*Bangladesh Pharmaceutical Journal* **17**(1): 63-79, 2014 **- Review paper**

# Review on Chemistry and Bioactivities of Secondary Metabolites from Some Medicinal Plants and Microbes of Bangladesh

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**Abstract**

Plants and microorganisms, being the major source of many drugs, have attracted scientists from ancient times. However, until recently an insignificant part of the plants and some microorganisms have scientifically been evaluated for their medicinal values. The present study was undertaken to discover new drug candidates from natural sources. Extensive chemical studies with 60 medicinal plants and several microbial strains of Bangladesh have resulted in the isolation and characterization of 150 compounds, including 50 new molecules. Terpenoids and alkaloids were the major constituents among the isolated compounds. The crude extractives and several purified molecules demonstrated statistically significant inhibition of growth of microorganisms, antioxidant, antidiabetic and HIV-inhibitory activities. Usnic acid, a lead compound isolated from the lichen, *Parmelia kamtschandalis*, showed potent antimicrobial activity, whereas dehydroaltenusin obtained from a *Streptomyces* sp. exhibited significant HIV-inhibitory effects.

*Keywords:* Medicinal Plants, secondary metabolites, antioxidant, antidiabetic, HIV-inhibitory activity.

## Introduction

Medicinal plants are the blessings for any country which contribute a lot for traditional health management as well as providing lead compounds for modern drug discovery. The varieties of molecules contained in plants have been proved to combat complicated diseases. Based on this, natural product scientists have always focused on the isolation of bioactive compounds from these precious herbs and trees. In addition, the giant pharmaceutical companies are also capitalizing these scopes for incorporating new drugs in the market (Burnett *et al.,* 2012; Christen and Cuendet, 2012; Hung *et al*., 2012; Lovkova *et al*., 2001 and Newman and Cragg, 2012).

Bangladesh being a subtropical country is a good repository of plants. There are around 5000 angiosperms distributed among 200 families. Approximately, 500 of these are being used in the traditional medicines for the treatment of different types of diseases. A significant percentage of the population depends on the natural product based medicines. In addition, the total medicinal plant market of Bangladesh is equivalent to US$14 billion each year. As part of our continuing studies on plants here, we summarize the chemistry and bioactivities of some of the isolated constituents from 48 medicinal plants of Bangladesh (Ara *et al*., 2006; Begum *et al*., 2011; Islam *et al*., 2009; Jahan *et al.*, 2009 and Rahman *et al*., 2011).

## Materials and Methods

*Chemical:* The chemical investigation of a plant involved collection and prop er identification of the plant materials, extraction, fractionation and purification of compounds and structural characterization of the purified secondary metabolites. On the other hand, the culture filtrate of the microorganism's broth culture was extracted with ethyl acetate. Various chromatographic techniques (Zhu *et al*., 2003; Moustafa *et al*., 2007; Widodo *et al*., 2008 and Jain and Bari, 2010) were utilized for isolation and purification of the compounds from the extractives. The structures of the purified compounds were determined by extensive analyses of UV, IR, NMR and mass spectroscopic data as well as by chemical derivatization, when needed. Whenever possible, the crude extracts, fractions and purified compounds were subjected to bioassays (e.g.

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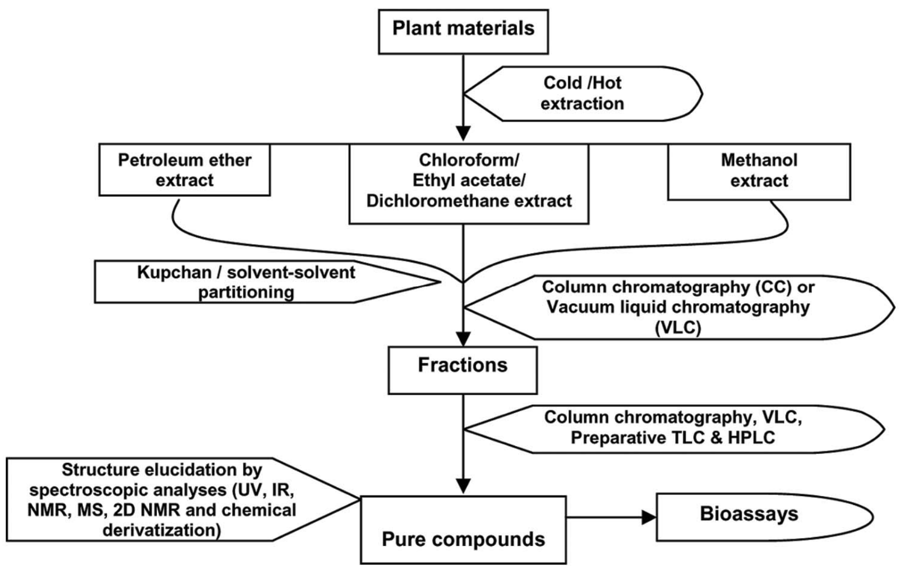
antimicrobial activity, antioxidant, antidiabetic, HIV inhibitory activities etc.) The whole process can be explained by scheme 1.

*Antimicrobial activity:* The antimicrobial activity of the purified compounds (Bhilabutra *et al*., 2007; Ahamed *et al*., 2007 and Ghani *et al*., 2012) was determined by the disc diffusion method (Sunilson *et al*., 2009). The bacterial strains were collected as pure cultures from the Institute of Nutrition and Food Science (INFS), University of Dhaka, Bangladesh. The samples were dissolved separately in chloroform and applied to sterile discs at 100 or 30 µg/ disc and carefully dried to evaporate the residual solvent. Here, kanamycin, amoxicillin, streptomycin and tetracycline were used as standard antimicrobial agents.




Scheme 1. Isolation, purification and bioassay of compounds.

*Antioxidant activity:* The antioxidant (free radical scavenging) activity of the compounds was assessed by the method of Brand-Williams (Brand-Williams *et al*., 1995; Aher *et al*., 2009 and Ham *et al*., 2010). Percentage inhibitions were plotted against respective concentrations used and from the graph obtained, the $IC_{50}$ was calculated. Tert-butyl-1-hydroxytoluene (BHT), a potential antioxidant, was used as positive control.

*Antidiabetic activity:* Antidabetic activity was investigated on alloxan-induced Long Evan's rats following the procedure published elsewhere (Mansour *et al*., 2002). The rats (weighing 100-200 g were used for the study) were obtained from international Centre for Diarrheal Disease Research, Bangladesh (ICDDR,B), Dhaka. The experimental procedure is shown in Table 1.

*Anti-HIV assay:* The purified compound was dissolved in DMSO, diluted to the desired concentration and tested in a XTT-based *in vitro* anti-HIV assay (Gulakowski *et al*., 1991).

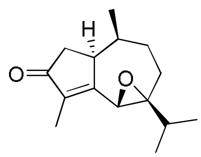
**Table 1. Design of the experiment for antidiabetic study.**

| | Phase-1 | Phase-2 |
|---|---|---|
| Test materials | Methanol extract of whole plant | Eclalbasaponin II |
| Duration | 4 weeks | 1 week (due to lack of sample) |
| Group of rats | | |
| Gr-1 | Normal untreated | Normal untreated |
| Gr-2 | Alloxan treated | Alloxan treated |
| Gr-3 | Glibenclamide treated (600 µg/kg bw orally) | Glibenclamide treated (600 µg/kg bw orally) |
| Gr-4 | Plant extract treated (300 mg/kg bw orally) | eclalbasaponin II treated orally (10 mg/kg bw orally) |
| Analysis | | |
| Body weight | At weekly interval | After a week |
| Blood sugar | At weekly interval for 28 days | At two days interval for 7 days |
| Hepato-toxicity | ALT, AST and ALP at 28th day | Not done |

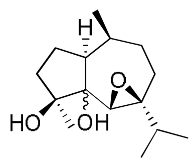
## Results

*Chemical:* Extensive chromatographic separation and purification of the extracts obtained from 48 medicinal plants of Bangladesh afforded a total of 150 pure chemical entities, including 37 new molecules (Rahman *et al*., 2001). The structures of these compounds were elucidated by extensive spectroscopic studies including 2D NMR and MS and chemical derivatization wherever needed. The structures of some of the isolated compounds are shown below:

**Sesquiterpenes from *Amoora rohituka* Roxb. (Meliaceae) (Chowdhury *et al*., 2003)**

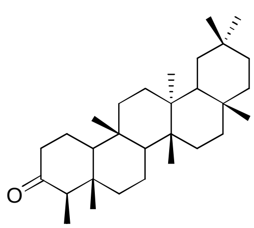


6β,7β-Epoxyguai-4-en-3-one

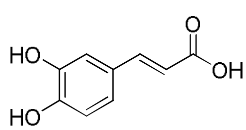


6β,7β-Epoxy-4β,5-dihydroxyguaiane

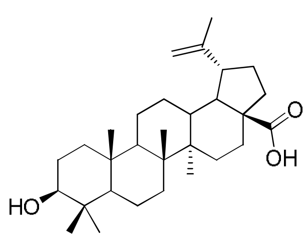
**Triterpenes and phenylpropanoid from *Amoora cucullata* Roxb. (Meliaceae) (Rahman *et al*., 2005), *Corypha taliera* Roxb. (Palmae) (Chowdhury *et al*., 2013) and *Mesua nagassarium* Burm.f. (Clusiaceae) (Islam, 2012)**



Fridelin

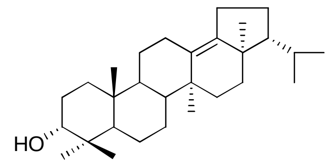


Caffeic acid

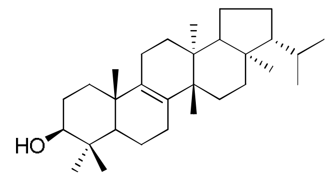


Betulinic acid

**Terpenoids from *Melicope indica* Wt. (Rutaceae) (Farruque *et al*., 2003)**

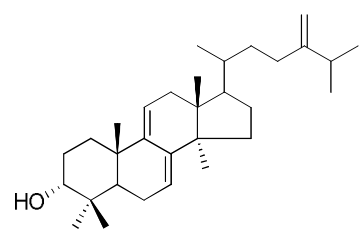


Neohop-13(18)-en-3α-ol

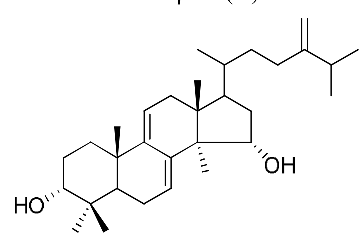


Fern-8(9)-en-3β-ol

**Steroids from *Artabotrys odoratissimus* R.Br (Hasan *et al*., 1987) and B from *Desmos longiflorus* Roxb.(Connolly *et al*., 1994) (Annonaceae)**

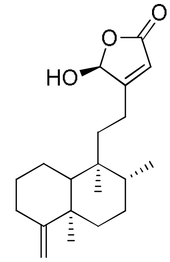


24-Methylene-lanosta-7,9(11)-dien-3β-ol (A)

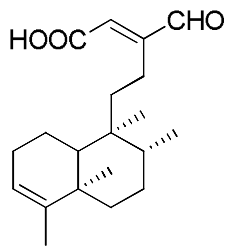


15α-Hydroxy-24-methylene-lanosta-7,9(11)-dien-3-ol (B)

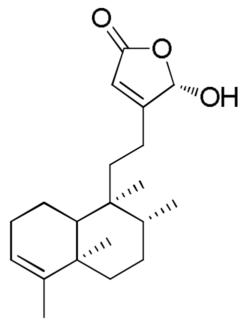
**Diterpene from *Polyalthia longifolia* var. *pendulla* (Annonaceae) (Hasan *et al*., 1995)**



16β-Hydroxykolava-4,3*Z*-dien-15,16-olide

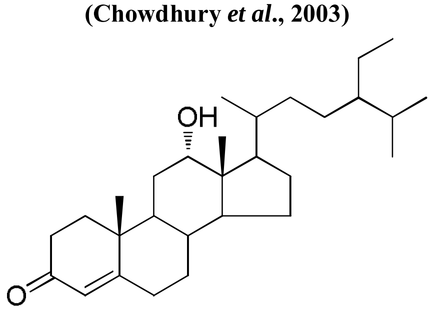


(-)-16-oxocleroda-3,13(14)*E*-dien-15-oic acid



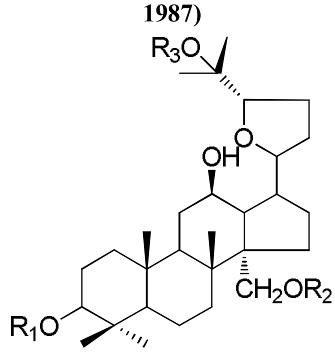
(-)-16α-hydroxycleroda-3,13 (14)*Z*-dien-15,16-olide

**Steroid from *Toona ciliata* M. Roem (Meliaceae) (Chowdhury *et al.*, 2003)**



12α-Hydroxystigmast-4-en-3-one

**Triterpene glycosides from *Corchorus capsualris* L. (Tiliaceae) (Hasan *et al.*, 1984; Quader *et al.*, 1987)**

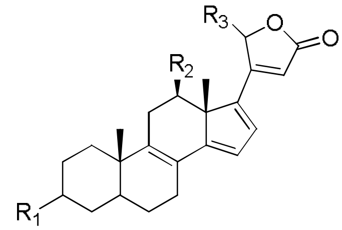


$R_1 = R_2 = R_3$ = H: Capsugenine

$R_1 = R_3$ = H, $R_2$= Glucose: Capsugenine-30-*O*-β-glucopyranoside

$R_1$= H, $R_2 = R_3$= Glucose: Capsugenine-25, 30-*O*-β-glucopyranoside

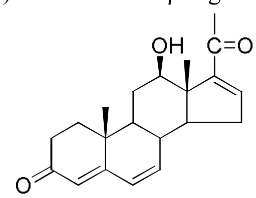
**Steroids from *Nerium oleander* L. (Apocynaceae) (Huq *et al.*, 1999a; Huq *et al.*, 1999b)**



$R_1$= OH, $R_2$= $R_3$= H: 3-Hydroxy-5-carda-8,14,16,20(22)-tetraenolide

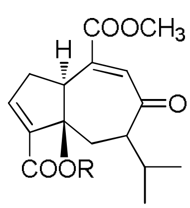
$R_1$= $R_3$= H, $R_2$ = OH: 12-Hydroxy-5-carda-8,14,16,20(22)-tetraenolide

$R_1$= glu, $R_2$= H, $R_3$= OH: 21-Hydroxy-5-carda-8,14,16,20(22)-tetraenolide-3-β-digitaloside



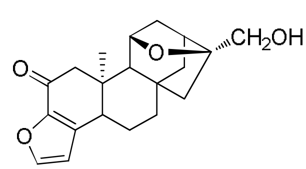
Neridienone A

**Terpenoids from *Polygonum viscosum* Buch. (Polygonaceae) (Datta *et al.*, 2002)**



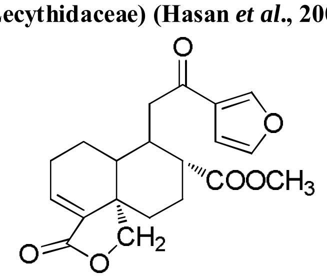
R = H: Viscoazusone; R = $CH_3$: Viscoazulone

**Terpenoids from *Coffea bengalensis* Roxb. (Rubiaceae) (Hasan *et al.*, 1995)**

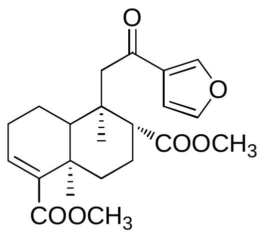


Bengalensol

**Diterpenoids from *Barringtonia recemosa* L. (Lecythidaceae) (Hasan *et al.*, 2000)**

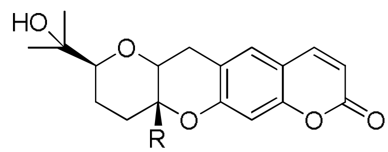


Nasimalun A



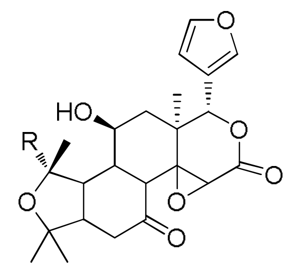
Nasimalun B

**Coumarins and limonoids from *Clausena heptaphylla* Roxb. (Rutaceae) (Begum *et al.*, 2011; Sohrab *et al.*, 1999)**



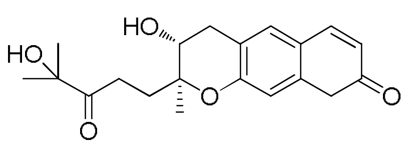
R = H: Lunamarin A;

R = $CH_3$: Lunamarin B

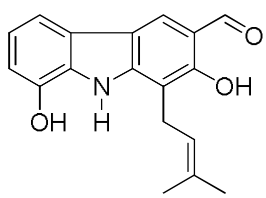


R = OMe: Clausenolide-1-methyl ether

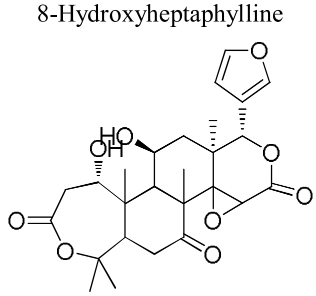
R = OH: Clausenolide



Lunamarin C

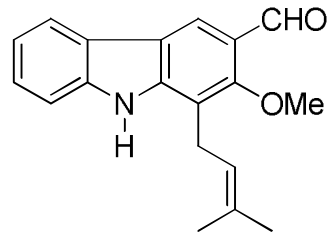


8-Hydroxyheptaphylline

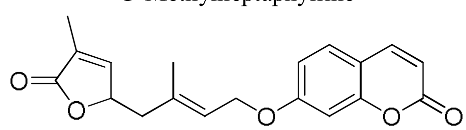


Clausenarin

**Alkaloid and coumarins from *Clausena suffruticosa* Roxb. (Rutaceae) (Begum *et al.*, 2008)**

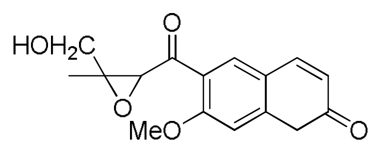


*O*-Methylheptaphylline

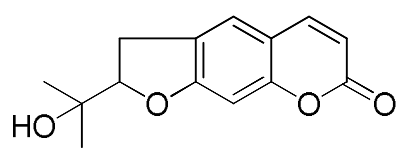


Capnolactone

**Coumarins and flavonoid from *Micromelum minutum* G. Forster (Rutaceae) (Sohrab *et al.*, 2004)**

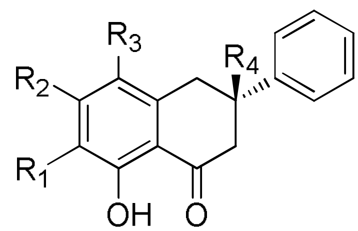


Hopeyhopol



Marmesin

**Flavonoids from *Unona discolor/Uvaria chinensis* Vahl. (Annonaceae) (Asha *et al.*, 2003)**

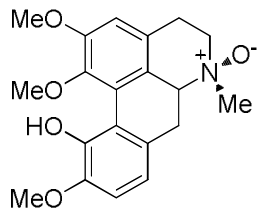


$R_1 = CH_3$, $R_2 = H$, $R_3 = CHO$, $R_4 = H$: 8-Formyl-6-methyl-5-hydroxyflavanone

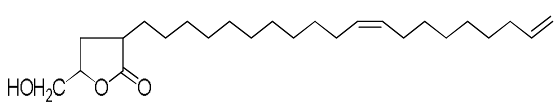
$R_1 = CH_3$, $R_2 = OH$, $R_3 = CHO$, $R_4 = OH$: 8-Formyl-6-methyl-2β,5,7-trihydroxyflavanone

$R_1 = CHO$, $R_2 = OH$, $R_3 = CH_3$, $R_4 = OH$: 6-formyl-8-Methyl-2β,5,7-trihydroxyflavanone

**Alkaloid and Acetogenin from *Miliusa velutina* (Dunal) Hook. (Annonaceae)(Jumana *et al*., 2000a; Jumana *et al*., 2000b)**

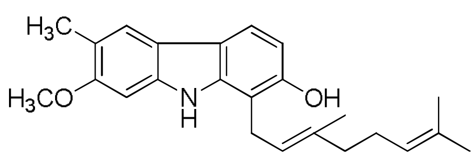


(+)-Isocorydine-α-N-oxide

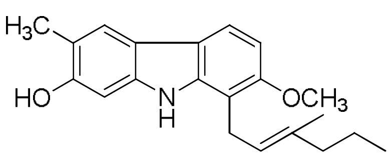


Isogoniothalamusin

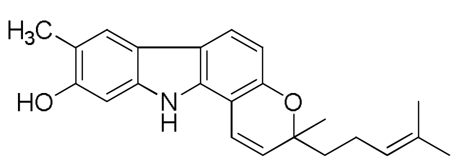
**Coumarins from *Murraya koenigii* L. (Rutaceae) (Nutun *et al*., 1999)**



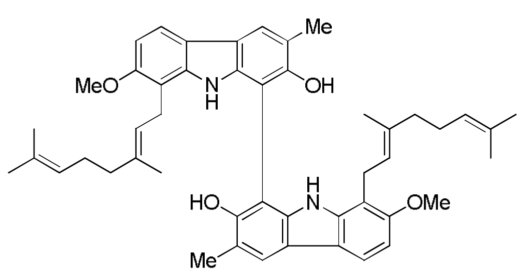
Murrayanol



Isomurrayanol

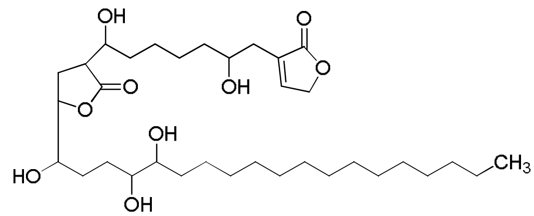


Isomahanime

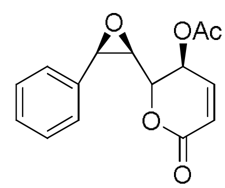


Bismurrayafoline E

**Styryl lactone from *Goniothalamus sesquipedalis* Wall. (Annonaceae) (Hasan *et al*., 1994; Hasan *et al*., 1996)**

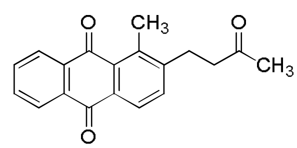


Gigantopentocin

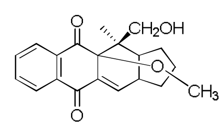


5-Acetoxy isogoniothlamineoxide

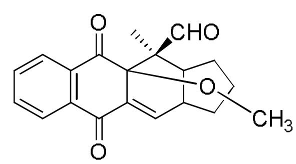
**Anthraquinones and napthaquinones from *Stereospermum chelonoides* (L.f.) DC (Bignoniaceae) (Haque *et al*., 2006)**



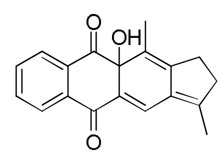
Stereochenol A



Stereochenol B

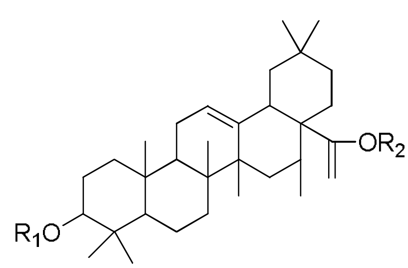


Sterekunthal B



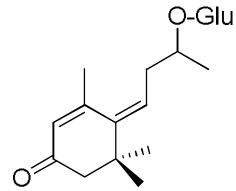
Sterequinone C

**Saponins from *Eclipta prostrata* L. (Asteraceae) (Rahman *et al*., 2006; Rahman and Rashid, 2008)**

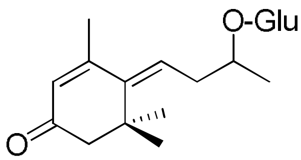


$R_1$ = β-D-glucose, $R_2$ = H: Eclalbasaponin I; $R_1$ = $R_2$ = β-D-glucose; Eclalbasaponin II

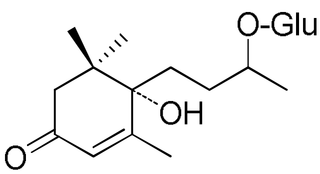
**Glycosides from *Pterospermum semisagittatum* Buch. (Sterculiaceae) (Khan *et al*., 2003)**




(*Z*)-4-[3′-(β-D-Glucopyranosyloxy)-butyli-dene]-3,5,5-trimethyl-2-cyclohexen-1-one

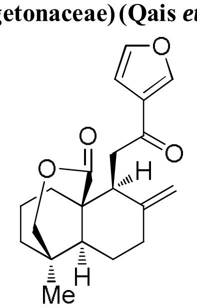



(*E*)-4-[3′-(β-D-Glucopyranosy-loxy)-butyli-dene]-3,5,5-trimethyl-2-cyclohexen-1-one



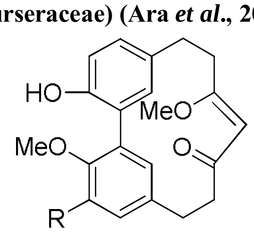

(*E*)-4-Hydroxy-4-[3′-(β-D-glucopyranosyloxy)-butylidene]-3,5,5-trimethyl-2-cyclohexen-1-one

**Diterpenoid from *Potamogeton nodosus* Poir. (Potamogetonaceae) (Qais *et al*., 1998)**



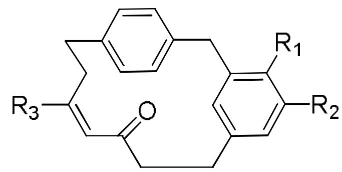

15,16-Epoxy-12-oxo-8(17),13(16),14-labdatrien-20,19-olide

**Diarylheptanoids from *Garuga pinnata* Roxb. (Burseraceae) (Ara *et al*., 2006)**




R = OH: 6'-Hydroxygaruganin V

R = H: Garuganin V



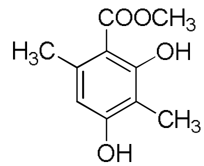

$R_1 = H$, $R_2 = R_3 = OMe$: Garuganin IV

$R_1 = OMe$, $R_2 = H$, $R_3 = OH$: 9'-Desmethylgarugamblin-I

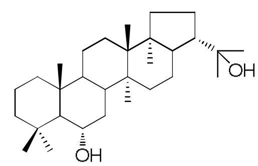
$R_1 = R_2 = R_3 = OMe$: Garuganin III

$R_1 = OH$, $R_2 = R_3 = OMe$: 1-Desmethylgaruganin III

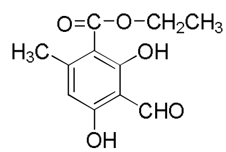
**Triterpene and phenolics from *Parmelia kamtschandlis* Ach. (Parmeliaceae) (Mazid *et al*., 2001)**



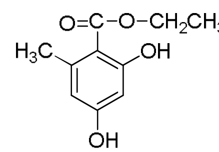

Methyl ß–orsellinate



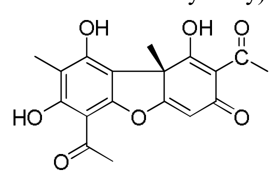

Hopane-6α,22-diol




Ethyl haemmatommate

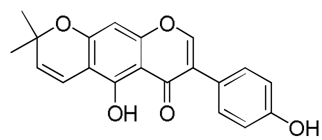



Ethyl (6-methyl-2,4-dihydroxy)-6-benzoate

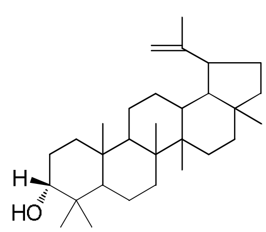



Usnic acid

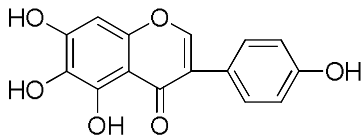
**Flavonoids and triterpene from *Erythrina variegata* L. (Fabaceae) (Rahman *et al*., 2007)**



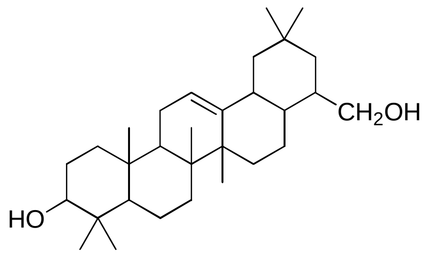

Alpinum isoflavone



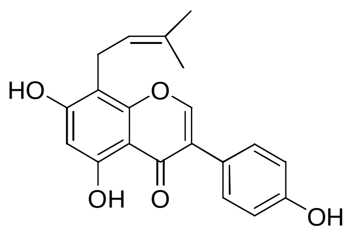

Epilupeol



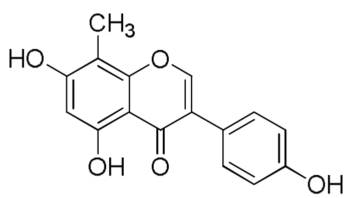
6-Hydroxygenistein



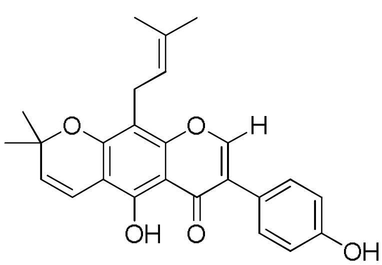
3β,28-Dihydroxyolean-12-ene



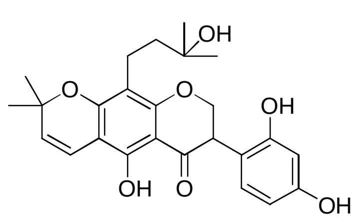
4′,5,7-Trihydroxy-8-prenylisoflavones



4′,5,7-Trihydroxy-8-methylisoflavone

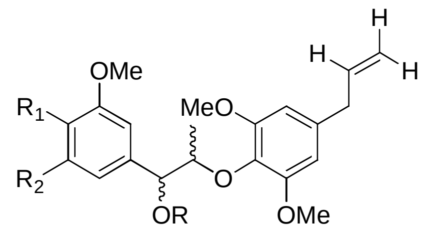


Scandenone



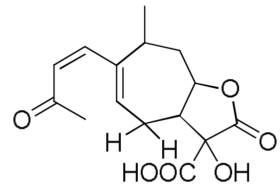
2′,4′,5-Trihydroxyl-8- (3-methylbut-1(*Z*)enyl)-2″,2″-dimethylpyrano [5″,6″:6,7] isoflavanone

**Neolignans from *Quisqualis indica* L. (Combretaceae) (Jahan *et al.*, 2009)**

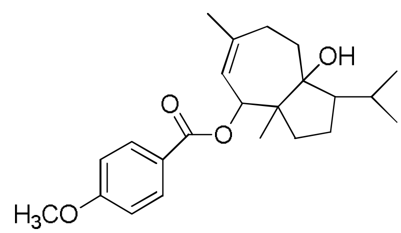


R = $R_2$ = H, $R_1$ = OH:
1-(4-Hydroxy-3-methoxyphenyl)-2-(4-allyl-2,6-dimethoxyphenoxy)-propan-1-ol
R = $R_2$ = H, $R_1$ = OMe:
1-(3,4-Dimethoxyphenyl)-2-(4-allyl-2,6-dimethoxyphenoxy)-propan-1-ol
R = $COCH_3$, $R_1$ = OMe, $R_2$ = H:
1-(3,4-dimethoxyphenyl)-2-(4-allyl-2,6-dimethoxyphenoxy)-propan-1-ylacetate
R = H, $R_1$ = OH, $R_2$ = OMe:
1-(4-Hydroxy-3,5-dimethoxyphenyl)-2-(4-allyl-2,6-dimethoxyphenoxy)-propan-1-ol

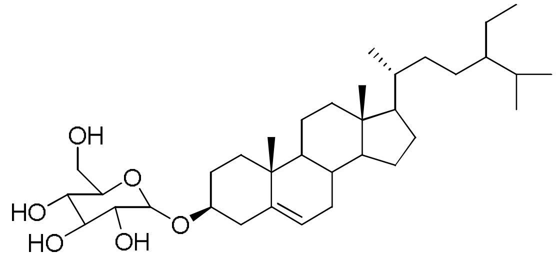
**Terpenoids *Xanthium strumarium* L. (Compositae) (Islam *et al.*, 2009)**



11-Hydroxy-11-carboxy-4-oxo-1(5), 2(*Z*)-xanthadien-12, 8-olide

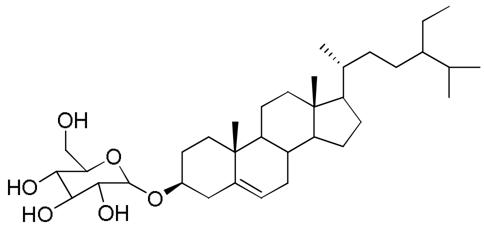


Lasidiol-10-anisate

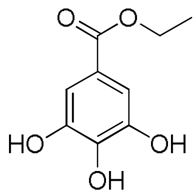


Daucosterol

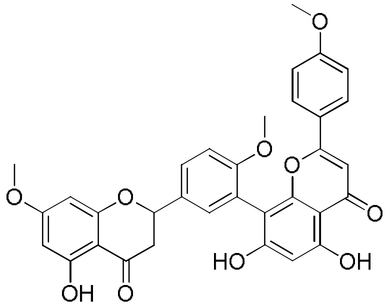
**Polyphenolics from *Podocarpus neriifolius* D. (Podocarpaceae) (Rumzhum, 2008)**




Daucosterol

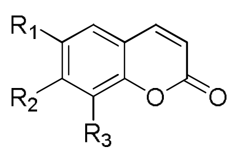



Ethyl gallate

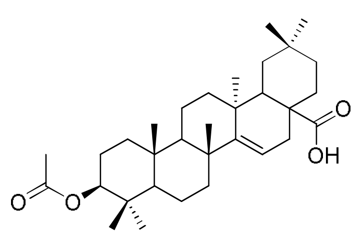



Amentoflavone-4´,4´´´,7- trimethyl ether

**Terpenoids and coumarins from *Jatropha podagrica* Hook. (Euphorbiaceae) (Rumzhum *et al*., 2011)**

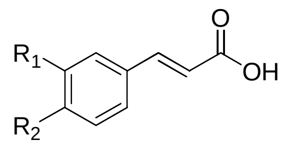



$R_1 = R_2 = COH_3$, $R_3 = OH$ : Fraxidin
$R_1 = COH_3$, $R_2 = R_3 = OH$ : Fraxetin
$R_1 = R_2 = COH_3$, $R_3 = H$ : Scoparone

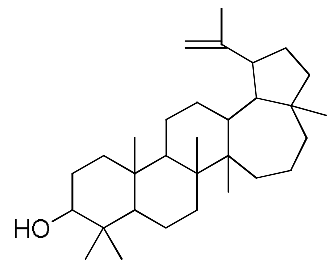



Acetylaleuritolic acid

**Phenylpropanoid and Triterpene from *Albizzia lebbeck* L. (Leguminosae) (Hussain *et al*., 2008), *Corypha taliera* Roxb (Palmae) (Chowdhury *et al*., 2013), *Albizia chinensis* (Osbeck.) Merr. (Fabaceae) (Sharmin *et al*., 2013) and *Mesua nagassarium* Burm.f. (Clusiaceae) (Islam, 2012)**

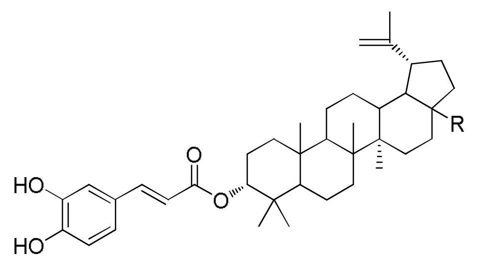



$R_1 = COH_3$, $R_2 = OH$: Methoxycinnamic acid
$R_1 = H$, $R_2 = OH$: Trans-*p*-coumaric acid

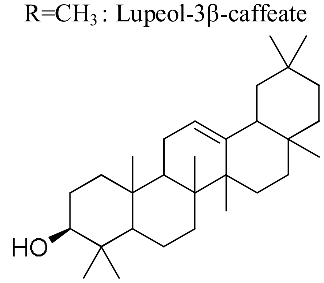



Lupeol

**Triterpenes from *Couroupita guianensis* Aubl. (Lecythidaceae), *Corypha taliera* Roxb (Palmae) (Chowdhury *et al*., 2013), *Bryophyllum daigremontianum* Raym. (Crassulaceae) (Sharker *et al*., 2013) (Begum *et al.,* 2009) and *Glycosmis pentaphylla* (Rutaceae) ( Ahmed, 2013)**

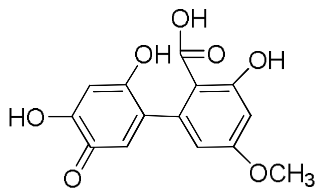



$R=CH_2OH$ : Betulin-3β-caffeate
$R=CH_3$ : Lupeol-3β-caffeate

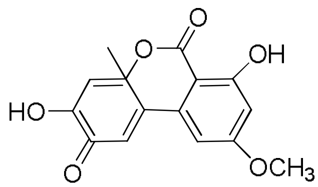



β-Amyrin

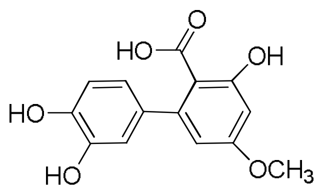
**Unusual phenolic compounds from *Streptomyces* sp. (Jabbar *et al*., 1998)**



Dehyroaltenusinic acid

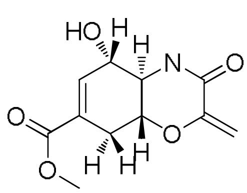


Dehyroaltenusin

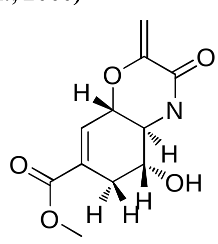


Altenusin

**Secondary metabolite from *Monocillium* sp. (Biswas *et al*., 2000)**

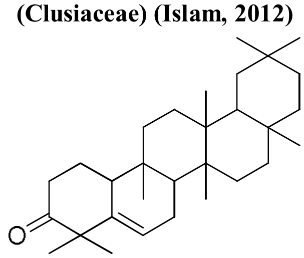


Monocillinol A

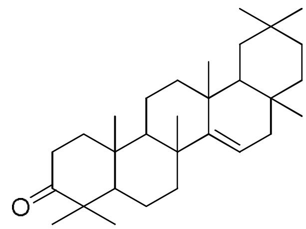


Monocillinol B

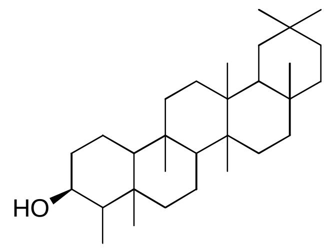
**Triterpenes and flavonoid from *Kalanchoe pinnata (Lam.)* (Crassulaceae) (Sharker *et al*., 2012), *Corypha taliera* Roxb (Palmae) (Chowdhury *et al*., 2013), *Syzygium cumini* L. (Murtaceae) (sikder *et al*., 2012) and *Mesua nagassarium* Burm.f. (Clusiaceae) (Islam, 2012)**



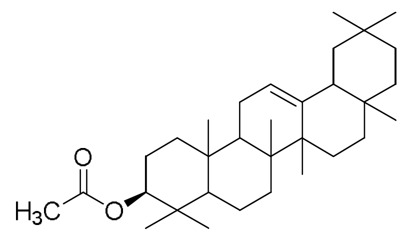
Glut-5(6)-en-3-one



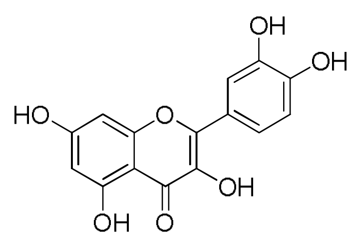
Taraxerone



β-Friedelanol

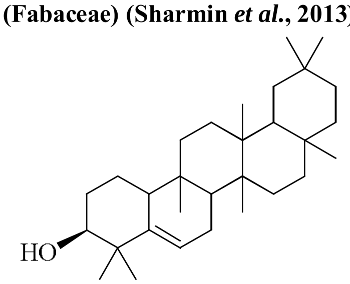


β-Amyrin-3-acetate

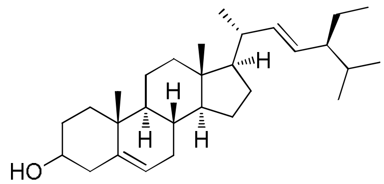


3,5,7,3',5'-Pentahydroxyflavone

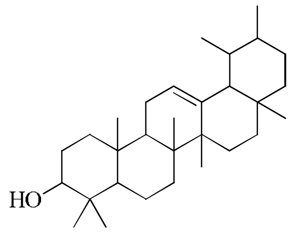
**Triterpenes from *Bryophyllum daigremontianum* (Raym.) (Crassulaceae) (Sharker *et al*., 2013), *Corypha taliera* Roxb (Palmae) (Chowdhury *et al*., 2013) and *Albizia chinensis* (Osbeck.) Merr. (Fabaceae) (Sharmin *et al*., 2013)**



Glut-5(6)-en-3β-ol

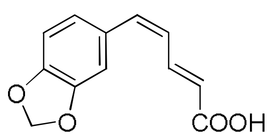


Stigmasterol

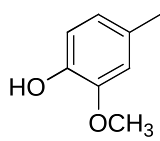


α-Amyrin

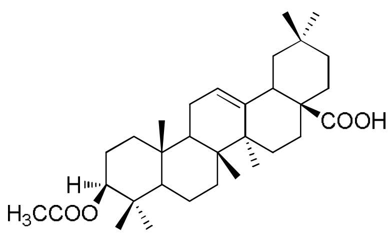
**Secondary metabolites from *Melocanna baccifera* Roxb. (Kuddus *et al.*, 2011)**



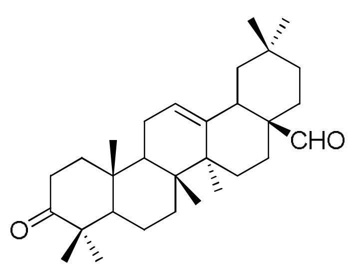
Isochavicinic acid



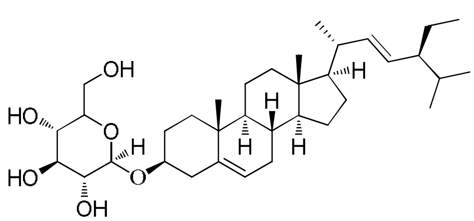
Eugenol



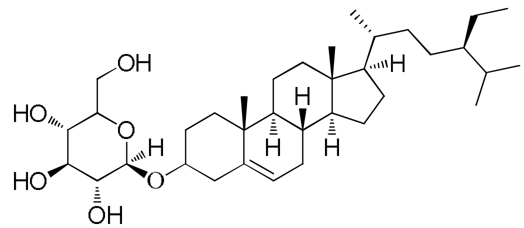
Olean-12-en-28-carboxy-3β-acetate



3-Oxo-olean-12-en-28-al

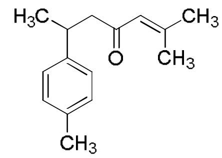


Stigmasterol glucoside

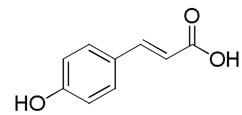


β-Sitosterol glucoside

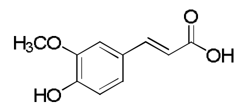
**Sesquiterpene and Phenylpropanoids from *Curcuma longa* L. (Zingiberaceae) (Kuddus *et al.*, 2010) and *Syzygium cumini* L. (Murtaceae) (Sikder *et al.*, 2012)**



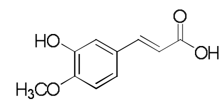
Turmerone



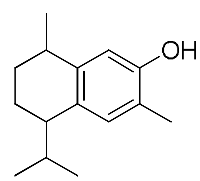
*Trans*-p-coumaric acid



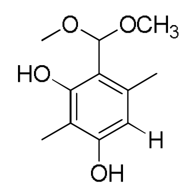
*Trans*-ferulic acid



*Trans*-isoferulic acid

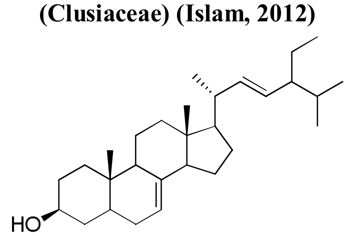


7-Hydroxycalamenene

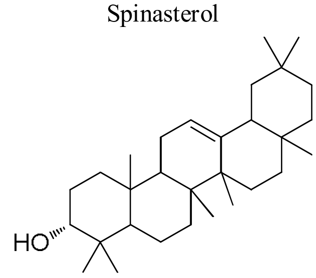


Methyl-β-orsellinate

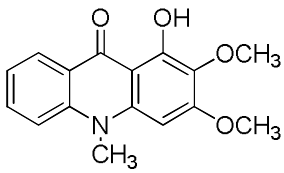
**Acridone-type alkaloid and triterpene from *Glycosmis pentaphylla* Retz. (Rutaceae) (Ahmed, 2013) and *Mesua nagassarium* Burm.f. (Clusiaceae) (Islam, 2012)**



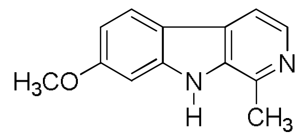
Spinasterol



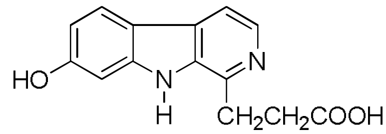
Epi-oleanolic acid



Arborinine

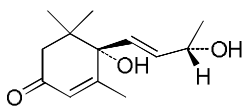


1-Methyl-7-methoxy-β-carboline

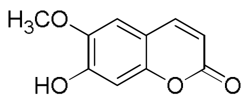


7-Hydroxy-beta carboline-1-propionic acid

**Constituents from *Ophiorrhiza mungos* Linn. (Rubiaceae) (Islam, 2010)**



Vomifoliol



Scopoletin.

*Biological:* The crude plant extracts and purified compounds were subjected to screening for antimicrobial, antioxidant, anti-diabetic and anti-HIV activities. The results of some of the assays are summarized in the following tables:

**Biological:**

***i) Antimicrobial activity:***

**Table 2. Antimicrobial activity of Garuganin V from *Garuga pinnata* at 100 μg/disc (Ara *et al.*, 2012).**

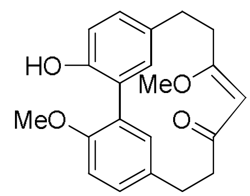
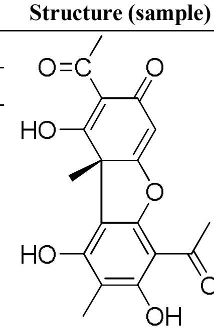
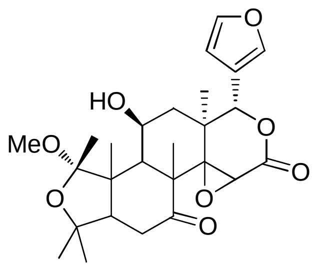
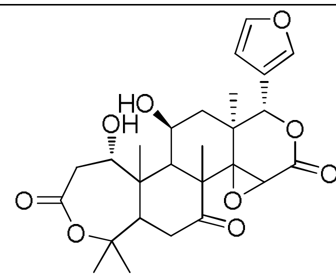
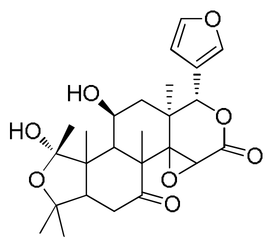
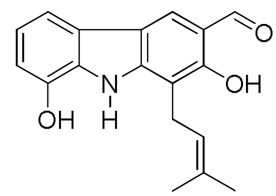
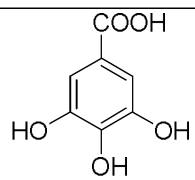
| Microbes | Diameter of zone of inhibition (mm) | | Structure (sample) |
|---|---|---|---|
| | Garuganin V | Kanamycin | |
| **Gram positive bacteria** | | | |
| *Bacillus cereus* | 40 | 21 | |
| *Staphylococcus aureus* | 35 | 23 |   Garuganin V |
| **Gram negative bacteria** | | | |
| *Escherichia coli* | 32 | 23 | |
| *aVibrio mimicus* | 36 | 21 | |
| *Fungus* | | | |
| *Aspergillus niger* | 31 | 20 | |
| *Candida albicans* | 35 | 20 | |

**Table 3. Comparative antibacterial activity of usnic acid and standard antibiotics (Rashid *et al.*, 2001).**

| **Microbes** | **Diameter of zone of inhibition (mm)** | | | | **Structure (sample)** |
|---|---|---|---|---|---|
| | **Usnic acid** | **Amoxycillin** | **Streptomycin** | **Tetracycline** | |
| | 30 μg/ disc | 10 μg/ disc | 10 μg/ disc | 30 μg/ disc | |
| *Bacillus subtilis* | 23 | 33 | 26 | 34 | |
| *Escherichia coli* | 25 | 08 | 22 | 18 |   Usnic acid |
| *Staphylococcus aureus* | 24 | - | - | 10 | |
| *Stap. epidermidis* | 23 | 39 | 12 | 24 | |

***ii) Antioxidant Activity***

**Table 4. Free radical scavenging of some purified compounds (Begum *et al*., 2009; Begum *et al*., 2011).**

| Structure | $IC_{50}$ (μg/ml) | Structure | $IC_{50}$ (μg/ml) |
|---|---|---|---|
|  Clausenolide-1- methyl ether | 270 |  Clausenarin | 169 |
|  Clausenolide | 102 |  8-Hydroxyheptaphylline | 106 |
|  Gallic acid (standard) | 75 | | ?? |

***iii) Antidiabetic activity:*** The glucose level obtained in the blood of normal and experimental rats are given in table 5 for *E. prostrata* extract and in table 6 for eclalbasaponin II. The safety of the extractives in animal was evaluated by observing the effects of the extractives on liver enzymes. The levels of enzymes, alanine aminotransferase (ALT), aspartate aminotransferase (AST) and alkaline phosphatase (ALP) in plasma of normal and diabetic rats are depicted in table-8. The plant extract treated animals showed no significant changes of these enzyme levels as compared to the normal rats. This suggested that the extractives were safe in rat models. However, the levels of these enzymes were much lower than the diabetic control rats receiving no drugs.

The methanolic extract (300 mg/kg) showed a significant ($P<0.05$) blood glucose reduction (14.50%) on 7th day in diabetic rats as compared to the untreated diabetic rats (Table 6). Consequently, serum sugar reducing activity became significant ($P<0.001$) after 21 (43.18%) and 28 days (48.38%) of drug treatment. The purified compound, eclalbasaponin II (10 mg/kg) also reduced the serum sugar level (16.07%) significantly ($P<0.001$) after 3 days of treatment when compared with the untreated diabetic rats. The blood sugar lowering effects were increased after 5 (36.53%) and 7 days (52.90%) by eclalbasaponin II. In alloxan-induced diabetic rats the levels of plasma AST, ALT and ALP were significantly ($P<0.001$) increased by 93.48%, 64.30% and 81.44%, respectively relative to their normal levels in rats (Table 8). On the other hand, treatment of the diabetic rats with methanolic extract of the *E. prostrata* caused a reduction in the activity 43.74%, 37.97% and 48.09% of ALT, AST and ALP in blood plasma as compared to the mean values in the diabetic rats. It was also observed that there was no significant difference in the liver enzyme levels between the normal, glibenclamide and *E. prostrata* treated rats. Therefore, the herb did not have any hepatotoxicity on rats (Rahman and Rashid, 2008). Similar hypoglycemic activity has been reported for glycoside D (β-D-galactopyranosyl) from *Calendula officinalis* (Fam.- Compositae) (Yoshikawa *et al*., 2001). Glycoside D and eclalbasaponin II are structurally related, both of which have been obtained from the member of the same family.

**Table 5. Blood sugar levels in normal and alloxan - induced diabetic rats (Phase I) (Rahman *et al*., 2011).**

| Groups | mmol /l | | | | |
|---|---|---|---|---|---|
| | 1st day | 7th day | 14th day | 21st day | 28th day |
| Normal (untreated) | 4.85±0.08 | 5.02±0.10 | 4.91±0.07 | 4.79±0.11 | 4.85±0.06 |
| Diabetic control | 12.03±0.18** | 12.98±0.19** | 14.05±0.23** | 15.09±0.28** | 17.20±0.22** |
| Glibenclamide Treated (1 mg/kg bw) | 12.18±0.55 | 10.82±0.18 | 9.53±0.21 | 7.08±0.16 | 6.43±0.16 |
| Methanolic extract Treated (300 mg/kg bw) | 12.69±0.32 | 10.85±0.16* | 9.37±0.20** | 7.21±0.24** | 6.55±0.11** |

Values are given as mean ± SEM for 6 rats in each group. Diabetic control (Group-2) was compared with normal (Group-1) on corresponding day. Experimental group (Group-4) was compared with diabetic control group on corresponding day; *P<0.05 ; **P<0.001

**Table 6. Blood sugar level in normal and alloxan - induced diabetic rats (Phase II) (Rahman *et al*., 2011).**

| Groups | mmol / L | | | |
|---|---|---|---|---|
| | 1st day | 3rd day | 5th day | 7th day |
| Normal untreated | 4.8 ± 0.56 | 5.03 ± 0.48 | 4.85 ± 0.55 | 4.95 ± 0.40 |
| Diabetic control | 12.40 ± 0.35** | 12.49 ± 0.44** | 12.97 ± 0.51** | 13.52 ± 0.34** |
| Glibenclamide treated (1 mg/kg bw) | 12.78 ± 0.25 | 12.01 ± 0.31 | 11.63 ± 0.26 | 10.51 ± 0.35 |
| Eclalbasaponin II treated (10 mg/kg bw) | 12.87 ± 0.68 | 10.80 ± 0.71** | 8.17 ± 0.65** | 6.06 ± 0.66** |

Values are given as mean ± SEM for 6 rats in each group. Diabetic control (Group-2) was compared with normal (Group-1) on corresponding day; Experimental group (Group-4) was compared with diabetic control group on corresponding day; *P<0.05; **P<0.001

**Table 7. Percentage reduction of blood sugar level in alloxan induced diabetes rats.**

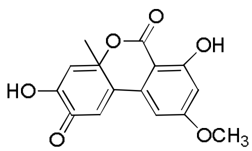
| Day | % Reduction of blood sugar | Day | % Reduction of blood sugar |
|---|---|---|---|
| | Crude extract | | Eclalbasaponin II |
| 1 | 0.000 | 1 | 0.000 |
| 7 | 14.50 | 3 | 16.07 |
| 14 | 26.16 | 5 | 36.53 |
| 21 | 43.18 | 7 | 52.90 |
| 28 | 48.38 | - | - |

**Table 8. ALT, AST and ALP levels of normal and alloxan-induced diabetic rats after 4 weeks.**

| Groups | U/L | | |
|---|---|---|---|
| | ALT | AST | ALP |
| Normal untreated | 28.34±0.88 | 166.66±2.15 | 60.16±3.39 |
| Diabetic control | 54.5±2.70** | 273.83±3.37** | 109.16±1.93** |
| Glibenclamide treated | 31.83±2.77 | 196.16±3.51 | 58.83±3.26 |
| Methanolic extract treated | 30.66±1.33** | 169.83±3.85** | 56.66±3.84** |

Values are given as mean ± SEM for 6 rats in each group. Diabetic control (Group-2) was compared with normal (Group-1). Experimental group (Group-4) was compared with diabetic control (Group-2). **P<0.001

*Anti-HIV activity:* The anti-HIV activity of dehydroaltenusin from *Streptomyces* sp. (Jabbar *et al*., 1999 is shown below). Dehydroaltenusin revealed significant anti HIV activity,



Dehydroaltenusin

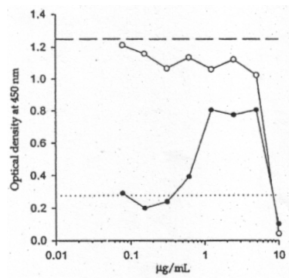



Figure 1. Graph showing the effects of dehydroaltenusin upon uninfected CEM-SS (o) and HIV-1 infected CEM-SS cells (•), as determinded after 6 days of culture. The higher optical density represents better anti HIV activity exhibited by the test compound

## Conclusion

A total of 60 plant species have been investigated. Many structurally unique and diversified compounds having interesting biological activities were isolated from these plants. Our studies show that Bangladeshi plants can be a promising source of novel drug candidates.

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