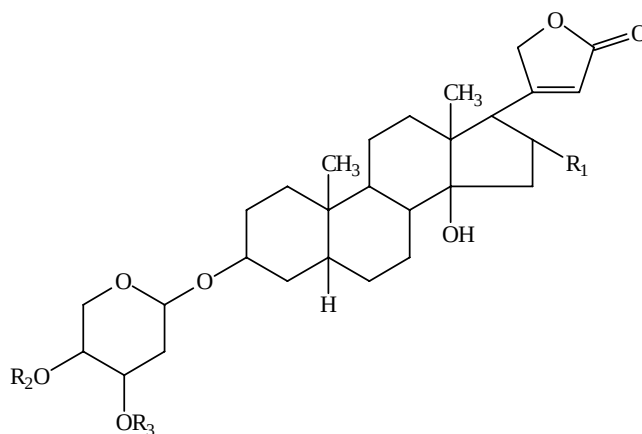
Digoxigenin R = H

Glycoside

Lanatoside – C
 Digoxigenin – glucosyl – bis digitoxoside
 Digoxin
 De acetyl lanatoside – C
 Acetyl digoxin
 Digoxigenin-3- β -D-digitoxosido- β -D-digitoxoside- β -D-Xyloside
 Digoxigenin-3-0- β -D-digitaloside
 Digoxigenin-3-0- β -D-digitoxosido- β -D-2, 6 dideoxy glucose
 Digoxigenin bis digitoxoside
 Glucodigoxigenin – mono digitoxoside
 Digoxigenin mono digitoxoside
 Digoxigenin-3-0- β -D-digitoxosido-digitoxosido- β -D-2, 6-dideoxy glucoside
 Neo lanatoside – C

R

Glucose – acetyl digitoxose – (digitoxose)₂ –
 Glucose – (digitoxose)₂ –
 (Digitoxose)₃ –
 Glucose – (digitoxose)₃ –
 Acetyl digitoxose – (digitoxose)₂ –
 (Digitoxose)₂ – Xylose –
 (Digitalose) –
 (Digitoxose)₂-(2, 6-dideoxy glucose) –
 (Digitoxose)₂ –
 Glucose – (digitoxose)₂ –
 (Digitoxose) –
 (Digitoxose)₂ – (2, 6 dideoxyglucose) –
 (Digitoxose)₂ – acetyl digitoxose – glucose –



Glycoside

Digoxigenin-3-0- β -D-glucosyl-(1 $\rightarrow$ 4)
 -3' -0-acetyl- β -D-digitoxoside
 3-0-acetylated digitoxoside (α -form)
 3-0-acetylated digitoxoside (β -form)

R₁

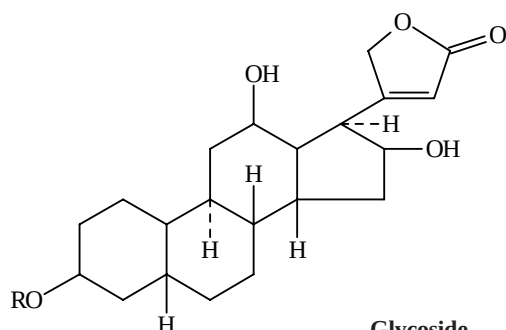
H
 H
 H

R₂

β -D-glucosyl
 H
 COCH₃

R₃

COCH₃
 COCH₃
 H

**Diginitagenin R = H****Glycoside**

Lanatoside – D

Diginitagenin bis digitoxoside

Diginitagenin mono digitoxoside

Glucodiginitagenin mono digitoxoside

RGlucose – acetyl digitoxose –
(digitoxose)₂ –(Digitoxose)₂ –

Digitoxose –

Glucose – digitoxose –

Gitaloxigenin R = H**Glycoside**

Gitaloxin

Glucogitaloxin

Glucoverodoxin

Verodoxin

Lanatoside – E

Glucolanadoxin

Lanadoxin

Glucogitaloxigenin –
bis digitoxoside

Acetyl gitaloxin

R – Glycones(Digitoxose)₃ –Glucose – (digitoxose)₃ –

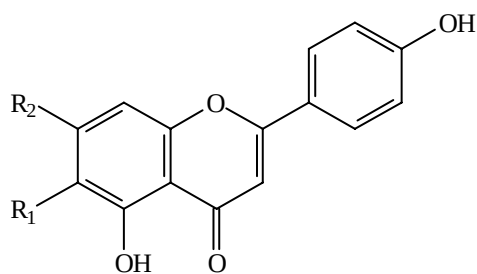
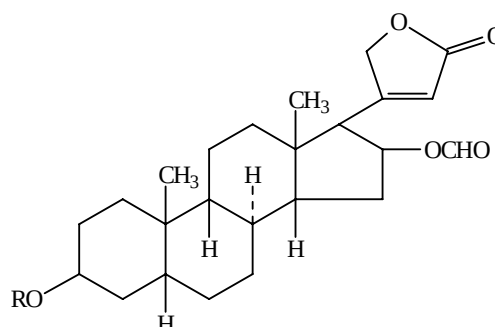
Glucose – digitalose –

Digitalose –

Glucose – acetyl digitoxose –
(digitoxose)₂ –

Glucose – (digitoxose) –

Digitoxose –

Glucose – (digitoxose)₂ –Acetyl digitoxose – (digitoxose)₂ –

Hispidulin (dinatin)

Scutellarein

Cirsimaritin

R₁OCH₃

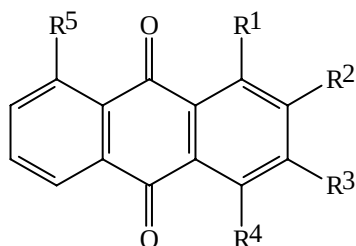
OH

OCH₃R₂

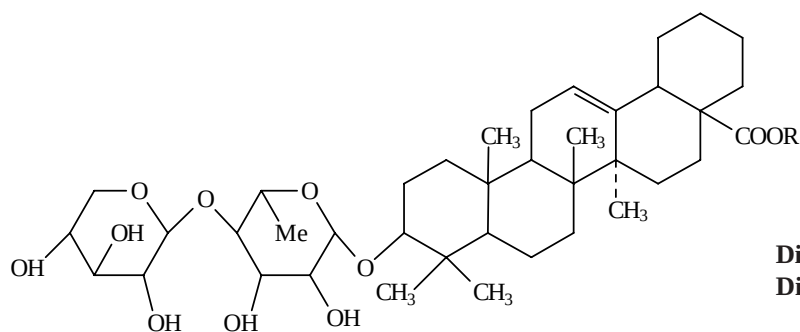
OH

OH

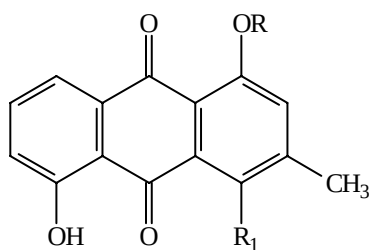
OCH₃



	R¹	R²	R³	R⁴	R⁵
1-methoxy 2-methyl anthraquinone	OCH ₃	CH ₃	H	H	H
3-methoxy 2-methyl anthraquinone	H	CH ₃	OCH ₃	H	H
1,4,8-trihydroxy-2-methyl anthraquinone	OH	CH ₃	H	OH	OH
3-methyl alizarin	OH	OH	CH ₃	H	H
1-hydroxy-2-hydroxy methyl-8-methoxy anthraquinone	OH	CH ₂ OH	H	H	OCH ₃
1-hydroxy anthraquinone-3-carboxylic acid	OH	H	COOH	H	H

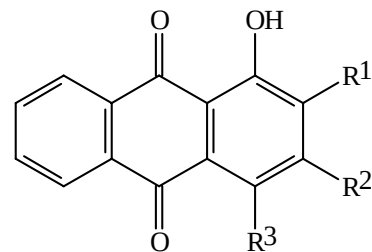


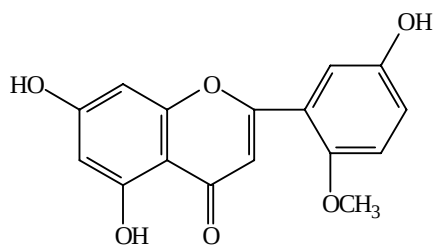
Digitoside – A R = glucose
Digitoside – B R = H



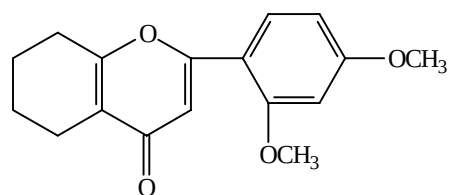
	R	R₁
Ziganein	H	H
Ziganein 1-methylether	CH ₃	H

R ¹ = H, R ² = CH ₂ OH, R ³ = OH	→	Digiferrol
R ¹ & R ² = CH ₂ OH, R ³ = H	→	Ferruginol
R ¹ = CH ₂ OH, R ² = R ³ = H	→	Digiferruginol

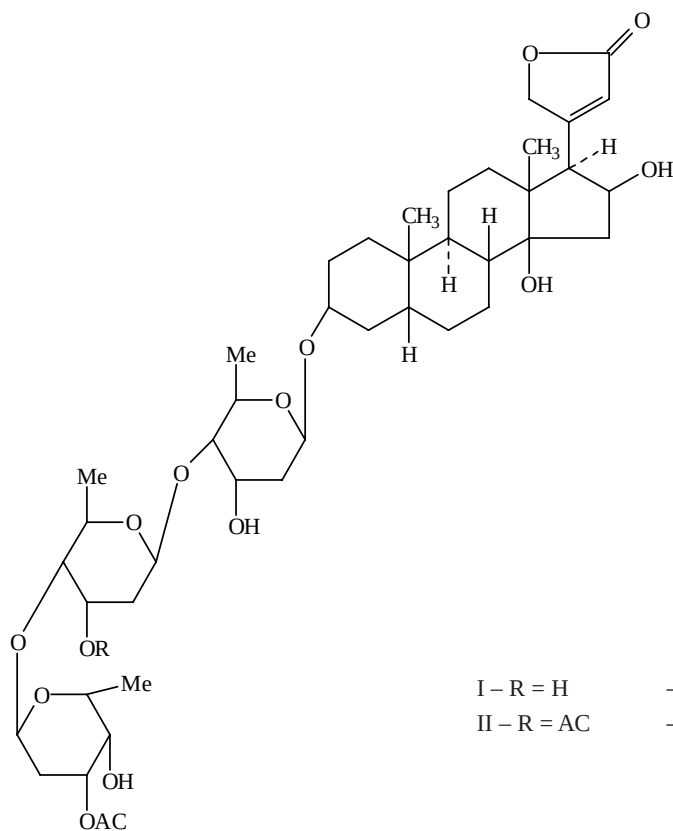




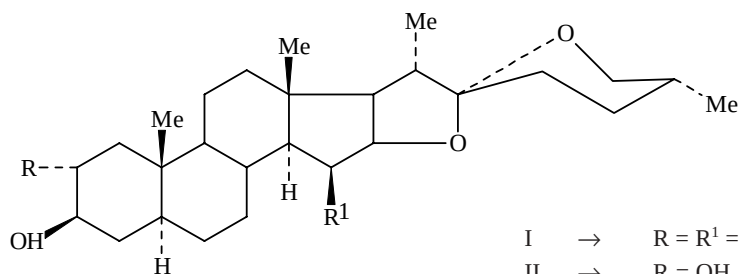
3', 5, 7-trihydroxy-6'-methoxy flavone.



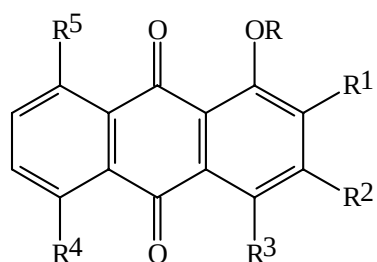
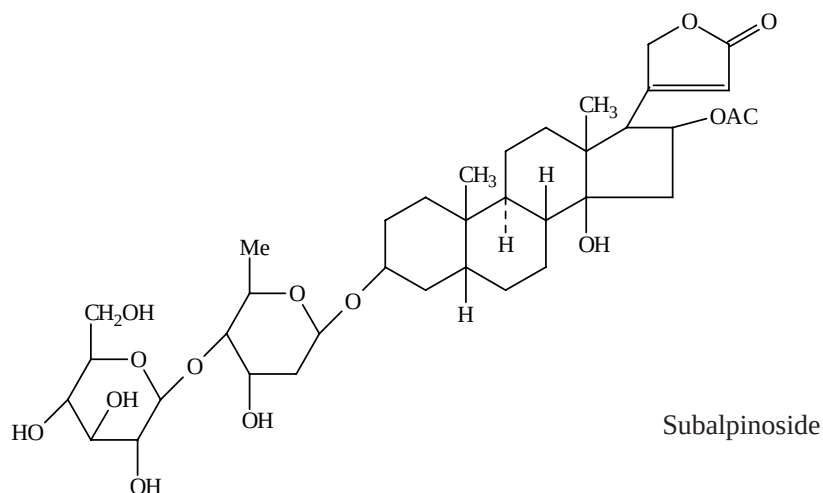
5,7-dihydro-4', 6-dimethoxy flavone.



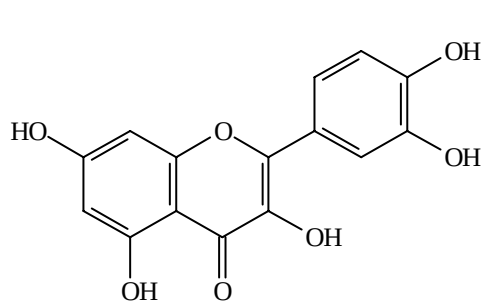
I – R = H → Digithapsin – A
 II – R = AC → Digithapsin – B



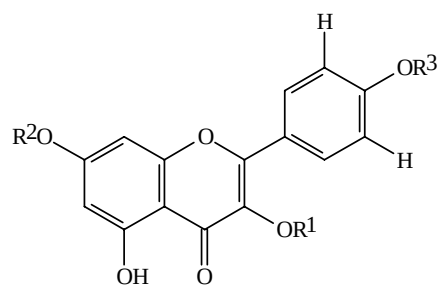
I → R = R¹ = H → Tigogenin
 II → R = OH, R¹ = H → Gitogenin
 III → R = H, R¹ = OH → Digalogenin
 IV → R = R¹ = OH → Digitogenin



	R	R ¹	R ²	R ³	R ⁴	R ⁵	
I	CH ₃	OH	CH ₃	H	H	H	Digitolutein
II	H	CH ₃	H	H	H	OCH ₃	Isochrysophanol-8-methyl ether
III	CH ₃	OH	CH ₃	H	OH	H	5-hydroxy digitolutein
IV	CH ₃	OH	CH ₃	OH	H	H	4-hydroxy digitolutein
V	CH ₃	OH	CH ₃	OH	OH	H	4, 5-dihydroxy digitolutein
VI	CH ₃	OCH ₃	CH ₃	OH	H	H	4-hydroxy digitolutein-2-methyl ether

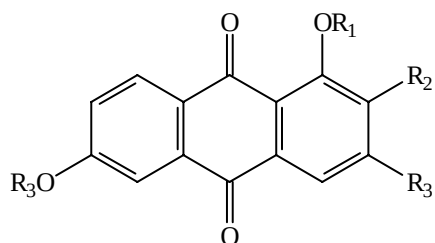
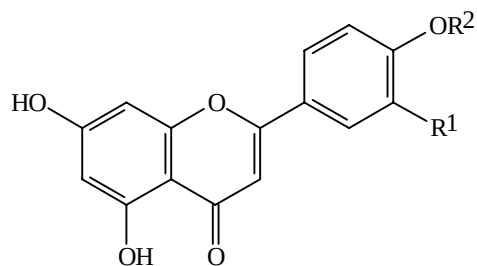


Quercetin



	R ¹	R ²	R ³
Kaempferol	H	H	H
Kaempferol-3,7,4'-trimethyl ether	CH ₃	CH ₃	CH ₃

Apigenin,	R ¹ = H	R ² = H
Luteolin	R ¹ = OH	R ² = H
Chrysoeriol	R ¹ = Ome	R ² = H
Diosmetin	R ¹ = OH	R ² = CH ₃

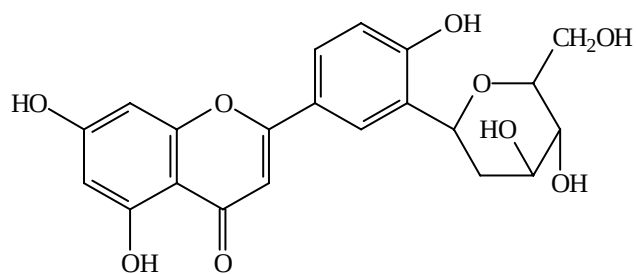
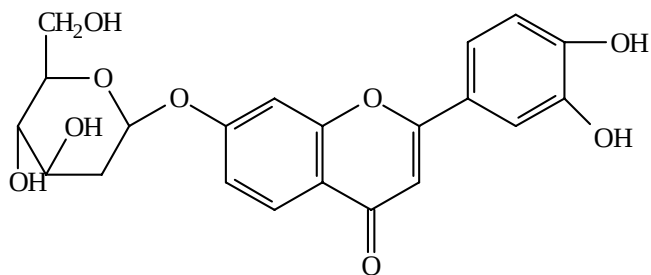


Digitoemodin

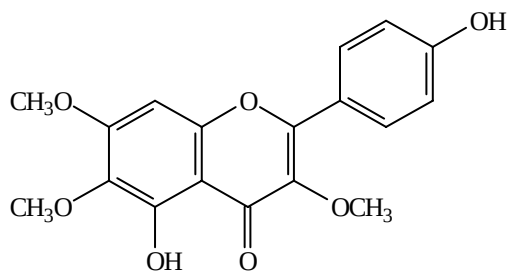
2-hydroxy-1,6-dimethoxy-3-methylantraquinone

R ¹	R ²	R ³
H	H	H
CH ₃	OH	CH ₃

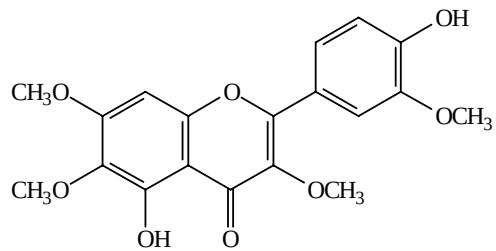
Cyanaroside – I



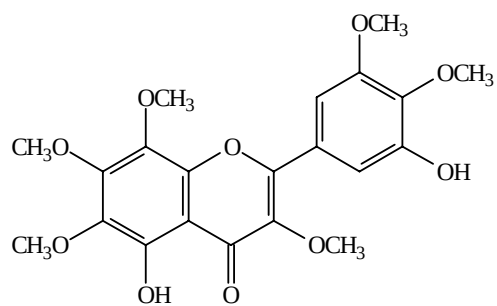
Dracocephaloside



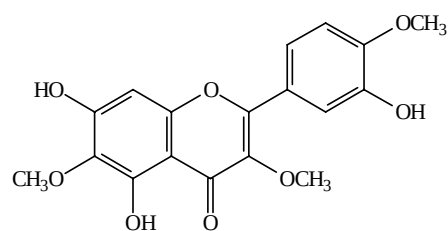
Penduletin



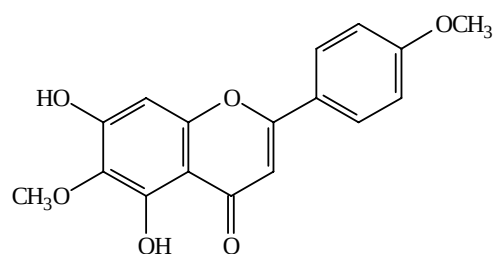
Polycladin



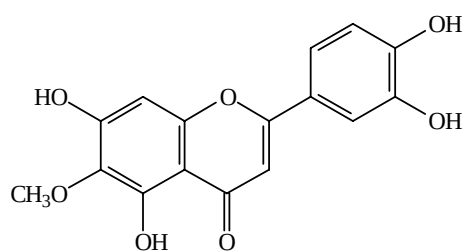
Digicitrin



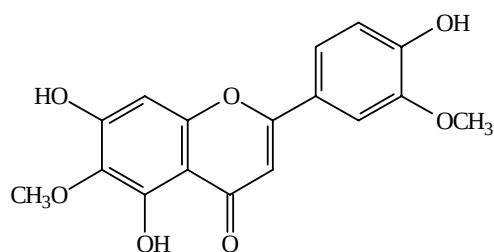
Centaureidin



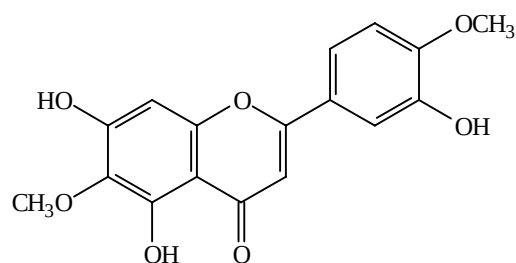
Pectolinarigenin



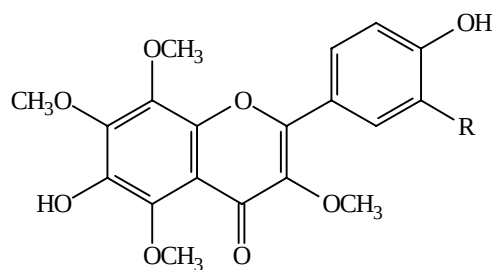
Nepetin



Jaceosidin



Desmethoxycentaureidin

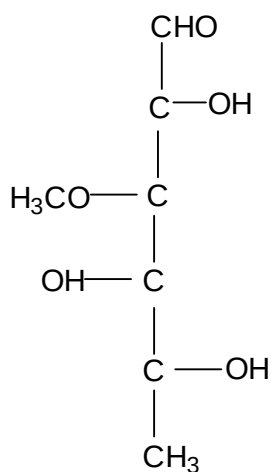


Calycpterin

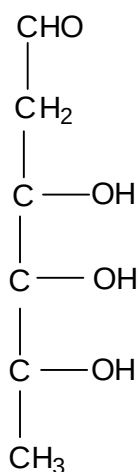
3' - methoxy calycpterin

R = H

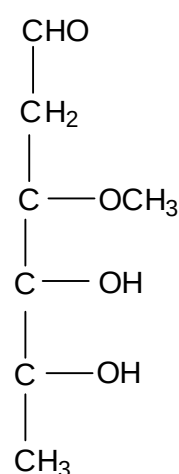
R = OCH₃

Sugars associated with *Digitalis* glycosides

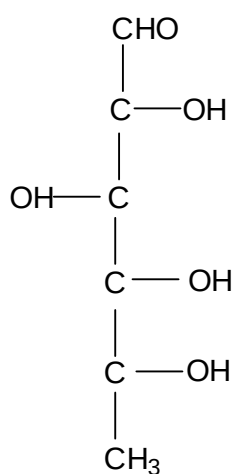
D-Digitalose



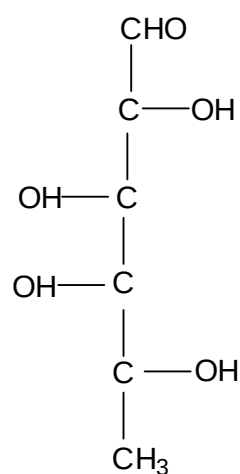
D-Digitoxose



D-Cymarose



D-Glucomethylose



D-Fucose

3. Conclusion

The emergence and use of *Digitalis* species to treat the failing heart has constituted one of the principal life saving drugs of the present century. The cardiac glycosides of *Digitalis* have been hailed as a small group of promising members to treat and prevent coronary and associated circulatory diseases. Taking into account the immense importance of this genus,

the phytoconstituents of the *Digitalis* species have been carefully examined and reported for their allied biological properties.

An overall conclusion on the occurrence and distribution of cardiac glycosides of the genus *Digitalis* highlighted a number of features, primarily the occurrence of the genin, the cardenolide. The cardenolides of *Digitalis*

constitute the five major genins and possess some unique features, which include, the presence of an OH at C-3, a methyl substituent at C-10 and a tertiary OH at C-14. The sugar moieties (glycones) are normally linked to the genin by a C-3, β - linkage to form the cardiac glycosides.

The glycones are composed all together of up to four sugar units which include naturally occurring sugars like glucose or rhamnose, in addition to some rare deoxy-sugars like the 2, 6-di deoxyhexoses (ex: digitoxose), the 3-0-methyl ethers (ex: cymarose, digitalose) and also D-fucose. The sugars namely D-Digitalose, D-Digitoxose, D-fucose, D-Cymarose and D-Glucomethylose are all of natural occurrence, but seem to be generally confined to the cardiac glycosides of *Digitalis*.

Among the 24 species belonging to this genus, only seventeen have been phytochemically investigated. This suggests that phytochemical work on this genus is by no means futile, as this taxa could still retain some promising new molecules which may be used to treat cardiac ailments in the near future. The wound healing properties of the *Digitalis* members may be attributed to the presence of flavonoid constituents apigenin and luteolin [88].

The cardiac glycosides digoxin, digitoxin, gitoxin and gitaloxin are frequently occurring candidates in the *Digitalis* group and may be considered as taxonomic markers of the genus *Digitalis*. The *Digitalis* species still pose as promising plant members with potential medicinal properties that could be explored extensively.

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