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REVIEW ARTICLE

KIRGANELIA RETICULATA (POIR) BAILL.: A REVIEW ON ITS BOTANY, ETHNOBOTANY, PHYTOCHEMISTRY AND PHARMACOLOGY

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ABSTRACT

Kirganelia reticulata (Poir.) Baill. is known for its importance in various traditional medicine around the world and are proved pharmacologically as an antiviral against Hepatitis B, hepatoprotective, antidiabetic and antioxidant. In Ayurvedic system of Indian medicine recognized its activity against jaundice, diuretic, fever, liver disorder, in bleeding gums, small pox, syphilis, etc. The review summarizes the up-to-date and comprehensive information concerning the botany, traditional use, phytochemistry and pharmacology of important drug. *Kirganelia reticulata* and discusses the possible future scope for future research. In present review covers a literature survey across from 1826 to 2012. The some information collected from published literature on species of *Kirganelia reticulata* (Poir.) Baill. (=*Phyllanthus reticulatus* Poir.) and traditional ayurvedic texts. Phytochemical studies have shown the presence of many valuable compounds such as lignans, flavonoids, steroids, coumerins, triterpenes, phenols, flavonones, alkaloids are common compounds in test species. The extract and the compounds isolated from *Kirganelia reticulata* show a wide spectrum of Biological activities including antidiabetic, antibacterial, antioxidant, hepatoprotective, antiplasmodial, anticiceptive, analgesic and anti-inflammatory properties. *Conclusion:* The present review summarizes information concerning the morphology, ecology, ethanopharmacologically, phytochemistry, and traditional diseases and applications of *K. reticulata*. This review target at gathering the research work undertaken till date on this plant in order to provide sufficient baseline information for future works and commercial exploitation.

Keywords: *Kirganelia reticulata, Ethnomedicinal, Phytochemical, Ethnopharmacology.*

1. INTRODUCTION

Kirganelia reticulata (Poir) Baill. is belonging to the family Euphorbiaceae, popularly known as 'potato plant or potato bush" and are variously named in different parts of the world. Synonymously, it is also named as *Phyllanthus reticulatus* Poir. and commonly used in Indian Ayurvedic system of medicine in various ailments related to liver, kidney, genitourinary system and stomach. It has properties of *Rasa (Kashaya, Tikta, Madhura, Guna (Lakhu)* and *Veerya (Seeta)*. The ayurvedic literature has shown its wide utilization as in vata, pitta, diabetes, burning sensation, burns, skin diseases, obesity and urinary retention, skin eruption[1]. The use of this drug is now gaining momentum because of its novel antiviral activity against Hepatitis B virus and for several other biological activities such as hypotensive effects viral infections; hepatotoxicity causing liver diseases, jaundice[2-8].

K. reticulata elaborates different class of organic compounds of, medicinal importance including alkaloids, flavonoids lignans, sitosterol, polyphenols, triterpenoids, saponins, coumerins phytosterols[9-12]. The maximum number of phytochemical compound is present in leaves then stem and root[13]. The present review assesses the potential of *K. reticulata* in relation to its traditional uses and in terms of finding based on modern bioscientific research. The link between conventional remedies and recent research in various areas has been well established in other plant derived products. The plant is known to contain several pharmacological important biomolecules whose well established in other plant derived products. Furthermore, this drug has several pharmacological important bio-molecules whose efficacy is well established by several biochemical and pharmacological studies. This review intent to compile various studies on this plant and critically evaluates the issues related to botany, traditional use in various parts of the world, phytochemistry and ethnopharmacology to highlights its importance in future research.

2. TAXONOMY AND DISTRIBUTION

Kirganelia reticulata (Poir) Baill. (=Syn. *Phyllanthus reticulatus* Poir.) is belonging to the family Euphorbiaceae. It is a large shrub growing in hedges, waste places and in forest. Leaves are usually ovate-oblong to elliptic, 1-5 cm long, 0.7-3 cm wide, produced on short lateral branchlets, looking like leaflets of a compound leaf. Flowers are borne in clusters on short axillary branchlets, small, yellowish, sexes separate on the same plant. The flowering shoots and pedicels are covered in short, velvety hairs. Fruit is berry-like, 4-6 mm across, blackish when ripe[14,15]. The flowering and fruiting season is during the month of March-July[16-21].

This plant is widely distributed throughout the tropical countries of the world including India, Sri Lanka, the Himalayas, China, Indo-china, Malaysia, into tropical Australia and is supposed to also occur in tropical parts of Africa[22-27]. The name 'Phyllathus means "leaf and flower" because the flower, as well as the fruit, seems to become one with the leaf. The genus (Euphorbiaceae) consists of about 6500 species in 300 genera, of which 200 are

American, 100 African, 70 from Madagascar and the remaining Asian and Australasian[28,29].

Figure 1: *K. reticulata* (Poir) Baill. plant.

3. HISTORICAL PERSPECTIVE

K. reticulata has been indexes in majority of published phytochemical, pharmacological and traditionally uses reviews and research articles till date with different named. In Poiret, 1804 is described this species based on a collection made by an unknown collector in tropical Asia and deposited in Lamarck herbarium in Paris. Although Poiret's protologue mentions that species grew "dans les Indes" the sheet no locality information and it is therefore unclear from where and from whom Lamarck received this plant. Given that the collection must have been made before 1804[30-32]. It is one of largest genera of the euphorbiaceae. It contains compounds known to be biologically active[33].In 1985, scientific research has identified within the genus potential sources of agents against cancer[34]and hepatitis B virus[35-37]. The objective of this review is to organize taxonomically all such citations as could be found. Ethnobotanical surveys were carried out in Bukoba Rural District to explore the traditional ethno-medical knowledge, the use and conservation of medicinal plants in the management of HIV/AIDS opportunistic infections and to determine whether levels of harvesting are sustainable. The district is currently an epicentre of HIV/AIDS and although over 90% of the population in the district relies on traditional medicines to manage the disease, this traditional knowledge still remains largely unknown. Human Immunodeficiency Virus (HIV)/ Acquired Immune Deficiency Syndrome (AIDS) is a major public health problem in many countries particularly those in sub-Saharan Africa. Hence in sub-Saharan Africa, traditional healers HIV/AIDS patients[38]. The traditional healers play a crucial role of providing primary health care by taking care of people living with HIV/ AIDS[39,40]. In 2006, almost two thirds (63%) of all persons infected with HIV/ AIDS in the world were living in sub-Saharan Africa[41]. Tanzania as it affects mostly the young and most economically productive population[42]. HIV/AIDS are susceptible to fungal and bacterial opportunistic infections that result from immunosuppression[43].It is one of the leading causes of deaths in Tanzania and worldwide[44]. The use of plants as (*K. reticulata*) medicine is common to many cultures, and a number of advanced pharmaceutical drugs were derived from plants[45]. Tanzania depends on traditional medicines for the management of various diseases including HIV/AIDS[46]. In Rural area of Tanzania especially in bukoba district, suffer from HIV/AIDS[47]. Many plants species is using in HIV/AIDS diseases but one of most plant is *K. reticulata* used in treating various disease related to HIV/AIDS in Bukoba rural district, Tanzania. The leaves part of *K. reticulata* used in treated of chronic cough chronic diarrhoea, cryptococcal meningitis, Herper zoster, oral candidiasis, oral sores, skin infections, skin rashes, tuberculosis[48]. Some importent medicinal uses of *K. reticulata* species in differents countries worldwide such as Africa, Sudan, Kenya, Tanzania, Pakistan, Indochina, Philippines, Malay Peninsula, Australia, India and Sri Lanka respectively. Many diseases and traditional uses.

4. VERNACULAR NAME AND TRADITIONAL USES

In **Table No. 1.** & **Table No. 2.** Lists showed the traditional uses, local names, modes of preparation and the induced effects.

In Indian folk medicine, the drug is used for different ailments including asthma, stomachic, diuretic, fever, and thirst, astringent, inflammation and carcinoma[49-53]. The leaves and bark are sweet and cooling and hence are used in constipation and urinary disorder while leaves juice is used for the treatment of diarrhoea in children[51]. Decoction of bark is used as astringent, diuretic and alternative[54]. For bleeding gums, pill of this drug along with camphor and cubebs is kept in the mouth[19,55]. In India, leaves juice of this drug are used in infant diarrhoea in the Lakhimpur district, Assam[56-63]. The roots are used in Madras as a red dye[64]. In Indo-china, the whole plant is used in the treatment of small pox and syphilis. The fruit is said to be eaten in the times of scarcity in E. Africa[65]. An ink is prepared from ripe fruits in the Philippines. In East Africa, fruits and roots are alleged to be used for criminal execution, eaten by stock animals[65] and also Digo and Swahili peoples (East Africa) are used root infusion for gonorrhoea, decoction as purgative other part of the medicine for hookworm[66]. Mostly in Tanzania, Dried whole plant of *K. reticulata* is used in decoction for gonorrhoea[67,68].

Table 1: Vernacular Name of *K. reticulata* (Poir) Baill.Worldwide

S. No.	Language	Vernacular Name
1.	Bengali	Panjuli, Panseuli, Chitki, Pankushi, pan chitki.
2.	Sanskrit	Krishna-kamboji, Poolika. Kale madh
3.	Ayurveda	Kaamboji.
4.	Hindi	Panjuli, Buinowla, Makhi, Panjoli,
5.	Gujarati	Datwan and Kam-Boi
6.	Kannada	Anamsule, Chippulinellu, Huli, Karesuli, Karihuli.
7.	Konkani	Kaili
8.	Marathi	Pavan and Pavana, Panpoi
9.	Assamese	Amlakhi
10.	Oriya	Bonoti-Hudi, Jandaki, Jojangi or Phajoli.
11.	Punjabi	Panjuli.
12.	Tamil	Abiranji Civappuppula, Karunelli, Karuppupilanji or Nirppu-Lanji.
13.	Telugu	Nallapuli, Nal-Lapuruguda, Nellapurududu or Pandicarranlue
14.	Malayalam	Niroori, Niroli, Nirnelli.
15.	English	Potato plant, Potato bush, Reticulated leaf- flower. Black-berried, featherfoil, Black- honey shrub, Netted-leaved leaf-flower.
16.	Chinese	Xiao guo ye xia zhu.
17.	Phillipine	Malatinta, Tinatinaan, Tintatintahan(Tagalog)- sungot-olang (Bisaya),
18.	Indonesia	Matang-buiud, Tintatintahan.(Biak), wawulutan (Sundanese), trembilu, Congcong belut (Javanese),
19.	Central and Rural Tanzania	Kitukuto, Kaumura.
20.	African	Aartappelbos.
21.	IsiZulu	Umchumelo
22.	XiTsonga	Thethenya
23.	Intaba	Yengwe
24.	Thailand	Kaang plaa khruea, mat kham (northern), am aai (eastern).
25.	Kenyan	Mkwamba,
26.	Japanese	Shima komi kansou
27.	Vietnamese	Phèn đen, Diệp hạ châu mạng, Cây no, Kỏ kang pá.
28.	Malaysia	Kayu darah belut, tampal besi.
29.	Switzerland	Mchunguchungu, mfuungozi, mkasiri., mviongozi, Mwino, mzizima.
30.	Cambodia	Prâpéénh chhmôôl.
31.	Laos	Am ai, kang pa.

5. PHYTOCHEMISTRY

The secondary metabolites present in *K. reticulata* are alkaloids, tannins, saponins, coumerins, sterol, triterpenoids, polyphenols, flavonoids, glycosides and essential oil[12,13,69-75]; flavonoids (tricin, quercetin, quercetrin, rutin, kaempferol etc.[9,76] Ellagitannins (geraniinic acid, corilagin, gallic acid, etc.)[76,77], titerpenoids (golchidonol, Stigmast-22-en-3-ol, stigmast-5-en-3-ol, 21α-hydroxyfriedel-4(23)-en-3-one etc.)[11,78], sterols (stigmasterol, β-Sitosterol-3-O-β-glucoside, β-sitosterol, Stigmasta-5,6-dihydro-22-en-3β-ol etc.)[9,10,76] and main lignans are reticulosides A and reticulosides B[79]. Some lignans and compounds isolated from *K. reticulata* as pentacosane, octacosane, lup-20(29)-en-3β-24-diol, sorghumol and sorghumol acetate, friedelin, epifriedenol, kokoonol, β-sitosterol, taraxerone, teraxeryl acetate, 21α-Hydroxyfriedelin-3-one, betulin, friedelan-3β-ol, betulinic acid, *p*-comeric acid, ellagic acid, pyrogallic acid, pirorisinol[9,10,70,75,78,80,81]. The chemical screening of *K. reticulata*, extracted out had founded antiplasmodial[82], antidiabetic[83], antimicrobial and cytotoxic[69] and hepatoprotective[84]. Bioactivities and also properties like isotachioside[85], epigallocatechin[86], mananthoside[87], carthamoside B_5[88], hovetrichoside A[89], 3,4-dihydroxyphenylpropanol 3-O-D-glucopyranosides[90], turpenionosides A[91], isoguanine [92], respectively[93] and isolated from leaves of this plant three known compounds found under NMR analysis as lupeol, lupeol acetate and stigmasterol[94-97]. Eight compounds, including two flavonoid glycosides, were isolated from the butanol-soluble fraction of the methanolic extract of the leaves of *K. reticulate.* The recently developed high-performance liquid chromatography solid-phase extraction–nuclear magnetic resonance (HPLC-SPE-NMR) technique, which has been demonstrated to be a powerful tool[98-100], for identification and quantification of various chemical constituent in the plant material (reference of above technique used for this plant). The qualitative phytochemical analysis, conducted on *K. reticulata* crude drug samples, result positive reaction for various groups of chemical constituents and chemical structures given in the **Table No. 3 & 4.**

The terpenoids isolated from *K. retculata* are glochidonol, stigmast-22-en-3-ol, Stigmast-5-en-3-ol, Turpenionosides A, Turpenionosides B etc., flavonods such as quecertin, kaempferol, rutin, Isoquercirtin, astragalin, Quercetin 3-O-α-L-rhamnopyranoside etc., ellagitannins include geraniinic acid corilagin and sterol such as sitosterol, β-

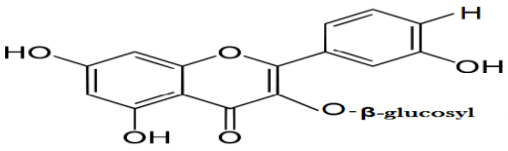
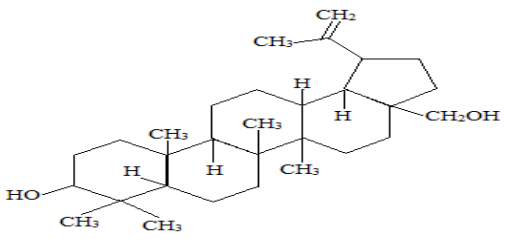
sitosterol, Stigmasterol etc. *K. reticulata* had been reported to have pharmacological effect such as in antibacterial activities found a maximum inhibitory activity is exihibited by both methanolic and ethanolic extracts. The entire plant powder of *K. reticulata* shows good antioxidant activity of about 90.0% and antidiabetic activity shows weak potential in allaxon- induced diabetic mice. It exhibited hepatoprotective activities in rats against CCl_4- induced liver damage.

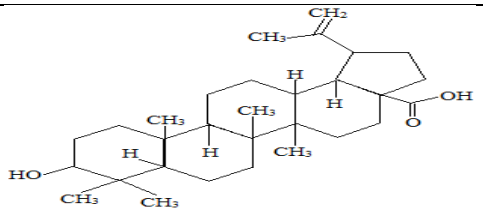
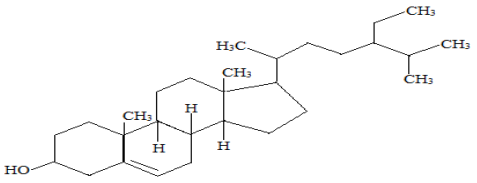
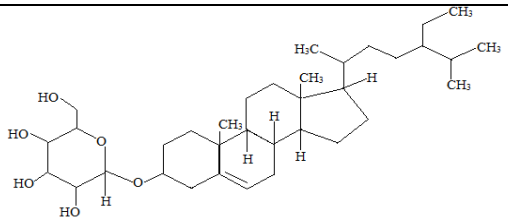
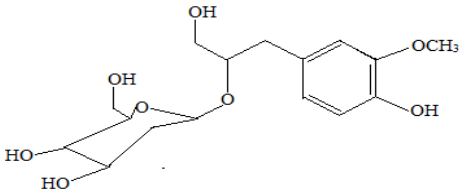
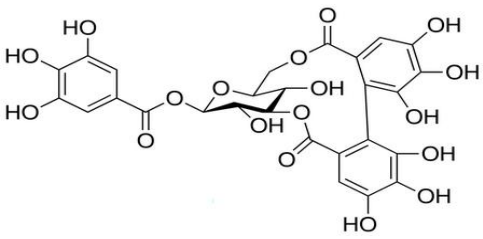
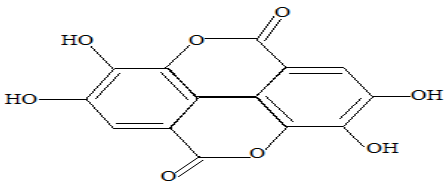
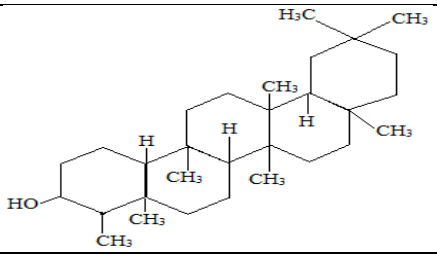
Table 2: Ethnomedicinal uses of *K. reticulata* (Poir) Baill. in different countries worldwide

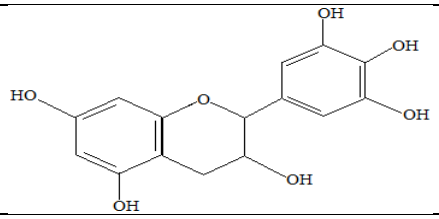
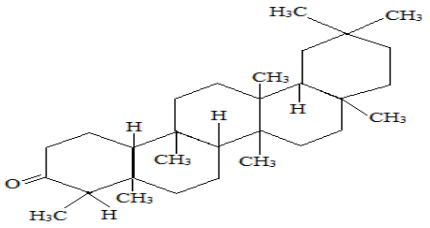
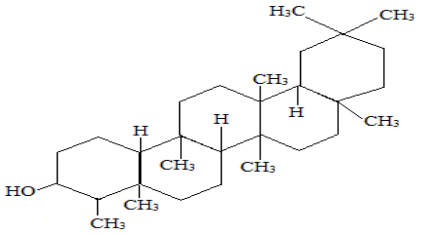
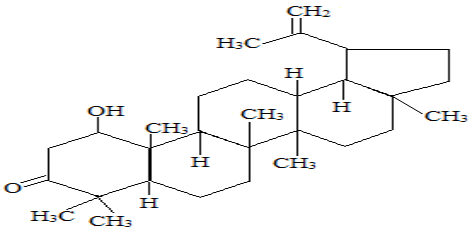
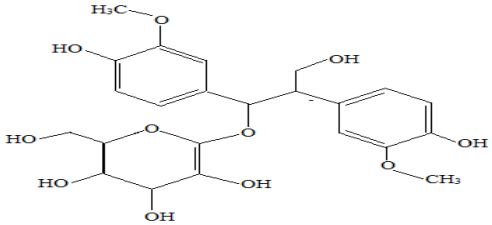
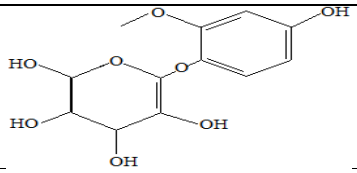
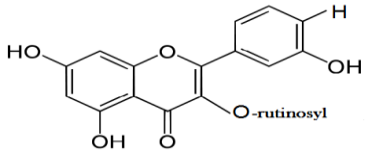
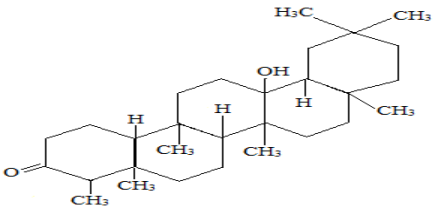
S. No	Region	Plant Part Used	Diseases and Uses	Ref
1.	West Africa	Wood Juice of stem Twig Leaves	Threshing sticks and roof binders Sore eyes Chewsticks Post-Partum treatment	114
2.	South Africa	Twig Powderd leaves Leaves and Bark	Chewsticks Sore, burns, suppuration and Chafed areas Diuretic or alterative foliage Possibly eaten by stock	115, 116
3.	Zimbabwe*(Eastern Province of Northern Zimbabwe; Chewa and Nagoni people)*	Whole plant	Anemia & Intestinal hemorrhage	117
4.	East Africa	Fruits Roots and fruits Roots and bark Juice of plant	Famine food Some time eaten by stock animal, criminal execution Red to black dye and poultary Blown into eyes for soreness	65, 118
5.	East Africa (Digo & Swahili People)	Root infusion	Gonorrhoea, Decoction, Purgative and part Of medicine for Hookworm	66
6.	Sudan	Whole plant	Diuretic and refrigerant	119
7.	Kenya	Bark	Dying for tanning fishing lines	120
8.	Northwestern Kenya Turkan people	Whole plant Twig	Eaten by camel, goat and sheep Chewing sticks/toothbrushes	120
9.	Tanzania	Whole plant Dried Root Dried bark, leaves Arial parts Fresh leaves, powder Dried fruits & roots Fresh leaves juice Dried root Dried root bark Fresh twig	Decoction for gonorrhoea Decoction for dysmenorrhoea Painful manstruration Intestinal hemorrhage & anemia Burns & sores Criminal poisoning Muscles spasms Abscesses, decoction for Gonorrhoea, muscle spasms, purgative, dysmenorrhea, diarrhea with anal bleeding, infusion for hookworm. Infusion for promoting Fertility Chewstick	67 103, 104 122 123
10.	Tanzania, near Lake Victoria Sukuma people	Roots	Pounded & decoction drunk in water for Headache	124
11.	Tanzania Masai Steppe Zigua people	Roots	Boiled decoction drunk to increase male fertility	124
12.	Philippines	Leaves/bark Leaf powder Bark Roots Fruit	Infusion as a diuretic, Alterative, depurative (purifying agent), refrigerants, and Odontalgic for toothachne, Applied to the abdomen for pinworm, Made into the pill with camphor for bleeding gums, Sores and burns Infusion for desentry, Diuretic, astringent Infusion for asthama, juice for infant diarrhoea, remedy for sore- eyes Astringent to bowels and against inflammations and blood disease	125,126 124,127 128
13.	Australia	Fruits	Infusion, internal pain, itches, heat rush, chicken pox	129

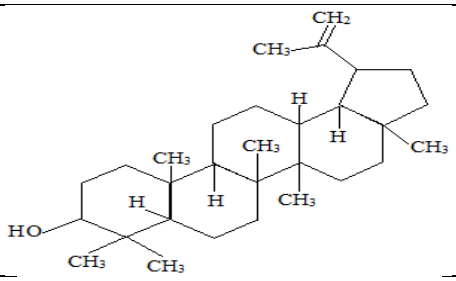
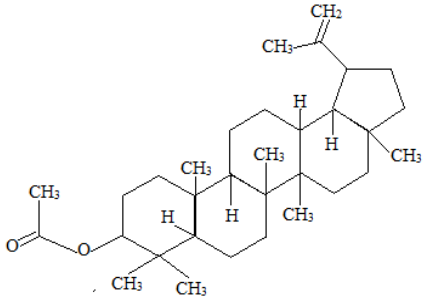
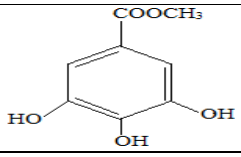
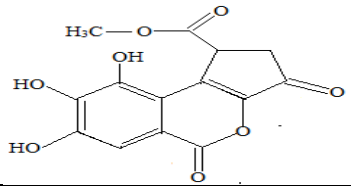
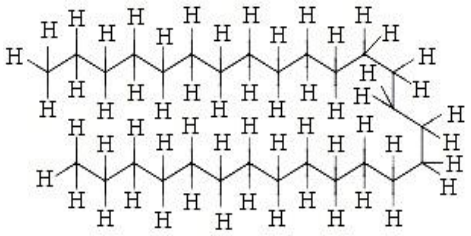
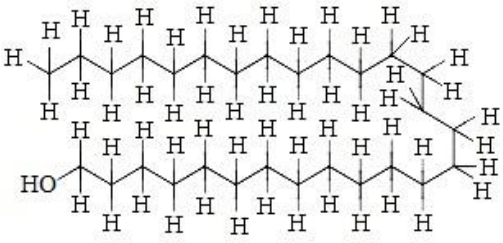
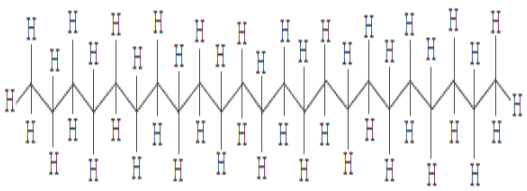
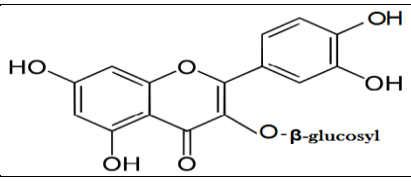
	(not clear which species of euphorbiaceae, or perhaps all cited this species was cited as a possible synonym for cecuringa melanthesoides- (F.Mull; H.K. Airy-Shaw)	Young leaves	several sickness, open sores & leprosy Applied locally for pinworm	
14.	Sri Lanka	Bark Root Powdered leaves Juice of leaves Fruits	Decoction used as astringent & diuretic Decoction for asthama Sores, burns & suppurations Children's diarrhoea In bowel inflammation, "disease of the blood"	49
15.	Pakistan (sind.)	Leaves	Diuretics and cooling medicine	57, 60, 62
16.	Indochina	Whole plant	Smallpox, syphillis,bleeding gums	130, 128
17.	India, Indochina	Bark	Alterative	131
18.	Malay Penisula	Stem &leaves Leaves	Rubbed on chest for asthma Decoction drunk for sore throat	132 128
19.	India	Leaves Bark	Diuretic and cooling medicine Decoction of four ounces twice or more daily as an alterative, "attenuant" (allegedly To weak enthe effects of a pathogen or drug), astringent to the Bowels; useful in Inflammations and disease of blood (unSpecified)	133
20.	India, Assam Lakhimpur	Juice of leaves	Infant diarrhea	56, 57, 58, 59, 60, 61, 63, 64
21.	India Maharastra: Konkan' Costal region	Leaves Juice of leaves	Reduced to thin extract with other "alterative" plant and made into pill With aromatics, this pill "rubbed down" in milk, twicw daily made into pill with camphor and cubes for bleeding gums.	57, 134, 60,61,62
22.	India East & West coasts	Root and root bark Leaves	Decoction of 4 ounce twice daily alterative, for veneral sores infusion of 1-2 ounces astringent, diuretic, cooling	134,61
23.	India	Dry bark &Leaves	Decoction as a diuretic, alterative and for cooling effect	

Table 3: Structures of isolated compounds and identified from *K. reticulata* (Poir) Baill.

S.NO.	Chemical Name	Isolated from part	Structure	Ref
1.	Astragalin (Kaempferol 3-O-β –D glucopyrano- side)	Leaves		**76**
2.	Betulin	Roots and stems		**76,10**
3.	Betulinic acid	Stem & Leaves		**78**

				
4.	Beta-Sitosterol	Roots, Stem & Stem bark		**10,75,9**
5.	Beta-sitosterol-3-O-β-glucoside	Leaves		**76**
6.	Carthamosides B_5	Whole plant		**12**
7.	Corilagin	Leaves		**76**
8.	Ellagic acid	Leaves		**76**
9.	Epifriedelinol	Roots		**9,10**

10.	Epigallocatechin	Whole plant		**12**
11.	Friedelin	Roots and stems		**76,10,9**
12.	Friedelan-3β-ol	Stem & leaves		**78**
13.	Golchidonol	Leaves, Stem and Roots		**10,11,78**
14.	HovertrichosidesA	Whole plant		**12**
15.	Isotachioside	Whole plant		**12**
16.	Kaempferol 3-rutinoside	Leaves		**76**
17.	Kokoonol	Roots		**9**

18.	Lupeol	Leaves		**97**
19.	Lupeol acetate	Leaves		**97**
20.	Methyl gallate	Leaves		**76,77**
21.	Methyl brevifolincarboxylate	Leaves		**76**
22.	Octacosane	Roots		**9**
23.	Octacosanol	Roots		**10**
24.	Pentacosane	Stem bark		**75**
25.	Quercetin 3-O-β-D-glucopyranoside (isoquercitrin)	Leaves		**76**

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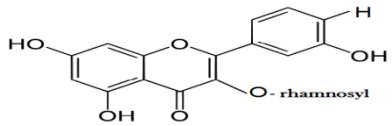
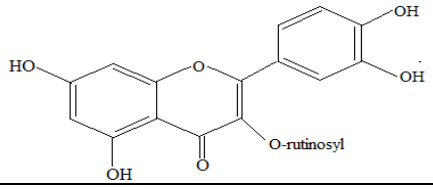
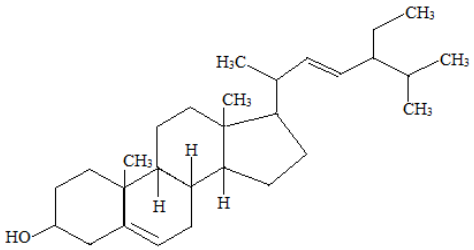
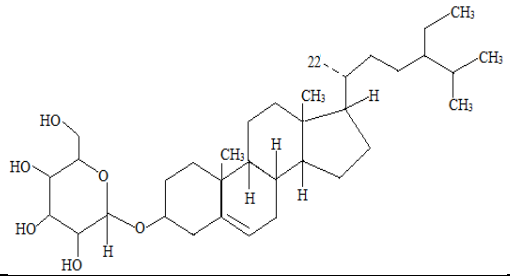
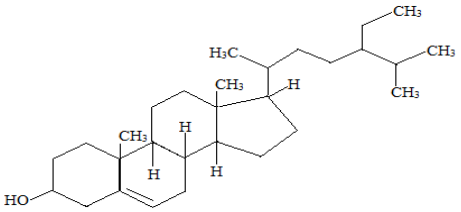
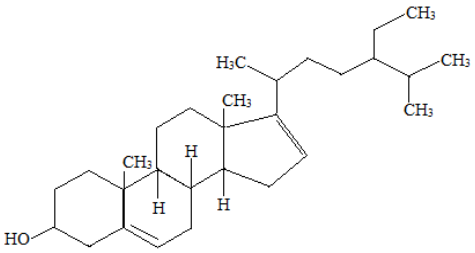
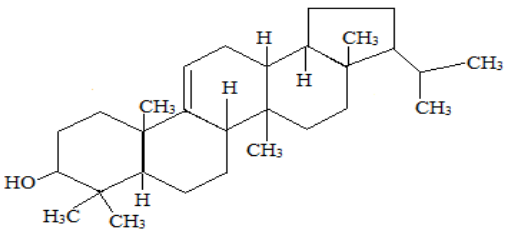
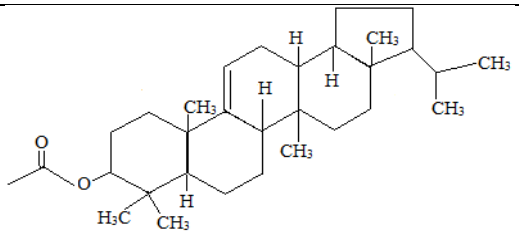
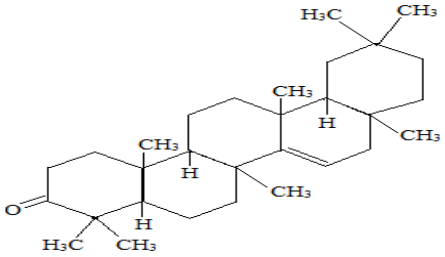
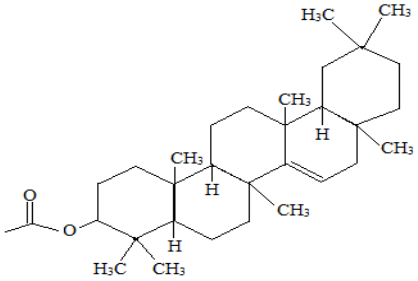
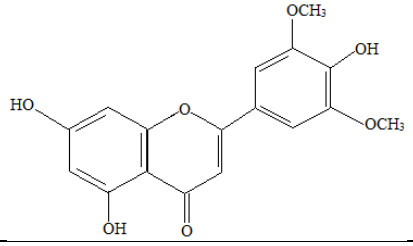
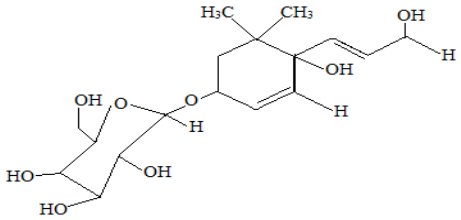
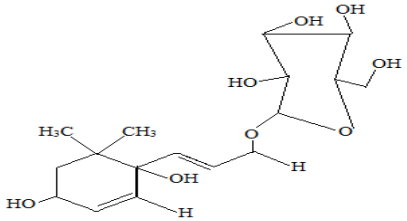
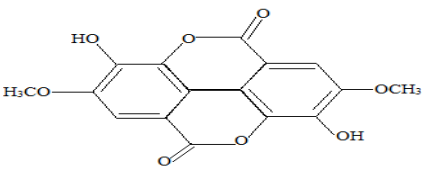
26.	Quercetin (Quercetin 3-O-α-L rhamnopyranoside)	Leaves		**76**
27.	Rutin (quercetin 3-rutinoside)	Leaves		**76**
28.	Stigmasterol	Leaves		**97,76**
29.	Stigmastasterol-3-O-β-glucoside	Leaves		**76**
30.	Stigmast-22-en-3-ol	Leaves		**11**
31.	Stigmast-5-en-3-ol	Leaves		**11**
32.	Sorghumol	Roots		**9**
33.	Sorghumol acetate	Roots		**9**

				
34.	Taraxerone	Roots		**10**
35.	Taraxerone acetate	Roots		**9**
36.	Tricin	Roots		**9**
37.	Turpenionosides A	Whole plant		**12**
38.	Turpenionosides B	Whole plant		**12**
39.	2,7-Di-O-methylellagic acid	Leaves		**76**

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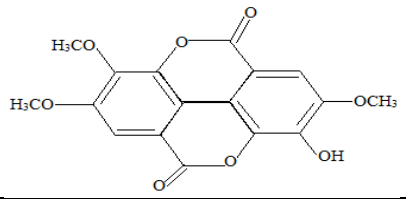
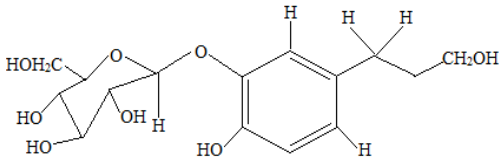
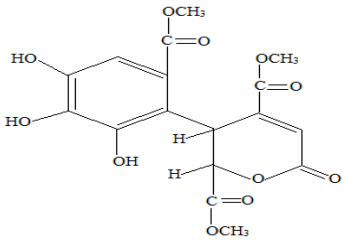
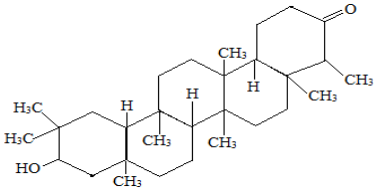
40.	3,4,3'-Tri-O-methylellagic acid	Leaves		**76**
41.	3-4-dihydroph-enylpropanol 3-O-β-D-Gluco- pyranoside	Whole plant		**12**
42.	(5R*, 6R*)-4,6-dimethoxycarbonyl-5-[2',3',4'-trihydroxy-6'-(methoxycarbonyl)-phenyl]-5,6-dihydro-2H-pyran-2-one	Leaves		**76**
43.	21α-Hydroxy- friedelan-3-one	Roots and Stem bark		**10,75**

Table 4: Compounds present in *K. reticulata* throughout extractions:[13,72]

S.N.	Solvent Used	Compounds obtained from the plant		
		Leaf	**Stem**	**Root Bark**
1	**Pet. Ether**	alkaloids, carotenoids, coumerins, dihydrochalcones, steroids	------	------
2	**Methanol**	alkaloids, anthocyanins, anthocyanidins, catacholic compounds, coumarins, dihydrochalcones, emodins, flavonoids, flavones, glycosides, lignans, phenols, triterpenoid	alkaloids, anthocyanins, flavonoids, flavonols, glycosides, phenols, saponins, triterpenoids	alkaloids, anthocyanins, antraceneglycosides, flavonoids, flavonols, glycosides, phenols, triterpenoids
3	**Water**	alkaloids, anthocyanins, coumarins, dihydrochalcones, emodins, flavonoids, flavones, phenols, Saponins triterpenoid	alkaloids, antraceneglycosides, flavonoids, flavonols, glycosides, triterpenoids	Alkaloids, flavonoids, flavones, glycosides, saponins, triterpenoids

6. ETHNOPHARMACOLOGICAL ACTIVITY

In worldwide, the plant was reported for various ethnopharmacological activities such as tumor-promoting activity found (Hecker, personal communcitation);[101] hypotensive activity[102]antifungal and in vitro Hypotensive activity[67,10,103] etc. These are described as following:

6.1. *Antidiabetic activity, Anti- hyperglycaemic And hypoglycaemic activities*

The plant *K. reticulata* is claimed to have antidiabetic activity in tribal area. To validate the tribal claim, the petroleum ether and ethanolic extracts of leaves of the *K. reticulata* were orally tested at 500 and 1000 mg/kg for hypoglycaemic effect in alloxan induces diabetic mice. It shows antidiabetic activity at the dose of 1000mg/kg. The phytochemical screening of the residues revealed the presence of terpenoids glycosides, protein, carbohydrates and absence of alkaloids and steroids[83,105,106].

6.2. *Antibacterial activities*

The in vitro antibacterial activities of leaf extract (Methanol and Ethanol) from 10 genus species. Which are medicinally important, were investigated by agar-well diffusion method against four food borne human pathogens (*Staphylococccus aureus*, *Salmonella typhi*, *Vibrio cholera* and *Pseudomonas aeruginosa*). Leaf extracts contained high level of phenols and exhibit differential antibacterial

activity against all four tested human pathogenic bacteria. The phenolic constituents of the tested extracts are closely associated with antibacterial activity. Highest antibacterial activity is exhibited by *K. reticulata* and can be used as a promising source of antibacterial drug[107], methanol, chloroform and hexane extracts from leaves of *K. reticulata*, used in Indian ayurvedic medicine for the treatment of several ailments of microbial and non-microbial origin were evaluated for potential antibacterial activity against methicillin- isolated from clinical specimen was studied. The minimum inhibitory concentration (MIC) and minimum bactericidal concentration (MBC) resistant *Staphylococcus aureus* (MRSA). Antibacterial activity and biofilm production of crude extracts against MRSA (ATCC 25923) values of the methanol, chloroform and hexane extracts were in the range of 12.5 to 50.0 mg/ml and 25.0 to 100.0 mg/ml, respectively. Amongst the evaluated extracts, the methanolic extract showed the strongest antibacterial effect as well as biofilm inhibition. Micro plate screening used for detection of biofilm formation by *Staphylococci* is a quantitative model to study its adherence level and has been a sensitive method[108]. and the in vitro antibacterial activity of crude methanolic, chloroform and hexane extracts of the leaves of *K. reticulata* were investigated. Susceptibility of some Gram-negative organisms (*Escherichia coli*, *Pseudomonas aeruginosa*, *Salmonella typhi)* and Gram-positive organism (*Staphylococcus aureus*) were tested. Agar well diffusion and broth dilution methods were used to determine the minimum antibacterial activity against all the tested microorganisms. The extracts exhibited antibacterial activities with zones of inhibition ranging from 9.07-30.10 mm, 8.17-24.57 mm and 5.60-14.67 mm for methanol, chloroform and hexane extracts respectively. Screening of crude extracts showed notable minimum inhibitory concentration (MIC) and minimum bactericidal concentration (MBC) at concentrations of 100 to 6.25 $mgml^{-1}$. The organisms were more sensitive to the methanolic extract of the leaves, where as extracts from other solvents like chloroform and hexane showed moderate to weak activity respectively. Similar results have been showed in MIC and MBC[16].

6.3. *Antioxidants activities and Free radical scavenging*

Antioxidant activity of entire plant of *K. reticulata* by performing different in *vitro* antioxidant assays, including 2,2-Diphenyl-1- Picrylhydrazyl (DPPH) radical scavenging, beta-carotene bleaching, superoxide anion radical scavenging, reducing power and metal chelating assay at different concentrations (100, 200 and 400µg/ml). The entire plant powder of *K. reticulata* shows good antioxidant activity of about 90.0% when compared with standard butylated Hydroxy Toluene (BHT) (85%) at a concentration of 400µg/ml. Results obtained reveal that methanolic extracts of entire plant of *K. reticulata* tapossess higher antioxidant activity when compared when compared with ethanolic extract. Thus, this study suggests that *K. reticulata* plantcan be used as a potent source of nature antioxidants[109], Free radicals are implicated for many diseases including Diabetes mellitus, arthritis, cancer, ageing. etc. In treatment of these diseases, antioxidant therapy has gained utmost importance. *K. reticulata* popularly important medicinal plant. Keeping in view of the cited activity, it is contemplated to screen the plant for *in vitro* antioxidant activity using different models *viz.* DPPH radical scavenging, ABTS radical scavenging, iron chelating activity and lipid peroxidation assay, nitric oxide scavenging assay, alkaline DMSO assay, total antioxidant capacity and non- enzymatic haemoglobin glycosylation assay . The results were analyzed statistically by regression method. Its antioxidant activity was estimated by IC50 value and the values are 20.36 µgm/ml (DPPH radical scavenging), 42.59 µgm/ml (ABTS radical scavenging), 32 µgm/ml (Iron chelating activity) and 41.91 µgm/ml (lipid peroxidation), 122.8 µgm/ml (nitric oxide scavenging) and 2.57 µgm/ml (alkaline DMSO). In total antioxidant capacity assay, 1 mg of extract is equivalent to 51 µg of ascorbic acid. It showed 66.64% inhibition of haemoglobin glycosylation. In all the testing, a significant correlation existed between concentrations of the extract and percentage inhibition of free radicals, metal chelation or inhibition of lipid peroxidation. The antioxidant property may be related to the polyphenols and flavonoids present in the extract. These results clearly indicate that *K. reticulata* is effective against free radical mediated diseases[110], antioxidant properties of the medicinal plant *K. reticulata*. The different solvent extracts of *K. reticulata* leaves were screened for their *in vitro* phytochemical and antioxidant activity. Leaves were extracted with solvents of different polarities like aqueous, ethanol, methanol, chloroform, acetone and hexane. The distributions of the main active principles such as alkaloid, flavonoids, phenols, steroids tannins etc. present in the plant were analyzed. It was also focused to determine the total phenolic and flavonoid content present in the extracts. Extracts showed promising results for total antioxidant capacity and reductive capability when compared with standard drug. The ethanol extract was found to possess excellent phytochemical and antioxidant activities. The antioxidant property may be attributed to the presence of flavonoids and phenolics present in the drug. The ability of the crude extracts of *K. reticulata* towards reduction, presence of phenol, flavonoid and antioxidant is an indication of its broad spectrum potential which may be employed in the management of various diseases[72]. Many plants possess antioxidant ingredients that provided efficacy by additive or synergistic activities. Antioxidant activity of the methanol crude extract of entire plant of *K. reticulata* was assessed using DPPH, superoxide anion and metal chelating assays at different concentrations. The potent extract of *K. reticulata* was tested for *in vivo* efficacy. The methanol extract exhibited potent antioxidant activity compared to known antioxidant. *In vivo* studies on potent extract of *K. reticulata* demonstrated dose dependent reduction in hepatic malondialdehyde (330.70, 279.40 and383.79µMmg-1 protein) with simultaneous improvement in hepatic glutathione (7.03, 18.16 and 6.88µgmg-1 protein) and catalase levels (678.10, 787.00 and 522.00µgmg-1 protein) respectively for 50, 100mgkg-1 dose and control) compared to control group. Due to its natural origin and potent free radical scavenging ability *K. reticulata* could be used as a potential preventive intervention for free radical mediated diseases[111].

6.4. *Antiplasmodial activity*

Antiplasmodial of *K. reticulata* medicinal plants were extracted and tested for in vitro antiplasmodial activity

against chloroquine- sensitive (K67) and chloroquine-resistant (ENT36) strains of Plasmodium falciparum. Out of 16 extracts, 12 were active against ENT36 strain while seven were active against K67 strain, that is, IC50 < or = 50 micrograms/ml. The most active extracts on both strains were those of leaves of *K. reticulata* with IC50 < or = 10 micrograms/ml. The stembark of Terminalia spinosa Engl. (Combretaceae) and the stems of Dissotis brazzae Cogn. (Melastomataceae) had IC50 < or = 10 micrograms/ml for strains K67 and ENT36, respectively. A phytochemical analysis of these plants revealed the presence of different classes of primary and secondary metabolites[82].

6.5. *Antinociceptive activity*

K. reticulata is used in folk medicinal practices of Bangladesh as an antinociceptive (reducing sensitivity to painful stimuli). The study was to investigate the antinociceptive activity of methanolic leaf extract of *K. reticulata* in Swiss albino mice. A model of acetic acid-induced gastric pain in mice was utilized to determine the antinociceptive effects. In writhing assays induced by acetic acid, the methanolic leaf extract showed significant inhibition compared to control. The maximum writhing inhibition (39.1%) was found at a dose of 200 mg extract/kg body -weight which, however, was lesser than that of the antinociceptive drug, aspirin (50.4%), when used at a dose of 200 mg/kg body weight. Maximum tolerance (35.0%) was showed at 400 mg extract/kg body weight, compared to that of the standard drug, glibenclamide at 10 mg/kg body weight (57.8%). The methanol extract of *K. reticulata* leaves had beneficial effects as a pain reliever which validates the use of the plant in Bangladesh folk medicinal practices as a treatment for pain[106].

6.6. *Analgesic activity*

The petroleum ether, ethyl acetate, and methanol extracts of *K. reticulata* were chosen for pharmacological screening. In the acetic acid-induced writhing test, the ethyl acetate extract in doses of 150 and 300 mg=kg showed 51.23 and 65.12% inhibition of writhing, respectively. A significant elongation of tail-flick time was evident both in the ethyl acetate and the methanol extracts (42.38 and 60.49%) only at the 300 mg=kg dose level. The extracts of *K. reticulata* possess significant shows analgesic properties[112].

6.7. *Antiviral activity*

K. reticulata is a reputed medicinal plant used in Bangladesh and India for the treatment of gastric complaints including colic, constipation etc. The study was to evaluate the antiviral activity of this plant against hepatitis B virus (HBV) using HBsAg positive serum sample from hepatitis B virus infected patients. Two semi-purified organic fractions designated as PR1 and PR2 of the fat free ethanolic extract were tested at both lower and higher concentrations (20 mg/ml and 40 mg/ml respectively) for their anti hepatitis B virus surface antigen (anti-HBsAg) activity using an *in vitro* system by Reverse Passive Haemagglutination (R-PHA) method. SERRODIA-Anti-HBsAg- Diagnostic kit was used for detection of Anti-HBsAg antibody. Both fractions showed anti-HBsAg activity. But it was found the fractions have little inhibitory action on HBsAg at lower concentration whereas at the higher concentration they have prominent inhibitory action on the antigen. To the best of our knowledge this is the first report of the antiviral activity of *K. reticulata* against HBV. The Anti-HBsAg. activity observed by the fractions may be due to the binding of the agents with the antibody binding sites present on HBsAg. Thus the fractions might be the potential sources of the active principles responsible for antiviral activity[53].

6.8. *Anti-inflammetry activities*

To study pharmacognostic evaluation and anti - inflammatory activity of K. reticulata fruit. The hydroalcoholic extract of ripe fruits and petroleum ether, ethyl acetate, and methanolic extracts of aerial parts was also screened for anti-inflammatory activity by carrageenan induced left hind paw oedema in rat at doses of 200 mg/kg and 400 mg/kg, orally[112,113].

6.9. *Insectisidal activities*

Chemical constituents as well as insecticidal activity of the crude methanol extract from the leaves of *K. reticulata.* Were investigated. (5*R**,6*R**)-4, Dimethoxycarbonyl-5-[2′,3′,4′-trihydroxy-6′-(methoxycarbonyl) phenyl]-5,6-dihydro-2*H* pyran-2-one along with 3,4,3′-tri-*O*methylellagic acid, and methyl gallate were isolated from the dichloromethane extract. Determination of their structures was based on spectroscopic analysis. Compound 1 possessed a very weak insecticidal activity against *Spodoptera frugiperda* (Sf9) with an IC50 value of 27.27 µg/mL[77].

6.10. *Hepatoprotective activity*

Two partially purified organic fractions designated by PR1 and PR2 of the fat free ethanol (95%) extract of aerial parts of *K. reticulata* were tested for the hepatoprotective activity in rats against CCl4-induced liver damage. The rats receiving the fractions showed promising hepatoprotective activity as evident from significant changes of pentobarbital-induced sleeping time, changes in serum levels of sGPT, sGOT, sALP and bilirubin and also from histopathological changes as compared to CCl4-intoxicated rats[84].

6.11. *Toxicity*

The hexane and methanol extracts of *K. reticulata* leaves were inactive in the *in vitro* cytotoxicity study. The dichloromethane extract showed IC50 values of 11.89 µg/mL in KB and 16.08 µg/mL in MCF7, but was inactive in the NCI-H187 human tumor cell line. The dichloromethane extract was then further purified using column chromatography, Two other compounds isolated from the dichloromethane extract were identified as 3,4,3′-tri-*O*methylellagic acid, and methyl-3,4,5-trihydroxybenzoate (methyl gallate) by the spectrometric methods[77].

CONCLUSION

The scientific research on *K. reticulata* suggests a huge biological potential of this plant. It is strongly believed that detailed information as presented in this review on the phytochemical and various biological properties of the

plant might provide detailed evidence for the use of this plant in different diseases. It has various traditional uses that differ from one country to another whereas some important uses for the treatment of diabetes, dysentery, fever, gonorrhoea, syphilis and stomachache and skin diseases are almost common. *K. reticulata*, a potent herbal medicine is attracting researchers since many decades due to its high therapeutic value. There is a demand to standardize the properties of *K. reticulata* and their detailed clinical trials. Pharmacological and chemical studies have demonstrated that the extracts of the plant possess various pharmacological actions viz. antiviral, anti-inflammatory antimicrobial, antidiabetic, hepatoprotective and antioxidants, antihepatitis B, and antiplasmodial. Owing to the impressive precli-2*H*-nical therapeutic potential, the plant extracts have been evaluated in human trials for the treatment of HIV, AIDS, hypertension and diabetes. *K. reticulata* is reported to contain lignans, flavonoids, polyphenols, triterpenes, sterols and alkaloids. The phytochemicals exhibited different structural characteristics with various pharmacological actions. The lignans glycosides isolated from *K. reticulata* significantly inhibited alloxon induced diabetic mice. The presence of high contents of phenolic compounds in the aqueous extract of *P. reticulatus* was found to have strong and significant antioxidant activity. Triterpenoids isolated from aqueous and methanolic extract of leaves, stem bark and root bark of *K. reticulata* exhibited very high antioxidant activity. Phytochemical and phytoanalytical information appears to be very useful and might lead to development of novel agents for various disorders and could be explored further for commercial purposes. However, there are many aspects, which need to be explored like well-controlled clinical trials using large sample size (large number of patients) for the efficacy and toxicity, the mechanism of biological activity of active constituents present in the plant. On the basis of biological activities of *K. reticulata*, crude extract and derived phytochemicals and their uses as pharmacological agents in traditional and modern research are possible but will first require more clinical trials and product development. The current evidence is large limited to correlation between identified phytochemicals and mode of action for any pharmacological activity. Mechanism of action studies are expected to lead the way in the discovery of new agents with improved and intriguing pharmacological properties. This could be achieved by molecular modeling studies involving interaction of bioactive phytochemicals from *K. reticulata* with their respective molecular targets and the extract of *K. reticulata* could be further explored in the future as a source of useful phytochemicals for the pharmaceutical industry.

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