Journal of Scientific & Industrial Research
Vol. 65, April 2006, pp 283-298

A comprehensive review on the chemistry and pharmacology of *Corchorus* species—A source of cardiac glycosides, triterpenoids, ionones, flavonoids, coumarins, steroids and some other compounds

M S Y Khan*, S Bano, K Javed and M Asad Mueed
Centre for Interaction between University & Industry, R & D Extension and Projects Office, Hamdard University, New Delhi 110 062

Received 08 February 2005; revised 24 January 2006; accepted 03 February 2006

An exhaustive literature survey on the secondary metabolites of *Corchorus* species has been carried out. Cardiac glycosides, triterpenoids, sterols, phenolics, ionones, carbohydrates and fatty acids have been reported from different species. Many of these compounds have been found to possess significant biological properties e.g. digitalis glycosides like action, anticonvulsive activity, antiesterogenic action, anticancer activity and antipyretic activity etc.

Keywords: Biological properties, Carbohydrates, Cardiac glycosides, *Corchorus* sp, Ionones, Phenolics, Sterols, Triterpenoids

Introduction

Corchorus (Family: *Tiliaceae*) is a genus of annual herbs. Nearly 40 species are known to occur in nature and distributed in the tropics of both the hemispheres[1]. Seeds of *C. acutangulus* are used as a tonic, stomachic, purgative, in fever and in obstruction of the abdominal viscera. Leaves of *C. capsularis*, *C. depressus* and *C. olitorius* are demulcent, bitter, tonic, laxative, carminative, refrigerant, febrifuge, diuretic, useful in chronic cystitis, gonorrhoea and dysuria[1-3]. *C. depressus* is given to increase the viscosity of the seminal fluid[4]. *Corchorus* species have been reported to increase sexual ability in males. The evaluation is based on real experience and collective information from the local people who used them in their daily routine[5].

In view of the important medicinal properties attributed to this genus, this paper presents a comprehensive review giving chemical constituents (Table 1) and the biological activities of *Corchorus*, besides structures of the compounds, wherever known (Chart 1).

Cardiac Glycosides, their Aglycones and a few Uncharacterized Glycosides/Aglycones

Several glycosidic compounds, referred to as corchorin, were isolated from different *Corchorus* species[6-10] but no definite conclusions could be drawn regarding the structures of these compounds. Similar was the fate of capsularin[11], chorchoritin[12] and corchsularin[13]. In the same manner, a number of aglycones namely corchsugenin[13], corchortoxin[14] and corchorgenin[15,16] were isolated. A significant advancement was made when these aglycones were chemically identified as strophanthidin 1[17], the familiar aglycone of the cardiac glycoside strophanthin. This was followed by identification of 2-deoxy riboside and 2-deoxy-3-O-methyl riboside of strophanthidin[18,19], though the position of the sugar residue was not defined.

Two digitalis glycosides, corchoroside A 2 {m p 188-90^o, $[\alpha]_D^{20}$ = +11^o (MeOH)} and corchoroside B 15[20] {m p 222-24^0 $[\alpha]_D^{20}$ = +68^o}, were isolated respectively from *C. capsularis* and *C. olitorius*. Both showed similar colour reactions. A monoglucoside[21-24] of corchoroside A from *C. olitorius*, a diglucoside and a triglucoside[25] of corchoroside A were also identified in seeds of *C. capsularis*. Monoglucoside of corchoroside A was named as olitoriside 3[26].

Seeds of *C. acutangulus* yield helveticoside **4**, corchoroside A **2** and an uncharacterized glycoside A (m p 155-60^o), which on hydrolysis gave the sugar digitoxose **9** while the aglycone part remained uncharacterized. An amorphous mixture of a glycoside, which on mild hydrolysis followed by chromatography gave strophanthidin **1** and strophanthidol **10**, was also obtained. The sugar part (paper and TLC examination)

*Author for correspondence
Tel: 91-11-26059686-88/extn 5890; Fax: 91-11-26059663
E-mail: msykhan@hotmail.com

Table 1— Chemistry of *Corchorus* Species

Sr No	*Corchorus* Species	Compounds isolated	References
Cardiac glycosides			
1	*C. capsularis*	2, 15 (seeds)	20
		Strophanthidin glycoside (seeds), capsulasone, corchorol,	31b
		Capsularol (leaves)	44
2	*C. olitorius*	2,15 (seeds)	20
		3 (seeds)	26
		Strophanthidin trioside (seeds)	31a
		Coroloside, deglycocoroloside (seeds)	32
		6, 7, 8, 13 (seeds)	33, 34
		16-20 (seeds)	35
3	*C. acutangulus*	2, 4 (seeds)	27
		3, 5 (seeds)	30
4	*C. trilocularis*	14,15 (seeds)	43
Triterpenes			
5	*C. capsularis*	21 (roots)	49a
		25, 26, Oxo-corocin (roots)	50
		35, 36 (leaves)	59, 60, 61
6	*C. olitorius*	21 (roots)	49a
		25, 26, Oxo-corocin (roots)	50
		25a (leaves)	51
7	*C. acutangulus*	27, 28, 29, 30 (aerial parts)	52, 53
8	*C. fascicularis*	31 (whole plant)	54
9	*C. depressus*	22, 23, 24 (whole plant)	55
		32, 33 (whole plant)	56
		Depressosides C & D	57
		34, Depressoside F	58
10	*C. trilocularis*	37, 38, 39 (whole plant)	62
Ionones			
11	*C. olitorius*	40, 41, 42, 43, 44 (leaves)	63
Phenolics			
12	*C. capsulari*	45, 46 (bark)	64
		46 (leaves)	64
13	*C. acutangulus*	47 (whole plant)	65
14	*C. depressus*	47, 48 (leaves & flowers)	66
		49, 50 (whole plant	55
		56, 57 (whole plant)	58
15	*C. olitorius*	51, 52 (leaves)	63
		53, 54, 55 (leaves)	51, 67
		58, 59 (leaves)	63
		60, 61 (leaves)	63, 67
		62 (seeds)	68

(*Contd*)

Table 1— Chemistry of *Corchorus* Species—*Contd*

Sr No	*Corchorus* Species	Compounds isolated	References
Sterols			
16	*C. capsularis*	63 (seeds, leaves, roots)	69, 44, 46, 49a
		64 (leaves)	44, 70
17	*C. olitorius*	63 (roots)	49a
		64 (leaves)	51
18	*C. depressus*	64 (whole plant)	55
19	*C. fascicularis*	63	54
Fatty acids			
20	*C. olitorius*	65,66,67,68,69,70 (leaves)	70
		Glyceryl monopalmitate (leaves)	51

was found to be a mixture of digitoxose **9** and boivinose **11** along with another uncharacterized fast moving sugar possibly 2,6-di-deoxy monomethoxy hexose[27]. Loshkarev[28] reconfirmed the presence of corchoroside A in the seeds of *C. olitorius*. An extract of the seeds of *C. olitorius* and *C. capsularis*, after enzymic hydrolysis, gave a fair yield of corchoroside A, while this extract without enzymic treatment gave a lower yield of the expected product **2**[29]. Two other polar glycosides[30] isolated from seeds of *C. acutangulus* were identified as olitoriside (**3**, m p 205-08°) and erysimoside (**5**, m p 178-82°). The structures of these compounds were determined based on chemical and IR spectral data, the sugars were characterized by paper chromatography. Seeds of *C. olitorius*, besides erysimoside, gave a cardenolide glycoside, trioside of strophanthidin, having a structure identical with the polar glycoside of *C. capsularis*[31a].

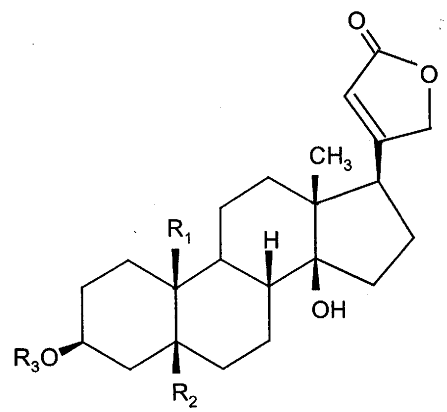
Seeds of *C. capsularis* gave a polar glycoside[31b], O-D- glucopyranosyl-β-(1→3)-O-D- glucopyranosyl β-(1→4)-D- boivinopyranosyl-β-(1→3)- strophanthidin. Energetic hydrolysis yielded glucose and no other hexose or pentose, whereas mild acid hydrolysis provided strophanthidin as an aglycone. Controlled enzymic hydrolysis with β-glucosidase gave olitoribiose, glucose and boivinose, suggesting the sugar residue to be gluco-olitoribiose. Complete enzymic hydrolysis of the product gave corchoroside A suggesting that the glycoside is a higher homologue of corchoroside A. The periodate oxidation studies suggested that the nature of the linkage of glucose units is 1→3- β- linkage (laminaribiose residue). Laminaribiose residues were found for the first time as part of the cardiac glycosides[31b].

Seeds[32-35] of *C. olitorius* gave glycosides, coroloside and deglycocoroloside, cardiac glucosides, canarigenin 3-O-β-D-glucopyranosyl-(1→4)-O-β-D-allomethylpyranose/altromethylopyranose **13**, cannogenol 3-O-β-D-glucopyranosyl-(1→4)-O-β-D-boivinopyranoside **6**, periplogenin 3-O-β-D-glucopyranosyl-(1→4)-O-β-D-digitoxopyranoside **7** and digitoxigenin 3-O-β-D-glucopyranosyl-(1→6)- O-β-D-glucopyranosyl-(1→4)- O-β-D-digitoxopyranoside **8** and some new cardiotonic oligoglycosides corchorusosides A-E **16-20**. *C. olitorius* seeds from Japan[36] contained cardiac glycosides (approx 1.0% level wet weight). The dark greyish green seeds contained more cardiac glycosides as compared to the dark greyish yellow or yellowish green seeds. The methanolic extract of seeds gave digitoxigenin glycosides, coroloside and glucoevatromonoside, as well as strophanthidin glycosides, erysimoside, olitoriside, corchoroside A and helveticoside, as the main cardiac glycosides.

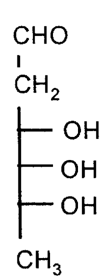
Chloroform - butanol (1:3) fractions from the seeds[37] of *C. capsularis* yielded polar glycosides A and B. Chloroform - alcohol (2:1) extracted residue gave glycoside B and a new polar glycoside C. Comparison with an authentic sample showed glycoside A to be erysimoside, which had not previously been reported from *C. capsularis* seeds. Glycoside C crystallized from isopropanol-methanol-ether, m p 200-10°/218-25° and was not identical with any compound isolated earlier from any *Corchorus* species.

Fermented seeds[38] of *C. hirtus* gave strophanthidin heterosides, glycosides a, b, c and d. Glycoside c was found to have boivinose **11** however a, b, and d were found to have boivinose and glucose as sugars. Petroleum ether extracted seeds[39] of *C. capsularis* and *C. olitorius* gave helveticoside (**4**, m p 168-71^0, $[\alpha]_D^{20}$=+31.9± 2^0). Its structure was confirmed by chemical and IR spectral data. Seeds[40] of *C. capsu-*

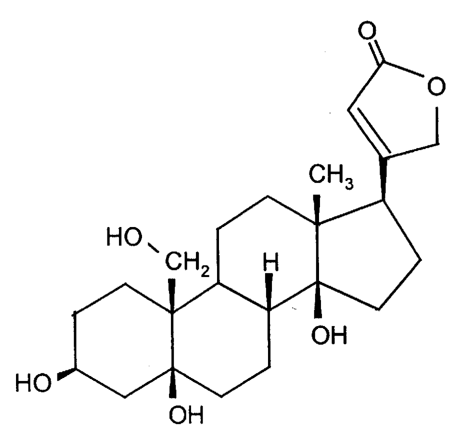
Chart 1



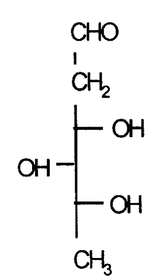
(1) Strophanthidin (R_1= CHO, R_2= OH, R_3=H)
(2) Corchoroside A (R_1=CHO, R_2=OH, R_3=β-D-boivinose)
(3) Olitoriside (R_1=CHO, R_2=OH, R_3=β-D-boivinose-β-D- glucose)
(4) Helveticoside (R_1=CHO, R_2=OH, R_3=β-D- digitoxose)
(5) Erysimoside (R_1=CHO, R_2=OH, R_3=β-D- digitoxose- β-D- glucose)
(6) Cannogenol 3-O-β-D- glucopyranosyl- (1→ 4)-O-β-D-boivinopyranoside) (R_1=CH_2OH, R_2= H, R_3= β-D- glucopyranosyl-(1→ 4)-O-β-D-boivinopyranoside)
(7) Periplogenin 3-O-β-D- glucopyranosyl-(1→ 4)-O-β-D-digitoxopyranoside) (R_1=CH_3, R_2=OH, R_3=β-D- glucopyranosyl-(1→ 4)-O-β-D-digitoxopyranoside)
(8) Digitoxigenin –3-O-β-D- glucopyranosyl- (1→ 6)-O-β-D- glucopyranosyl- (1→ 4)-O-β-D-digitoxopyranoside (R_1=CH_3, R_2= H, R_3=-β-D- glucopyranosyl-(1→ 6)-O-β-D- glucopyranosyl-(1→ 4)-O-β-D- digitoxopyranoside



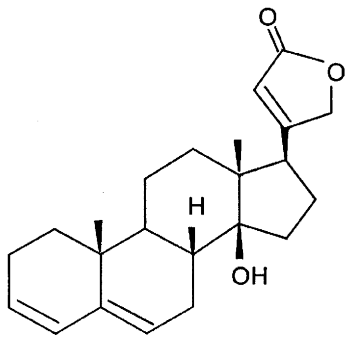
(9) D-Digitoxose



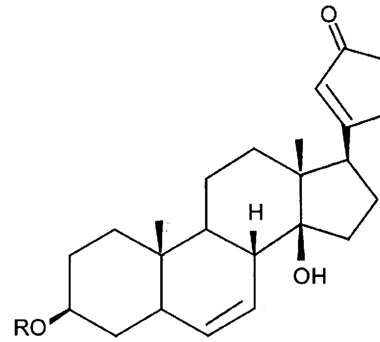
(10) Strophanthidol



(11) D- Boivinose



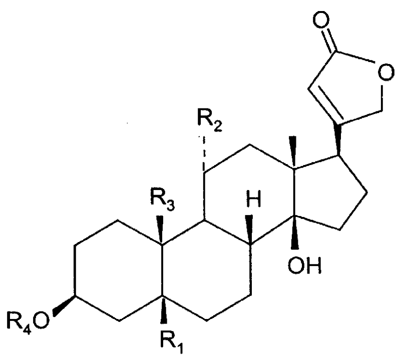
(12) 3,5- Dianhydroperiplogenin



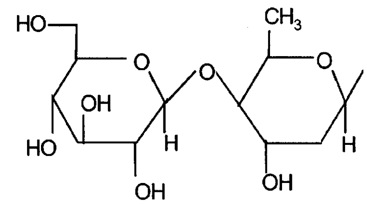
(13) Canarigenin (R=-O-β-D- glucopyranosyl-(1→ 4)-O-β-D-allomethylpyranose/altromethylpyranose

(14) Trilocularin(R=β-D-Boivinose)

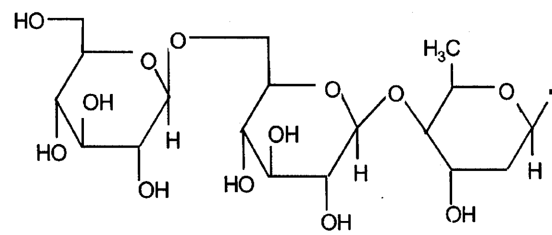
(15) Corchoroside –B (R=α-L-Rhamnopyranose)



Q_1=



Q_2=



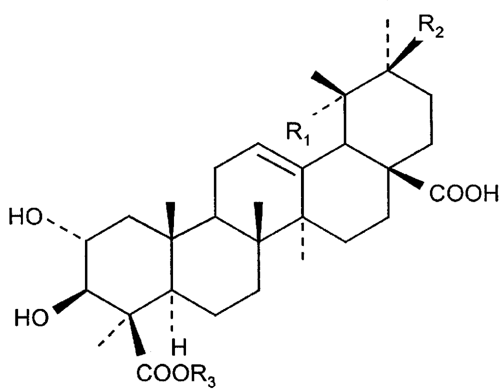
(16) Corchorusoside- A (R_1=R_2=OH, R_3=CH_3, R_4=Q_2)

(17) Corchorusoside- B (R_1=H, R_2=OH, R_3=CH_3, R_4= Q_1)

(18) Corchorusoside- C (R_1=OH, R_2= H, R_3=CH_3, R_4=Q_1)

(19) Corchorusoside- D (R_1=H, R_2=OH, R_3=CH_2OH, R_4=Q_1)

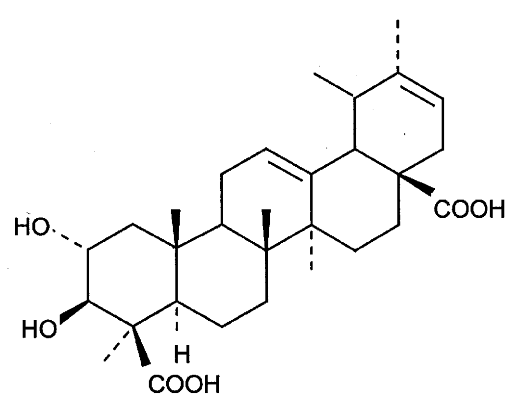
(20) Corchorusoside- E (R_1=OH, R_2=H, R_3=CH_2OH, R_4= Q_1)



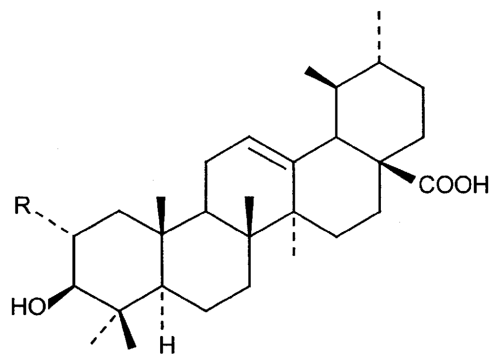
(21) Corosin (R_1=OH, R_2=R_3=H)

(22) Cordepressic acid (R_1= R_3=H, R_2=OH)

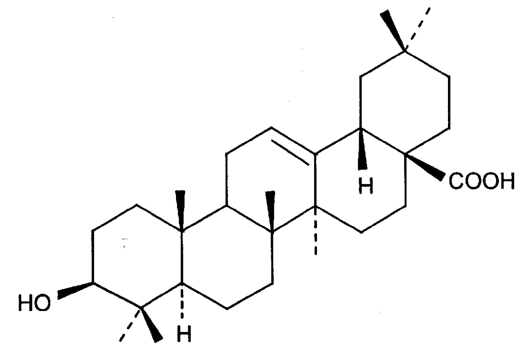
(23) Cordepressin (R_1= H, R_2 = OH, R_3 = β-D-Galactose)



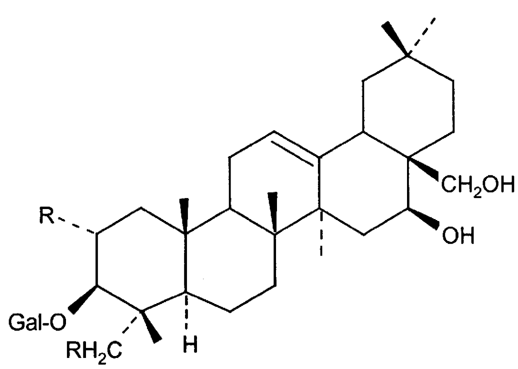
(24) Cordepressenic acid



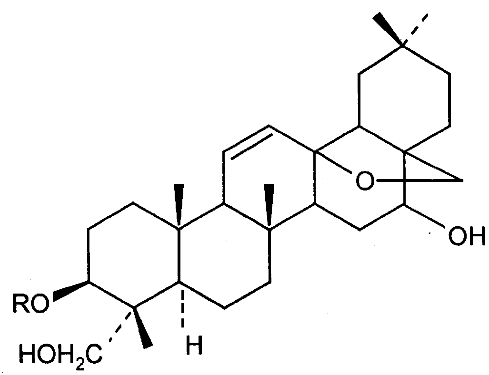
(25) Ursolic acid (R=H)
(26) Corosolic acid (R= OH)



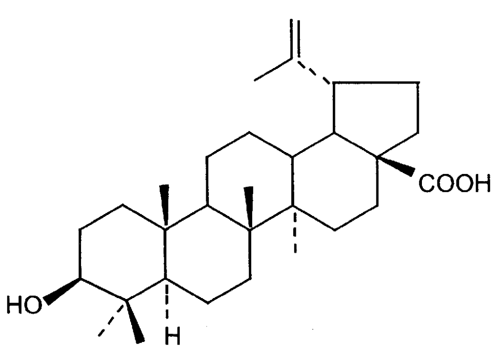
(25a) Oleanolic acid



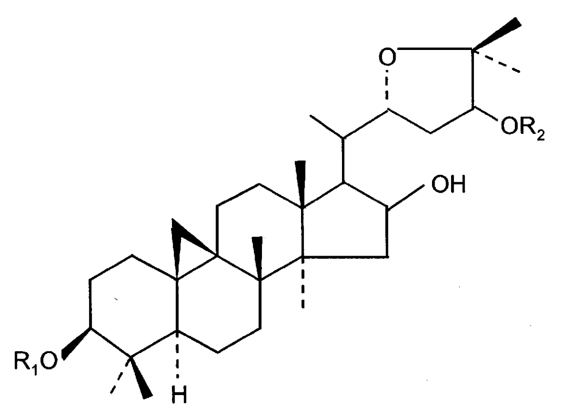
(27) Chorchorusin-A (R=H)
(28) Chorchorusin-C (R=OH)



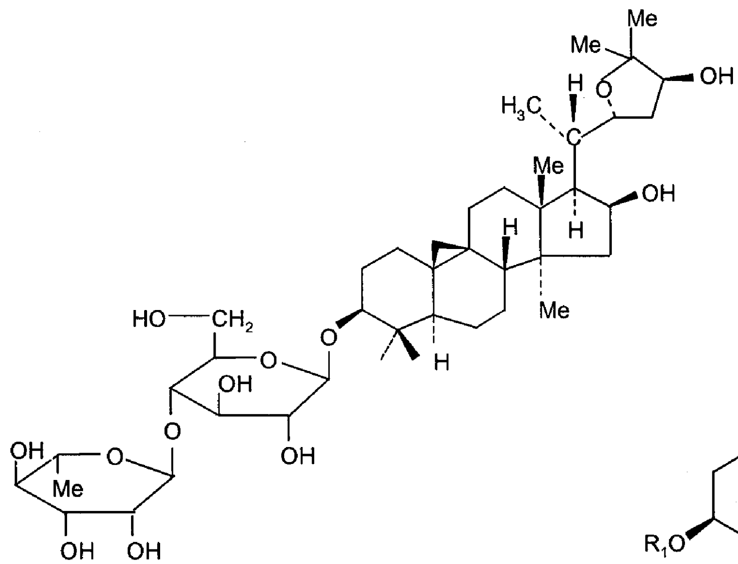
(29) Corchorusin-B (R=β-D-Galactopyranose)
(30) Corchorusin-D (R= Glucose-Galactose)



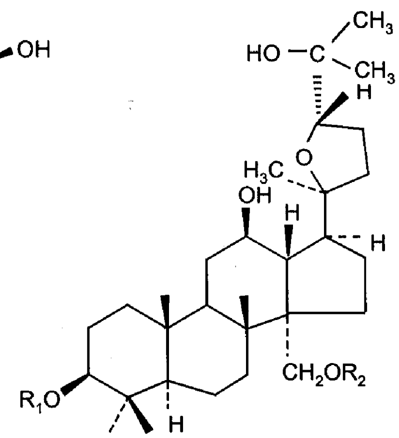
(31) Betulinic acid



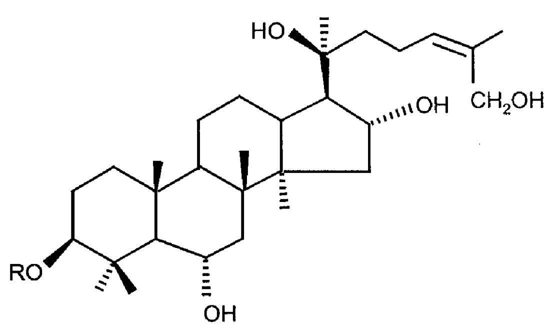
(32) Depressoside-A (R_1=Glucose, R_2=H)
(33) Depressoside-B (R_1=Glucose, R_2=Ac)



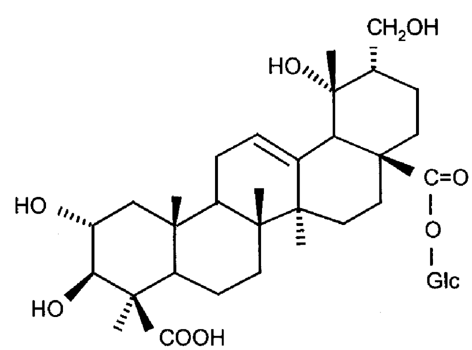
(**34**) Depressoside E



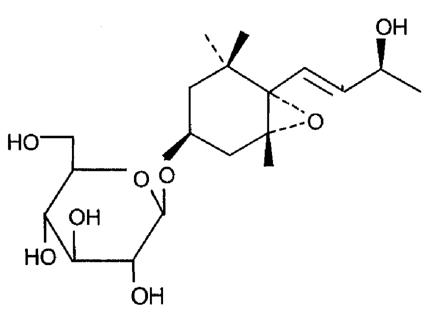
(**35**) Capsin (R_1=Glucose, R_2=H)
(**36**) Capsugenin 30-O-Glucopyranose (R_1=H, R_2=Glucose)



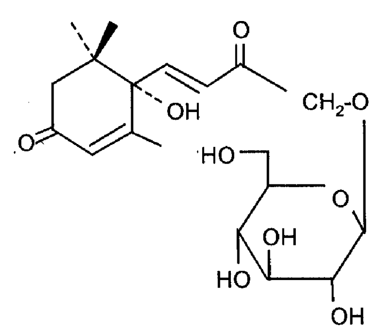
(**37**) Trilocularol A (R=H)
(**38**) Trilocularol A-3 glucoside (R=β-D-Glucose)



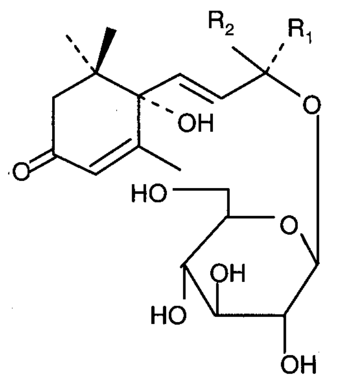
(**39**) Triloculároside A



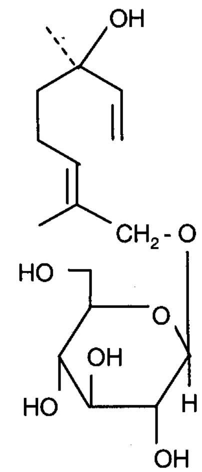
(**40**) Corchoionoside – A



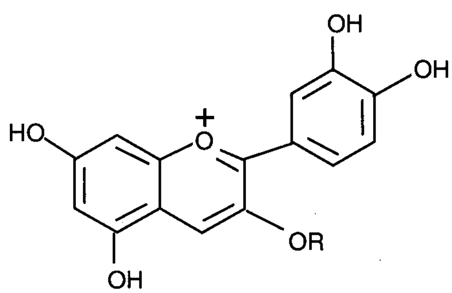
(**41**) Corchoionoside-B



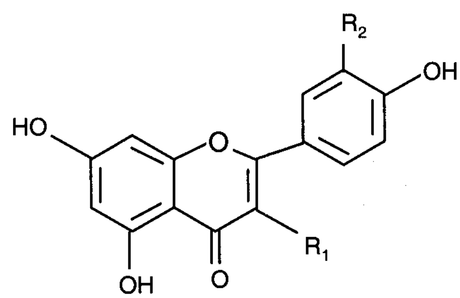
(**42**) Corchoionoside C (R_1=CH_3, R_2=H)
(**43**) (6*S*, 9*R*)-Roseoside (R_1= H, R_2=CH_3)



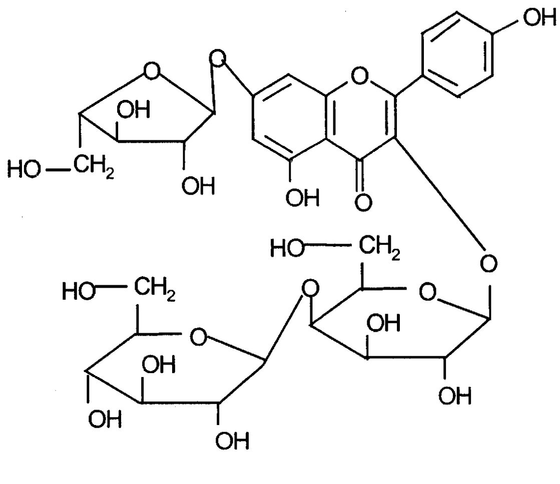
(**44**) Betulabuside A



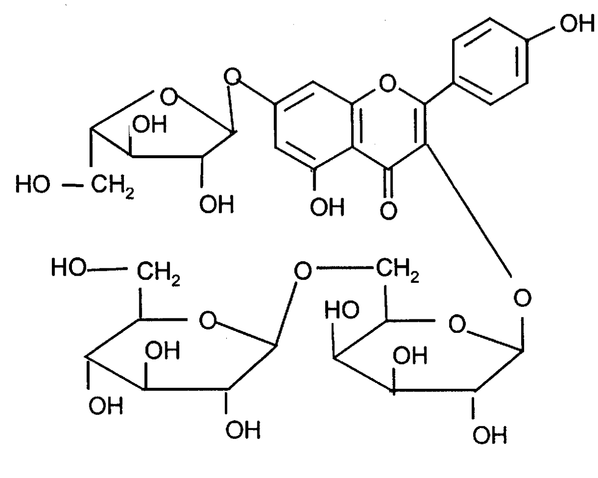
(**45**) Cyanidin (R=H)
(**46**) Cyanidin glucoside (R= Glucose)



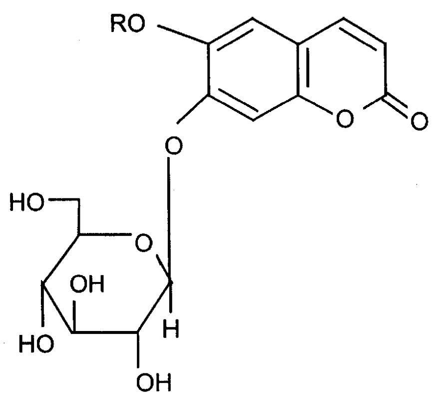
(**47**) Quercetin (R_1= R_2=OH)
(**48**) Kaempferol (R_1=OH, R_2=H)
(**49**) Apigenin (R_1= R_2=H)
(**50**) Luteolin (R_1= H, R_2=OH)
(**51**) Astragalin (R_1= O-Glc, R_2=H)
(**52**) Isoquercetin (R_1= O-Glc, R_2=OH)
(**53**) Quercetin-3- galactoside (R_1= O-Gal, R_2=OH)
(**54**) Quercetin-3- (6 malonyl glucoside) (R_1= O-6 malonyl glucose, R_2=OH)
(**55**) Quercetin-3- (6 malonyl galactoside) (R_1= O-6 malonyl galactose, R_2=OH)



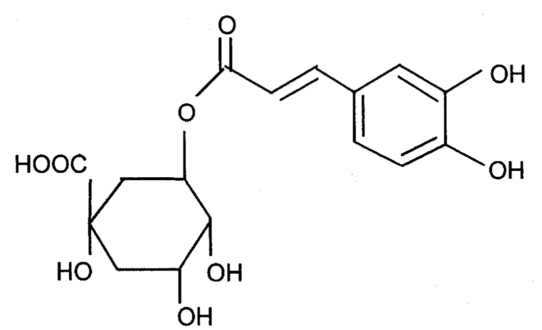
(56) Depressonol A



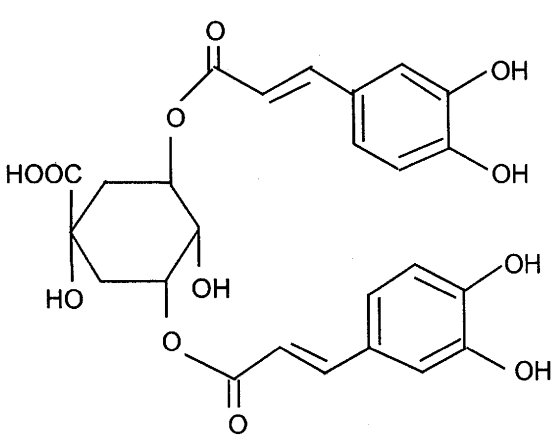
(57) Depressonol B



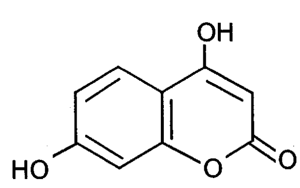
(58) Cichoriine (R=H)
(59) Scopolin (R=CH_3)



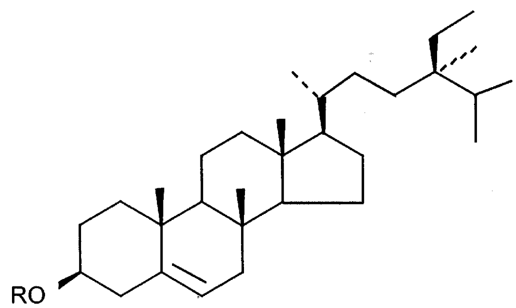
(60) Chlorogenic acid



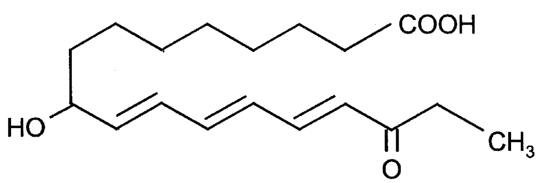
(**61**) 3,5-Dicaffeoylquinic acid



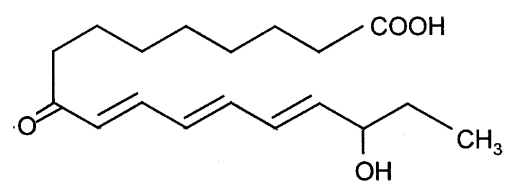
(**62**) 4,7-dihydroxycoumarin



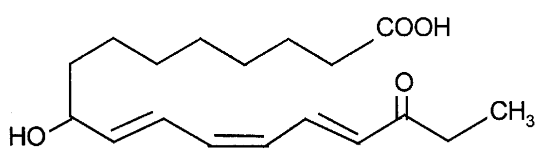
(63) β- Sitosterol (R=H)
(64) β- Sitosterol-β-D-glucoside (R=Glucose)



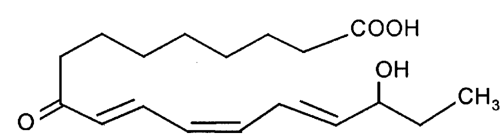
(65) Corchorifatty acid-A



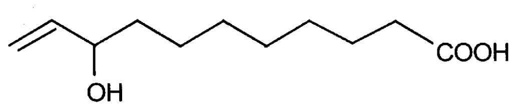
(66) Corchorifatty acid-B



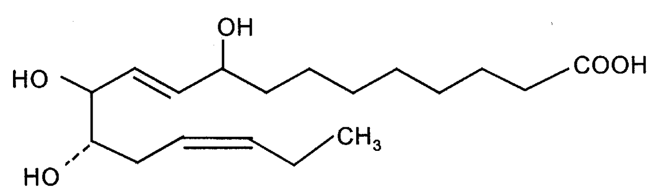
(67) Corchorifatty acid-C



(68) Corchorifatty acid-D



(69) Corchorifatty acid-E



(70) Corchorifatty acid-F

laris on autofermentation followed by extraction with methanol gave monosides corchoroside A **2** and helveticoside **4**, biosides, olitoriside **3** and erysimoside **5**, and a trioside, a glycoside of strophanthidin having boivinose and two glucose units as sugars. Seeds[41,42] of *C. trilocularis*, on autofermentaion, yielded two crystalline glycosides and two genins. Genins were identified as 3,5-dianhydroperiplogenin **12** and canarigenin **13**, which might be artifacts. The major glycoside, trilocularin **14,** was identified as 3-O-β-D-boivinoside of canarigenin. The minor glycoside was identical with corchoroside B **15**, which is α-L-rhamnopyranoside of canarigenin. Strophanthidin, strophanthidol, corchoroside A, helveticoside and olitorin were isolated from seeds of *C. olitorius*[43].

Leaves of *C. capsularis* yielded glycosides, capsulasone {m p 258-60°, $[\alpha]_D^{30}$ = +42.8° (EtOH)}, corchorol {$C_{22}H_{38}O_9$, m p 184°, $[\alpha]_D^{30}$ = –22.6° (EtOH)} and capsularol {$C_{41}H_{70}O_{11}$, m p 204-05°, $[\alpha]_D^{30}$ = –20.7° (EtOH)} besides KCl (4%) and small quantities of glucose, galactose and arabinose as free sugars. Capsularol, on acid hydrolysis, yielded glucose and an aglycone, capsularogenin {$C_{35}H_{60}O_6$, m p 217°, $[\alpha]_D^{30}$ = +2.97° (EtOH)}[44].

Polysaccharides and Some Other Sugars

An acidic polysaccharide, isolated from water-soluble mucilage extracted from dried leaves of *Corchorus olitorius*, was rich in uronic acid (65%), and consisted of rhamnose, glucose, galacturonic acid and glucuronic acid in a molar ratio of 1.0: 0.2: 0.2: 0.9:1.7 in addition to the acetyl group (3.7%). A methylation analysis, Smith degradation study and fragmentation analysis suggested that this polysaccharide mainly consisted of O-4 substituted galacturonic acid and glucuronic acid and O-2 substituted rhamnose residues and that most of the (1→4)- linked uronic acid residues were substituted at the O-3 position with glucuronic acid residues[45]. Free sugars, raffinose, sucrose, arabinose, fructose, glucose and galactose have been reported in the extracts of seeds of *C. capsularis* and *C. olitorius*, while raffinose, arabinose, fructose and glucose are reported in the root extracts[46]. Oligosaccharide components of the seeds of *C. capsularis* and *C. acutangulus* were isolated and identified as sucrose, raffinose, stachynose and verbascose[47]. Fructose and galactose were identified in the bark of *C. capsularis*[48].

Triterpenoids

A triterpenoid corosin, isolated from roots of *C. capsularis* and *C. olitorius*, on refluxing with HCl, gave corosic acid {$C_{30}H_{44}O_6$, m p 247-49°, $[\alpha]_D^{26}$ = +127 (0.9% in MeOH)}, however, structures of both these compounds were not established[49a]. Further extension of the work established structure of corosin **21**, which on treatment with sulphuric acid and acetic acid gave the anhydrolactone by dehydration of one molecule of water involving OH group at C-19 and carboxylic acid group at C-17 position[49b]. Ursolic acid **25**, corosolic acid **26** and oxo-corosin were isolated from fresh, undried roots of *C. capsularis* and *C. olitorius*[50]. Isolation of oleanolic acid **25a** also has been reported from the leaves of *C. olitorius* of Egyptian origin[51]. Four triterpenoid glycosides (chorchorusins A, B, C and D), isolated from aerial parts of *C. acutangulus*, were respectively defined as longispinogenin–3-O-β-D-galactopyranoside **27,** saikogenin-3-O-β-D-galactopyranoside **29**, 23- hydroxylongispinogenin-3-O-β-D- galactopyranoside **28** and saikogenin-3-O-β-D- glucopyranosyl- (1→2)- β-D- galactopyranoside **30**[52,53].

A pentacyclic triterpene betulinic acid **31** was isolated from *C. fascicularis*[54]. Whole plant[55,56] of *C. depressus* gave α- amyrin derivatives, cordepressic acid (2α, 3β, 20β-trihydroxy-urs-12- ene- 24, 28- dioic acid) **22**, cordepressin (2α, 3β, 20β-trihydroxy-urs-12-ene-24, 28 -dioic acid 24β-D- galactoside) **23** and cordepressenic acid (2α, 3β- dihydroxy-urs-12-20-diene-24-28- dioic acid) **24,** and cycloartane glucosides, depressoside A **32** and depressoside B **33** characterized as 9, 19- cyclolanosta-22 (*R*), 25- epoxy-3β, 16β, 24 (*S*)-triol-3-O-β-D- glucopyranoside and 9,19-cyclolanosta-22 *(R*), 25-epoxy-24 (*S*) acetoxy-3β, 16β-diol-3-O-β-D- glucopyranoside respectively. Two novel bidesmisidic cycloartane type glycosides, depressosides C and D were also isolated from whole plant of *C. depressus* and their structures were established as (22 *R*) 16β, 22-epoxy-3β, 26- dihydroxy-9, 19 cyclolanost- 24 E- ene 3, 26- di- O-β-D- glucopyranoside and (22 *R*, 24*S*)-22, 25-epoxy-3β, 16β, 24-trihydroxy-9, 19-cyclolanostane 3,24- di-O-β- glucopyranoside respectively[57].

The butanol soluble part of the ethyl alcohol extract of *C. depressus* gave depressosides E {**34**, (22*R*,24*S*)-22, 25-epoxy-cyclolanostane-3β, 16β, 24-triol-3 (α-L-rhamnopyranosyl-(1→4)-β-D-(22*R*,24*S*)-22, 25-epoxy-9, 19-cyclolanostane-3β,16β,24-triol–3(α-D-glucopyranosyl-β-D-glucopyranoside)}[58] and depressoside F, of which structure was not given.

The leaves of *C. capsularis* gave a new dammarane triterpene glycoside, capsin [**35**, 3-glucoside of 20, 24-epoxy-3β, 12β, 25, 30- tetrahydroxydammarane (capsugenin)][59,60]. Later on, one more new triterpenic glucoside capsugenin 30-O-glucopyranoside **36** was isolated from the mature leaves of *C. capsularis*[61]. Whole plant of *C. trilocularis*[62] yielded two tetracyclic triterpenoids, trilocularol A [3β, 6α, 16α, 20 (*S*), 27- pentahydroxy- dammar-24 (*Z*)-ene, **37**] and its 3-glucoside **38**, besides one pentacyclic triterpenoid trilocularoside [2α, 3β, 19α, 30-tetrahydroxy-urs- 12- en-24, 28-dioic acid- 28-O-β-D- glucopyranosyl ester, **39**].

Ionones

Leaves[63] of *C. olitorius* contain ionone glucosides, corchoionosides A **40**, B **41** and C **42,** an ionone glucoside (6*S*, 9*R*)- roseoside **43** and a monoterpene glucoside betulabuside A **44**.

Phenolics

Isolation and characterisation of cyanidin **45** and cyanidin glucoside **46** from *C. capsularis* bark[64]; cyanidin glucoside from *C. capsularis* leaves[64]; quercetin **47** from *C. acutangulus* whole plant[65]; quercetin, kaempferol **48** from *C. depressus* leaves & flowers[66]; apigenin **49** and luteolin **50** from *C. depressus* whole plant[55] and astragalin **51** and isoquercitrin **52** from *C. olitorius* leaves[63] have been reported. Leaves[51,67] of *C. olitorius* (Egyptian origin) also contain four flavonoidal glycosides, astragalin (kaempferol-3-O-β-D-glucopyranoside), tolifolin (kaempferol-3-O-β-D-galactopyranoside), isoquercitrin (quercetin-3-O-β-D-glucopyranoside) and jugulanin (kaempferol- 3-O-β-L-arabinopyranoside), besides quercetin- 3- galactoside **53**, quercetin-3-(6 malonyl glucoside) **54** and quercetin-3- (6 malonyl galactoside) **55** (tentative). The butanol soluble part of the ethyl alcohol extract of *C. depressus*[58] gave flavonol glycosides, depressonol A **56** [kaempferol-3-[β-D-glucopyranosyl-(1→4)-β-D-galactopyranoside] 7-[α-L-arabinofuranoside] and depressonol B **57** [kaempferol-3-[β-D-glucopyranosyl- (1→6)- β- D- galactopyranoside] 7-[α-L-arabinofuranoside].

Two coumarin glucosides, cichoriine **58** and scopolin **59** were isolated from the leaves of *C. olitorius*[63], the first report of the isolation of coumarins from this genus. Isolation of 5- caffeoylquinic acid (chologenic acid)[63, 67] **60** and 3,5- dicaffeoylquinic acid[67] **61** from the leaves of *C. olitorius* have also been reported. From chloroform extract of defatted seeds of *C. olitorius*, a new coumarin was isolated as 4,7-dihydroxycoumarin **62**[68].

Sterols

Isolation of β-sitosterol **63** from *C. capsularis* seeds[69], roots[46, 49a] and leaves[44], *C. olitorius* roots[49a] and *C. fascicularis*[54]; β-sitosterol-D-glucoside **64** from *C. capsularis* leaves[44,70] and *C. depressus* whole plant[55] and β-sitosterol and β-sitosterol 3-O-β-D-glucopyranoside from the leaves of *C. olitorius* of Egyptian origin have been reported[51].

Fatty Acids

Fatty acid composition of seed oil of *C. olitorius* was reported earlier[71]. Leaves[72] of *C. olitorius* gave four higher fatty acids with a trienone system, corchorifatty acids A **65**, B **66**, C **67**, D **68**, an undecanoic acid, corchorifatty acid E **69** and a trihydroxy fatty acid, corchorifatty acid F **70**. Presence of glyceryl monopalmitate has been reported in leaves of Egyptian origin[51].

Biological Actions

Cardiovascular Activity

Corchortoxin (strophanthidin), a cardiac aglycone, isolated from the seeds of *C. capsularis* showed a cardiac activity similar to digitalis genins, which however, was not better than the activity of seed extract[14]. Corchorosides A and B isolated from the seeds of *C. capsularis* and *C. olitorius* were also found to have a digitalis like action[20]. Esterification of OH group in position 3′ and 4′ of corchoroside A and in position 3′, 4′ and 19 of corchorosol A by acetic acid led to a number of new acetylated cardenolides, the partially acetylated derivatives of which were separated by TLC. Corchorosol derivatives were more effective on heart than the corchoroside derivatives. Parenteral activity decreased with an increase in the acetylation degree while the enteral activity decreased under these conditions[73]. All cardenolides, oligoglycosides (corchorusosides A-E) isolated from the seeds of *C. olitorius* showed potent inhibitory activity against Na, K -ATPase, which was equivalent to that of digitoxin ouabain[33].

Clinical effects of Soviet manufactured strophanthoids (cardiac glycosides with strophanthin like action i.e. rapidity of effect, effect on coronary vessels, degree of diastolic effect, diuretic action etc.) were studied on 2000 human patients with cardiac decompensation. Most active drugs were found to be olitoriside and corchoroside from *C. olitorius*[74].

Seed extract of *C. olitorius* was tested on seven isolated intact Langendroff perfused rabbit hearts. Left ventricular pressure, coronary flow and heart rate were recorded. The effects of seeds extract with three different concentrations (1.28, 12.8 and 128 mg/ml) showed that at low concentration, the seed extract induced an increase in both left ventricular pressure and coronary flow. The increase was found statistically significant for left ventricular pressure. At high concentration, left ventricular pressure and coronary flow decreased significantly, while the heart rate increased sharply and terminated with ventricular fibrillation. Results suggested the presence of active ingredients in the seed extract associated with direct effects on the myocardium[75].

A new glycoside from *C. fascicularis* showed spasmolytic action on guinea pig ileal smooth muscle against acetylcholine-, bradykinin-, and histamine-induced contractions. This glycoside showed positive colour reactions for flavonoids and gave glucose on hydrolysis. It showed little cardiodepressant activity in amphibian heart perfusion[76].

Antihistaminic Activity

Corchoionoside A **40**, B **41** and (6*S*, 9*R*)- roseoside **43** from *C. olitorius* inhibit the histamine release from rat peritoneal exudate cell induced by antigen- antibody reaction[63].

Hepatobiliary, Renal and Haematological Changes

An increase in body weight (including weight of liver) was noticed in test animals after feeding with a protein-enriched diet from *C. olitorius* seeds. AST, ALT and total lipid of liver increased significantly whereas AST and ALT of serum decreased[77]. A cholesterol free diet containing dried green leaves powder of *C. olitorius* lowered hepatic cholesterol concentration and increased neutral fecal bile acid and neutral sterols excretion in rats[78].

Effects of multiple weekly dose of methanolic extract of *C. olitorius* (15, 20, 25 mg/kg.i.p.) on liver and kidney functions and haematological parameters in mice were studied. No significant alteration of RBC count and haemoglobin content was observed in all dose levels of the treatment whereas significant increase in clotting time was seen in moderate and high doses. The extract caused significant increase in WBC count only at a high dose level of treatment. SGOT, SGPT, NPN and plasma cholesterol levels increased significantly at medium and high dose levels. Serum alkaline phosphatase and total bilirubin levels were also increased by both moderate and high dose levels of treatment. Low doses of the extract did not exhibit any significant change of creatinine and serum protein levels, but the high dose level significantly increased creatinine level[79].

Antimalarial Activity

Aqueous extract of *C. olitorius* showed a strong growth inhibition (>96%) of the malaria parasite *Plasmodium falciparum*[80].

Anticonvulsant Activity

Methanolic extract of *C. olitorius* showed a significant anticonvulsive activity by altering the levels of catecholamines and brain amino acids in mice[81].

Antioesterogenic Activity

Methanolic extract of *C. olitorius* seeds[82] caused a remarkable delay in sexual maturation in mice as evidenced by the age at vaginal opening and appearance of first esterus (cornified smear). It also resulted in a significant diminution of Δ^5-3β-hydroxysteroid dehydrogenase (HSD) and glucose-6- phosphate dehydrogenase (G-6-PD) activity along with a reduction in the weight of ovary, uterus and pituitary. The probable cause of delayed maturation may be due to the suppressed ovarian steroidogenesis.

Methanolic extract of *C. olitorius* seeds[83] arrested normal oestrus cycle of adult female mice and significantly decreased weight of ovaries and uterus. Cholesterol and ascorbic acid contents in ovaries were significantly increased in treated mice. After 17 days of treatment, two key enzymes, Δ^5 -3- β-hydroxysteroid dehydrogenase and glucose-6-phosphate dehydrogenase, were decreased significantly. High level of substrates and low level of enzymes indicated inhibition of steroidogenesis in treated mice, which may be due to the presence of flavonoids.

Anticancerous Activity

Alcoholic extract of entire plant *C. aestuans* showed anti-cancer activity against human epidermal carcinoma of the nasopharynx in tissue culture[84].

Analgesic and Antipyretic Activity

Cordepressic acid[85] **22** possesses antipyretic activity on yeast-induced pyrexia at a dose of 100 mg/kg body weight in albino rats. The effect was particularly marked when it was administered intraperitoneally. It also exhibited a significant analgesic activity on acetic acid induced writhing in mice at a dose of 100 mg/kg orally and on response to electrical stimulus of mice in pododolorimeter at a dose of 500 mg/kg orally. However, it was devoid of analgesic activity against thermal/ mechanical stimuli. Toxicity studies showed it tolerant up to 500 mg/kg, i.p. in mice. *C. depressus* whole plant extract[86] (hexane & chloroform soluble) exhibited prominent antipyretic activity in rabbits receiving subcutaneous yeast injections and it did not show any toxic or adverse effect up to an oral dose of 1.6 g/kg.

Inhibitory Effect on Nitric Oxide Production

Corchorifatty acids A **65**, B **66** and C **67** showed an inhibitory effect on lipopolysaccharide-induced NO production in cultured mouse peritoneal macrophages[72].

Acknowledgements

The authors are thankful to (late) Hakeem Abdul Hameed Sahib, Founder, Chancellor and Builder of Hamdard University and to Mr Abdul Mueed, President, Hamdard National Foundation for providing infrastructural facilities and for their keen interest in these studies.

References

1 *The Wealth of India, Raw Materials*, vol 2 (National Institute of Science Communication and Information Resources, CSIR, New Delhi) 1950, 326-346.

2 Chopra R N, Chopra I C, Handa K L & Kapoor C D, *Indigenous Drugs of India* (UN Dhar & Sons, Kolkatta) 1958, 501-502.

3 Satyavati G V, Raina M K & Sharma M, *Medicinal Plants of India*, vol I (ICMR, New Delhi) 1976, 278-281.

4 Wahid A & Siddiqui H H, *A Survey of Drugs*, 2nd edn (Published by IHMMR, Delhi) 1961, 151; 4 a. Hakim A, *Bustanul Mufradat* (Zafar Book Depo, Delhi) 1999, 100; 4 b. Kabiruddin, *Makhzanul Mufradat* (Faisal publications, Deoband) 2000, 139.

5 Bhatt D C, Patel A M, Parekh P P & Parmar R P, Plants used for sexual debility in central Gujarat (India), *J Econ Taxon Bot*, **27** (2003) 943-946.

6 Sen N K, Constitution of corchorin- the active principle of jute seeds (*Corchorus capsularis*). I., *J Indian Chem Soc*, **7** (1930) 905-911.

7 Soliman G & Saleh W, Constituents of the seeds of *Corchorus olitorius*. l. Corchorin and its identity with strophanthidin, *J Chem Soc*, (1950) 2198-2200.

8 Alam A, Khalique A & Ahmed M, Constitution of corchorin, a bitter principle of jute seeds, *Curr Sci*, **23** (1954) 332.

9 Moslemuddin M & Ahmed M, Corchorin. I, *J Indian Chem Soc*, **32** (1955) 577-580.

10 Chaudhury D N & Dutta P C, Corchorin, the bitter principle of *Corchorus capsularis* (jute seeds), *J Indian Chem Soc*, **28** (1951) 167.

11 Saha H & Choudhuri K N , Capsularin, a glucoside from jute leaf, *J Chem Soc*, **121** (1922) 1044-1046.

12 Sen N K, Constitution of corchoritin –A new crystalline bitter from jute seeds. l, *J Indian Chem Soc*, **8** (1931) 651-665.

13 Khalique M A & Ahmed M, Corchsularin. A new bitter from jute seeds. l. Its isolation and constitution of corchsularose, *J Org Chem*, **19** (1954) 1523-1528.

14 Karrer P & Banerjee P, Corchortoxin, a cardiac agent from jute seeds, *Helv Chim Acta*, **32** (1949) 2385-2392.

15 Sen N K & Chakravarti J K, Corchorgenin: A cardiac principle from *Corchorus olitorius*, *Sci and Cult*, **19** (1953) 102.

16 Chakravarti J K & Sen N K, Bitter constituents of the seeds of *Corchorus olitorius*; corchorgenin, a new cardiac-active aglycone, *J Am Chem Soc*, **76** (1954) 2390-2392.

17 Sen N K, Chakravarti J K, Kreis W, Tamm C & Reichstein T, Glycosides and aglycones. CLXXXIV. Glycosides of the jute seeds of *Corchorus capsularis* and *C. olitorius*. Identification of corchorin, corchorigenin, and corchsularin with strophanthidin, *Helv Chim Acta*, **40** (1957) 588-592.

18 Orlov V K & Lazur G V, Glycosides of jute seeds. II, *Zhur Khim*, **27** (1957) 3-10 [*Biol Khim Abst*, 1958, abstr 10088].

19 Orlov V K,The glycosides of jute seeds. III, *Zhur Khim*, **1** (1958) 123-128 [*Biol Khim Abstr,* 1959, abstr 12679].

20 Frerejacque M & Durgeat M, Digitalis like poisons of jute seed, *Compt Rend*, **238** (1954) 507-509.

21 Abubakirov N K, Maslennikova V A & Gorovits M B, Glycosides of *Corchorus olitorius.* I. Olitoriside, *Zhur Obshchei Khim*, **28** (1958) 2279-2283.

22 Abubakirov N K, Maslennikova V A & Gorovits M B, A new glucoside from jute seeds, *Chem Abstr*, **53** (1959) 6290.

23 Abubakirov N K, Maslennikova V A & Gorovits M B, Glucosides of *Corchorus olitorius*. ll. Structure of olitoriside, *Zhur Obshchei Khim*, **29** (1959) 1235-1240.

24 Abubakirov N K, New cardiac glycosides from plants of Central Asia, *Zh Biol Khim Absts*, (1965) Abstract No. 3F 833.

25 Kreis W, Tamm C & Reichstein T, Glycosides and aglycones. CLXXV. Glycosides of the seeds of *Corchorus capsularis*, *Helv Chim Acta*, **40** (1957) 593-604.

26 Samilova R D & Lagodich T A, Olitoriside- A glycoside from the seeds of *Corchorus olitorius* L. (review of the literature) *Vrach Delo*, **1** (1977) 27-31.

27 Rao E V & Rao DV, Cardenolides of the seeds of *Corchorus acutangulus* Lam., *Indian J Pharm*, **30** (1968) 214-216.

28 Loshkarev P M, Corchoroside A, a glycoside from *Corchorus olitorius* seeds, *Aromat Rast*, **15** (1969) 618-628.

29 Ferrari G & Casagrande C, Cardioactive glycoside- corchoroside A, *Chem Abstr*, **70** (1969) 38053.

30 Rao E V & Rao D V, Cardenolides of the seeds of *Corchorus acutangulus*. II polar glycosides, *Indian J Chem*, **7** (1969) 1276.

31 a. Rao E V, Rao K N & Rao D V, Polar glycosides of the seeds of *Corchorus olitorius*, *Indian J Pharm*, **34** (1972) 168; b. Rao D V & Rao E V, Constitution of a new polar glycoside from the seeds of *Corchorus capsularis*, *Indian J Chem*, **10** (1972) 479-481.

32 Maslennikova V A & Abubakirov N K, New jute glycosides. Coroloside and deglucocoroloside, *Bioorg Khim*, (1975) 10.

33 Yukihiro G, Takatoshi N, Shinobu S, Hiroshi M, Kazunari K, Hiroshi A & Masatake T, Identification and analyses of cardiac glycosides in *Corchorus olitorius* and their acute oral toxicity to mice, *Tennen Yuki Kagobutsa Toronkai Koen Yoshishu*, **40** (1998) 371-376.

34 Takatoshi N, Yukihiro G, Shinobu S, Kazunari K, Hiroshi A & Masatake T, Cardenolide glycosides from seeds of *Corchorus olitorius*, *Phytochemistry*, **49** (1998) 2097-2101.

35 Yoshikawa M, Murakami T, Shimada H, Fukada N, Matsuda H, Sashida Y & Yamahara J, Corchorusosides A, B, C, D, and E, new cardiotonic oligoglycosides from the seeds of *Corchorus olitorius* L (moroheiya), *Heterocycles*, **48** (1998) 869-873.

36 Yukhihiro G, Shinobu S, Takatoshi N, Hiroshi A & Masatake T, Identification and analysis of main cardiac glycosides in *Corchorus olitorius* seeds and their acute oral toxicity to mice, *J Food Hyg Soc Japan*, **39** (1998) 256-265.

37 Rao E V & Rao DV, Isolation of erysimoside from the seeds of *Corchorus capsularis*, *Indian J Pharm*, **33** (1971) 58-59.

38 Anna K, Phytochemical investigations on *Corchorus hirtus* var. *pilobolus*, *Diss Pharm Pharmacol*, **21** (1969) 45-57.

39 Schmersahl P, Occurrence of helveticoside in *Corchorus capsularis* and *C. olitorius* seeds, *Tetrahedron Lett*, **10** (1969) 789-790.

40 Rao E V & Rao D V, Second Indo Soviet Symposium, Cardenolides from the seeds of *Corchorus capsularis*, *Chemistry of Natural Products including Pharmacology* (New Delhi) 1970.

41 Rao D V & Rao E V, New cardenolides from the seeds of *C. trilocularis*, *Phytochemistry*, **14** (1975) 533-537.

42 Rao E V, Rao D V, Pavanaram S K, Von, E J & Reichstein T, Glycosides and aglycones, 329, Structure of corchoroside B, *Helv Chim Acta*, **54** (1971) 1960-1968.

43 Rao E V, Rao K N & Rao D V, Cardenolides from the seeds of *Corchorus olitorius*, *Curr Sci*, **42** (1973) 731-732.

44 Qudrate- i- Khuda M, Khalique A & Das D C, Study of jute leaf. l. Constituents of the leaf, *Sci Res*, **2** (1965) 152-159.

45 Ohtani K, Okai K, Yamashita U, Yuasa I & Misaki A, Characterization of an acidic polysaccharide isolated from the leaves of *Corchorus olitorius* (Moroheiya), *Biosci Biotechnol Biochem*, **59** (1995) 378-381.

46 Manzoor-i-Khuda M & Islam A, Chemical constituents of jute- *Corchorus capsularis* and *Corchorus olitorius*, *Pak J Sci Ind Res*, **13** (1970) 363.

47 Rao E V, Rao D V & Reddy V M, Oligosaccharide components of the seeds of *Corchorus capsularis* and *C. acutangulus*, *Indian J Pharm*, **32** (1970) 17-18.

48 Khaleque A, Hannan A & Mollah A M, Examination of jute plant (*Corchorus capsularis*). 1. Constituents of the bark, *Bangladesh J Biol Agric Sci*, **1** (1972) 64-69.

49 a. Manzoor -i- Khuda M & Islam A, Chemical constituents of *Corchorus olitorius* and *Corchorus capsularis* (jute).ll. isolation of corosin & sitosterol from roots, *Pak J Sci Ind Res*, **14** (1971) 49-56; b. Manzoor -i- Khuda M & Gerhard H, Chemical constituents of *Corchorus capsularis* and *C. olitorius* (jute plant) III, structure of corosin, *Z Naturforsch*, **29** (1974) 209-221.

50 Manzoor -i- Khuda M & Gerhard H, Chemical constituents of *Corchorus capsularis* and *C. olitorius* (jute plant Part IV, isolation of corosolic acid, ursolic acid and oxo-corosin and correlation of corosin with tormentic acid, *Z Naturforsch*, **34** (1979) 1320-1325.

51 Kohda H, Tanaka S, Yamaoka Y, Moringa S, Ohara Y, Constituents of *Corchorus olitorius* L, *Nat Med*, **48** (1994) 213-214.

52 Mahato S B & Pal B C, Triterpenoid glycosides of *Corchorus acutangulus* Lam, *J Chem Soc Perkin Trans I*, **3** (1987) 629-634.

53 Mahato S B, Pal B C & Sarkar S K, New triterpenoids saponins from *Corchorus acutangulus*, *Phytochemistry*, **27** (1988) 1433-1438.

54 Kapoor S K, Ahmad P I & Zaman A, Chemical examination of *Corchorus fascicularis*, *Indian J Appl Chem*, **34** (1971) 237.

55 Khan M S Y, Javed K, Khan M H, Shamsi M A & Siddiqui A A, α-amyrin derivatives from *Corchorus depressus*, *Phytochemsitry*, **30** (1991) 1989-1992.

56 Ahmad V U, Ali A, Ali Z, Baqai F T & Zafar F N, Cycloartane triterpene glycosides from *Corchorus depressus*, *Phytochemistry*, **49,** (1998) 829-834.

57 Ahmad V U, Ali A, Ali Z, Zafar F N & Zahid M, Novel cycloartane saponins from *Corchorus depressus* L, *Chem Pharm Bull*, **48** (2000) 1597-1601.

58 Zahid M, Ali A, Ishurd O, Ahmed A, Ali Z, Ahmad V& PanY, New cycloartane and flavonol glycosides from *Corchorus depressus*, *Helv Chim Acta*, **85** (2002) 689-697.

59 Hasan C M, Islam A, Ahmed M, Ahmed M & Waterman P G, Capsugenin, a dammarane triterpene from *Corchorus capsularis*, *Phytochemistry*, **23** (1984) 2583-2587.

60 Quader M A, Gray A I, Waterman P G, Lavaud C, Massiot G, Hasan C M & Ahmed M D, Capsugenin 25,30-O-β- diglucopyranoside: a new glycoside from the leaves of *Corchorus capsularis, J Nat Prod*, **53** (1990) 527-530.

61 Quader M A, Ahmad M, Hasan C M & Waterman P G, Capsugenin-30-O-beta- glucopyranoside: A new glycoside from the leaves of *Corchorus capsularis*, *J Nat Prod*, **50** (1987) 479-481.

62 Ahmad A, Asim M, Zahid M, Ali A & Ahmad V U, New Triterpenoids from *Corchorus trilocularis*, *Chem Pharm Bull*, **51** (2003) 851-853.

63 Yoshikawa M, Shimada H, Saka M, Yoshizumi S, Yamahara J & Matsuda H, Medicinal foodstuffs. V. Moroheiya (1): Absolute stereostructures of corchoionosides A, B and C, histamine inhibitors from the leaves of Vietnamese *Corchorus olitorius* L.(Tiliaceae), *Chem Pharm Bull*, **45** (1997) 464-469.

64 Sharma J N & Seshadri T R, Survey of anthocyanins from Indian sources, ll, *J Sci Ind Res*, **14B** (1955) 211-214.

65 Sharma R C, Khan M S Y, Zaman A & Kidwai A R, Chemical examination of *Corchorus acutangulus*, *Indian J Chem*, **1** (1963) 502.

66 Harsh M L & Nag T N, Flavonoids with antimicrobial activities of arid zone plants, *Geobios*, **15** (1988) 32-35.

67 Azuma K, Nakayama K, Koshioka M, Ippoushi K, Yamaguchi Y, Kohata K, Yamauchi Y, Ito H & Higashio H, Phenolic antioxidants from the leaves of *Corchorus olitorius* L, *J Agric Food Chem*, **47** (1999) 3963-3966.

68 Mukherjee K K, Mitra S K & Ganguly S N, A new coumarin from the seeds of jute (*Corchorus olitorius* L.), *Nat Prod Sci*, **4** (1998) 51-52.

69 Soliman G & Saleh W, Constituents of the seeds of *Corchorus olitorius*, ll, Isolation of beta sitosterol and corchorolic acid, *J. Chem Soc*, (1954) 1506-1508.

70 Islam A, Mahtab R & Ahmed M, Isolation and structural studies of a new triterpene glucoside from the leaves of *Corchorus capsularis* Linn, *J Bangladesh Acad Sci*, **4** (1980) 155-156.

71 Sen Gupta A & Mazumder U K, The triglyceride composition of *Corchorus olitorius* seed oil, *J Sci Food & Agr*, **24** (1973) 1391-1395.

72 Yoshikawa M, Murakami T, Shimada H, Yoshizumi S, Saka M, Yamahara J & Mastsuda H, Medicinal food stuffs XIV, on the bioactive constituents of moroheiya (2): New fatty acids, corchorifatty acids A, C, D, E and F, from the leaves of *Corchorus olitorius* L (Tiliaceae): structures and inhibitory effect on NO production in mouse peritoneal macrophages, *Chem Pharm Bull*, **46** (1988) 1008-1014 and Yoshikawa M, *Chem Abstr*, **131** (1999) 341961.

73 Schumersahl P, Semisynthetic derivatives from cardenolides of *Corchorus* species, *Arch Pharm Ber Deutsch Pharm Ges*, **304** (1971) 307-314.

74 Leshchinskii L A, Karbasnikova G V, Zebelyan O M & Vasilkova A A, Use of some cardiac glycosides with strophanthin like action in the pharmacotherapy of chronic circulatory insufficiency, *Kardiologiya*, **18** (1978) 76-83.

75 Khatib S, Alkofahi A, Hasan M, Najib N & El- oqlah A, Effect of *Corchorus olitorius* seed extract on left ventricular pressure, coronary flow and heart rate of the isolated rabbit heart, *Biomedical Letters*, **57** (1998) 147-152.

76 Tariq M, Bhardwaj S L, Sharma R C, Gupta S K, Gupta L, Pharmacological studies on the glycoside isolated from *Corchorus fasciculasis* Lam, *Indian J Exp Biol*, **11** (1973) 248-249.

77 Laskar S, Majumder S G, Basak B & Dey C D, Influence of jute (*Corchorus olitorius*) seed protein enriched diet on some enzymes and liver lipids of albino rats (*Rattus novergicus*), *Physiol Bohemoslov*, **35** (1986) 86-89.

78 Innami S, Tabata K, Shimizu J, Kusunoki K, Ishida H, Matsuguma M, Wada M, Sugiyama N & Kondo M, Dried green leaf powders of Jew's mellow (*Corchorus olitorius*), persimmon (*Diosphyros kaki*) and sweet potato (*Ipomoea batatas* Poir) lower hepatic cholesterol concentration and increase fecal bile acid excretion in rats fed a cholesterol- free diet, *Plant foods Hum Nutr*, **52** (1998) 55-65.

79 Mazumder U K, Gupta M, Pal D K & Bhattacharya S, Chemical and toxicological evaluation of methanol extract of *Cuscuta reflexa* Roxb. stem and *Corchorus olitorius* Linn seed on haematological parameters and hepatorenal functions in mice, *Acta Pol Pharm*, **60** (2003) 317-323.

80 Sathiamoorthy P, Lugasi E H, Schlesinger P, Kedar I, Gopas J, Pollack Y & Golan G A, Screening for cytotoxic and antimalarial activities in desert plants of the Negev and Bedouin market plant products, *Pharmaceutical Biol*, **37** (1999) 188-195.

81 Gupta M, Mazumder U K, Pal D K, Bhattacharya S & Chakrabarty S, Studies on brain biogenic amines in methanolic extract of *Cuscuta reflexa* Roxb. and *Corchorus olitorius* Linn seed treated mice, *Acta Pol Pharm*, **60** (2003) 207-210.

82 Gupta M, Mazumder U K, Pal D K & Bhattacharya S, Onset of puberty and ovarian steroidogenesis following administration of methanolic extract of *Cuscuta reflexa* Roxb. stem and *Corchorus olitorius* Linn seed in mice, *J Ethnopharmacol*, **89** (2003) 55-59.

83 Gupta M, Mazumder U K, Pal D K & Bhattacharya S, Antisteroidogenic activity of methanolic extract of *Cuscuta reflexa* Roxb. stem and *Corchorus olitorius* Linn seed in mouse ovary, *Ind J Exp Biol*, **41** (2003) 641-644.

84 Bhakuni D S, Dhar M L, Dhar M M, Dhawan B N & Mehrotra B N, Screening of Indian plants for biological activity, Part II, *Indian J Exp Biol*, **7** (1969) 250-262.

85 Vohora S B, Shamsi M A & Khan M S Y, Antipyretic and analgesic studies on the diacetate of a new triterpenic acid isolated from *Corchorus depressus* L, *J Ethnopharmacol*, **4** (1981) 223-228.

86 Ikram M, Khattak S G & Gilani S N, Antipyretic studies on some indigenous Pakistani medicinal plants II, *J Ethnopharmacol*, **19** (1987) 185-192.