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# A Review on Bioactive Compounds and Medicinal Uses of *Commiphora mukul*

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## ABSTRACT

*Commiphora mukul* possesses a vast ethnomedical history and represents a phytochemical reservoir of heuristic medical value. It plays a very important role in all these processes as a key ingredient of the treatment procedures. *C. mukul* contains wide numbers of phytochemical constituents i.e., flavonoid, terpenes, phytosterols etc. which have different biological activities like antimicrobial, anti inflammatory, anti carcinogenic activity and various other important medicinal properties. There is a need to review this plant in order to provide scientific proof for its application in traditional medicine system. Guggulsterone is a main active substance in gugulipid, an extract of the *C. mukul*, used to treat a variety of disorders in humans, including dyslipidemia, obesity and inflammation. In this review an effort was made to update the information on its phytochemicals and pharmacological properties.

**Key words:** Bioactive, phytochemicals, guggulsterone, pharmacological

## INTRODUCTION

The biological and pharmacological properties of many plants are still unknown. Importance of medicinal plants and traditional health systems are always a concerning issue to resolve the health care problems of the world (Sarwar *et al*., 2011). The major source for drug discovery still comes from herbs and plants in spite of the great development of synthetic molecules (Joshi and Joshi, 2007). The inherent properties of herbal medicine have increased to fill the lacunae created by synthetic medicines (Paarakh, 2010; Joshi *et al*., 2012a). World-over, the scientists are exploring the possibilities of utilizing or finding out pharmacologically active compounds from medicinal plants (Joshi *et al*., 2012b; Karmegam *et al*., 2012; Bairwa *et al*., 2011). *Commiphora mukul* is a small thorny plant (Fig. 1) indigenous to the India subcontinent and parts of the Near East (Mesrob *et al*., 1998). The flowers are red and the fruit is oval in shape and pulpy in nature. It is also known as guggul gum, guggal, guggulsterone, guggulu and gum guggul.

The ole-gum-resin of *C. mukul* is called gugulipid (Satyavati, 1991). The yellowish resin produced by the stem of the plant has been widely used in Ayurvedic medicine for more than 2000 years, mainly to treat arthritis Inflammation and to improve hepatic antioxidant defense system (Urizar and Moore, 2003; Kimmatkar *et al*., 2003; Al-Rejaie, 2012).

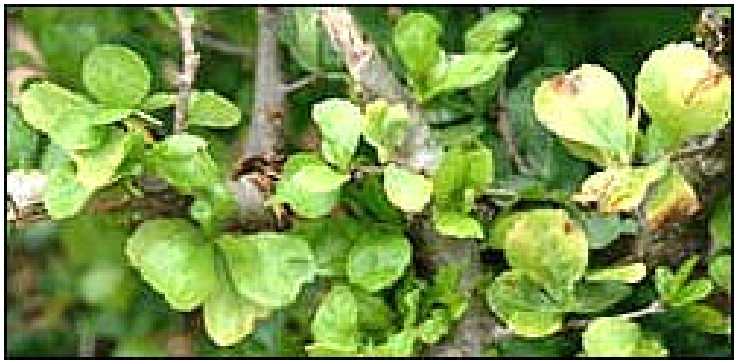

Fig. 1: Plant of *C. mukul*

The active ingredients in gugulipid are the ketosteroids cis- and trans-4,17 (20)-pregnadiene-3,16-dione, also known as E- and Z guggulsterone (Ding and Staudinger, 2005), are extracted from the resin, that is safer and more effective than many cholesterol lowering drugs (Szapary *et al.*, 2003). *C. mukul* was found relatively safe effective supplement for osteoarthritis of the knee (Singh *et al.*, 1995). This medicinal plant has a wide range of usefulness in indigenous medicine (Joshi *et al.*, 2012a). Like all oleo-resins, it causes an increase of leucocytes in the blood and stimulates phagocytosis (Speh and Vogan, 1980). Guggulu is a complex mixture of steroids, diterpenoids, aliphatic esters, carbohydrates, amino acids and triglycerides used into the preparation of several compound medicines (Rout *et al.*, 2012). *C. mukul* has been used as an anti-inflammatory, antispasmodic, anti-suppurative, thyroid-stimulant, nervous diseases, cardiovascular diseases, anthelmintic, depurative, skin disorders, leprosy, pyorrhea, muscle spasms, hypertension, urinary disorders, vulnerary, antiseptic, demulcent, aphrodisiac stimulant, liver tonic etc. (Singh *et al.*, 1990; Gupta, 1990; Singh *et al.*, 1997; Ghorai *et al.*, 2000; Chander *et al.*, 2002; Singh *et al.*, 2003; Deng, 2007; Saxena *et al.*, 2007; Siddiqui, 2011). *C. mukul* has antiarthritic, anti- inflammatory, antibacterial and antifungal activity (Chaturvedi and Singh, 1965; Kakrani, 1981; Pardhasaradhi *et al.*, 2001; Manjula *et al.*, 2006).

Dixit *et al.* (1980) reported the hypolipidemic effects of *Commiphora mukul* (guggulu) in dog and Presbytis monkeys. The active plant extract showed significant antibacterial activities against human pathogenic strains, adding credence to the ethnomedicinal uses of the plant (Dey *et al.*, 2011; Omer *et al.*, 2011). Antibacterial and antifungal activity of oils and active components of guggulu were also assayed against a variety of human pathogenic bacteria (Kazemi *et al.*, 2012). Bag *et al.* (2009) used plant generated bioactive compounds as an alternative antimicrobial agent against multi-drug resistant bacterial pathogens. Zongo *et al.* (2009) also worked on antimicrobial activity of alkaloids and conformed the importance of plant in traditional medicine against some infectious diseases. The hydroalcoholic extract of *C. mukul* significantly improved the cardiac function and prevented myocardial ischemic impairment manifested in the form of increased heart rate, decreased arterial pressure, increased left ventricular end diastolic pressure and altered myocardial contractility indices (Ojha *et al.*, 2008). Modern therapeutic uses of *C. mukul* are cover nervous diseases, leprosy, muscle spasms, pyorrhoea, scrofula, skin disorders, spongy gums, hypertension, ulcerative pharyngitis, urinary disorders and cardiovascular diseases. It is also an anti-oxidant agent and reduces the stickiness of platelets. The Ayurvedic herb *Inula racemosa*, in combination with *Commiphora mukul*, is used to reduce chest pain and dyspnea of angina

(Gupta, 1990; Chander *et al.*, 2002; Deng, 2007). The gum resin contains Z and E isomers of guggulsterone and its related gugggulsterols: guggulsterol-I, guggulsterol-II, guggulsterol- III, guggulsterol-IV, guggulsterol-V and guggulsterol-VI. Major components of essential oil from gum resin are myrcene and dimyrcene (Patil *et al.*, 1972; Purushothaman and Chandrasekharan, 1976). That plant is associated with lower levels of cholesterol and triglycerides. It might be beneficial for people with atherosclerosis (Lata *et al.*, 1991). Gugulipid, a fraction of *Commiphora mukul* has been developed at CDRI, Lucknow as a hyperlipidaemic agent (Metha *et al.*, 1968; Satyavati *et al.*, 1969).

## BIOACTIVE COMPOUNDS

Plants have been the basis of many traditional medicines because they are one of the richest sources of bioactive compounds and have continued to provide new remedies to mankind (Ingale and Hivrale, 2010). Some bioactive compounds has been reported in the extract of *C. mukul* such as dimyrcene (Delay and Ohloff, 1979), α-camphorene (Raldugin *et al.*, 1976), linoleic, oleic, stearic, palmitic acids, sitosterol (Kakrani, 1982), Z- and E-guggulsterones (Mesrob *et al.*, 1998), (8R)-3α,8-dihydroxy-polypoda-13E,17E,21-triene (myrrhanolC,4-pregnene-3,16-dione, 20S-acetyloxy-4-pregnene-3,16-dione, 4,17(20)-(cis)-pregnadiene-3,16-dione, 4,17(20)-(trans)-pregnadiene-3,16-dione, 16 β-acetyloxy-pregn-4,17(20)-trans-dien-3-one, 3 α-acetyloxy-5α-pregnan-16-one, 20R,22R-dihydroxycholest-4-en-3-one (Matsuda *et al.*, 2004).

**Amino acids:** The amino acids are reported in the extract of *Commiphora mukul* such as cystine, histidine, alanine, proline, tyrosine, tryptophan, valine, leucine and isoleucine (Arora *et al.*, 1971).

## EFFECT OF BIOACTIVE COMPOUNDS AND THEIR ACTIVITY

**Epiexcelsin and 5'-demethoxy-epiexcelsin:** These two lignans (Fig. 2, 3) were isolate by phytochemical study of *Commiphora mukul*. These lignans showed the significant inhibitory activity against α-glucosidase with the $IC_{50}$ 59.8±3.63455 and 75.2±8.1616 μM, weak inhibitory potential against chymotrypsin with the $IC_{50}$ of 110±0.025 and 649±0.013 μM, respectively (Abbasi *et al.*, 2005).

**Guggulsterone:** Sharma *et al.* (2009) observed the effects of guggulsterone on diabetic rat and found that guggulsterone showed a differential effect with a significantly improved PPARgamma expression and activity in *in vivo* and *in vitro* conditions, respectively. However, it inhibited 3T3-L1

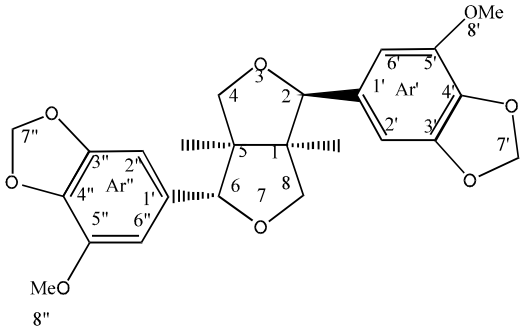


Fig. 2: Epiexcelsin

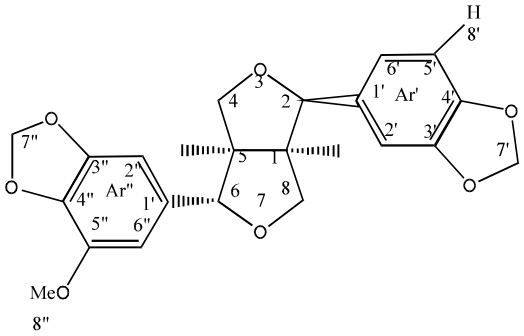


Fig. 3: 5'-demethoxy-epiexcelsin

preadipocytes differentiation *in vitro*. The results presented here suggest that the guggulsterone has both hypoglycemic and hypolipidemic effect which can help to cure type II diabetes (Sharma *et al*., 2009). Guggulsterone is a potent inhibitor NF-κB, COX-2 and MMp-9 (Shishodia and Aggarwal, 2004). As gugulipid, guggulsterone also inhibited platelets aggregation (Mester *et al*., 1979) and provide protection against myocardial ischemia induced by isoproterenol (Kaul and Kapoor, 1989). The protective action of guggulsterone is due to antioxidant property because it inhibits the generation of oxygen free radicals (Chander *et al*., 2002).

According to Shah *et al*. (2012) the Z- and E-guggulsterones, have been demonstrated to exhibit their biological activities by binding to nuclear receptors and modulating the expression of proteins involved in carcinogenic activities. Guggulsterones have also been reported to regulate gene expression by exhibiting control over other molecular targets including transcription factors such as nuclear factor (NF)-κB, signal transducer and activator of transcription (STAT) and steroid receptors (Shah *et al*., 2012). Yu *et al*. (2009) studied the effect of guggulsterone and observed that guggulsterone antagonized the chenodeoxycholic acid activated by nuclear Farnesoid X Receptor (FXR), which regulates cholesterol metabolism in the liver.

The Z-Guggulsterone and E-Guggulsterone are the active components and Non-Ketonic part of guggul which appear to be responsible for lowering blood lipids and hypolipidemic activity. Macha *et al*. (2010) were studied on guggulsterone targets smokeless tobacco induced PI3K/Akt pathway in head and neck cancer cells. According to them guggulsterone may be able to suppress carcinogenic growth in head and neck cells from smokeless (chewing) tobacco. Because in their research they observed that Guggulsterone (GS) is a biosafe nutraceutical, inhibits the PI3K/Akt pathway that plays a critical role in HNSCC development. However, the potential of GS to suppress Smokeless Tobacco (ST) and nicotine (major component of ST) induced HNSCC remains unexplored. They hypothesized GS can abrogate the effects of ST and nicotine on apoptosis in HNSCC cells, in part by activation of PI3K/Akt pathway and its downstream targets, Bax and Bad. So, they conclude that GS treatment not only inhibited proliferation, but also induced apoptosis by abrogating the effects of ST/nicotine on PI3K/Akt pathway in head and neck cancer cells (Macha *et al*., 2011). Guggulsterones seem to have special mechanisms for head and neck anti-carcinogenesis (Leeman-Neill *et al*., 2009; Macha *et al*., 2010). Guggulsterones also appear to reduce circulating levels of pro-inflammatory cytokines and markers such as IL-1b, IL-2 and TNF-α (Manjula *et al*., 2006). Guggulsterones are also able to reduce Cyclooxygenase-2 (COX2) mRNA levels and suppress its TNFa mediated induction (activation) (Shishodia and Aggarwal, 2004). Urizar *et al*. (2002) studied on a natural product that lowers cholesterol as an antagonist ligand for

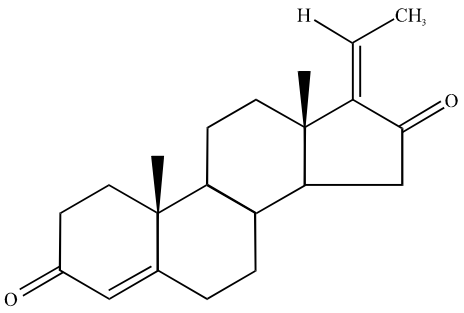


Fig. 4: 4, 17(20)-(trans)-pregnadiene-3

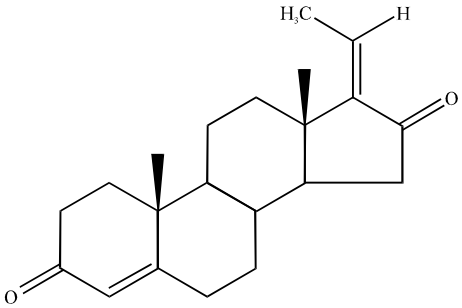


Fig. 5: 4,17(20)-(cis)-pregnadiene-16-dione(guggulsterone, Z-isomer), 16-dione (guggulsterone, E-isomer) (Patil *et al.*, 1973)

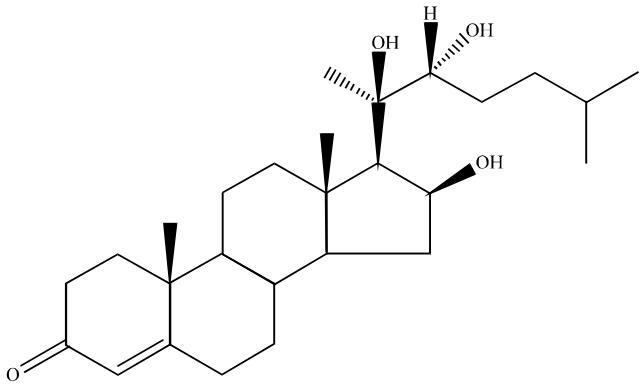


Fig. 6: Guggulsterol-I (Meselhy, 2003)

FXR and observed that sterol guggulsterone [4,17(20)-pregnadiene-3,16-dione] (Fig. 5) is the active agent, highly efficacious antagonist of the Farnesoid X Receptor (FXR) and a nuclear hormone receptor that is activated by bile acids (Urizar *et al.*, 2002).

Some researchers also studied guggulsterone and isolated the Z- and E- isomer of guggulsterone (Fig. 4 and 5) and its related guggulsterols like guggulsterol-I (Fig. 6), guggulsterol-II (Fig. 7), guggulsterol-III (Fig. 8), guggulsterol IV (Fig. 9), guggulsterol V (Fig. 10), Guggulsterol VI (Fig. 11) from the extract of resin. These compounds have hypolipidemic properties (Singh *et al.*, 2005; Mishra and Kaur, 2012).

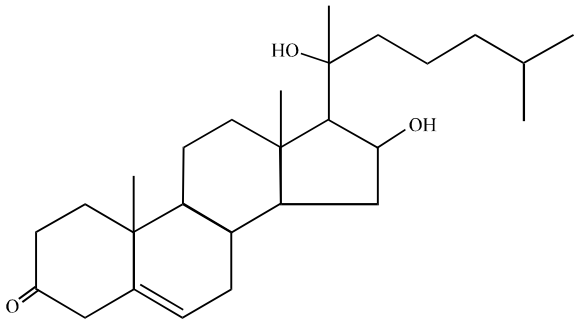


Fig. 7: Guggulsterol-II (Jain and Gupta, 2005)

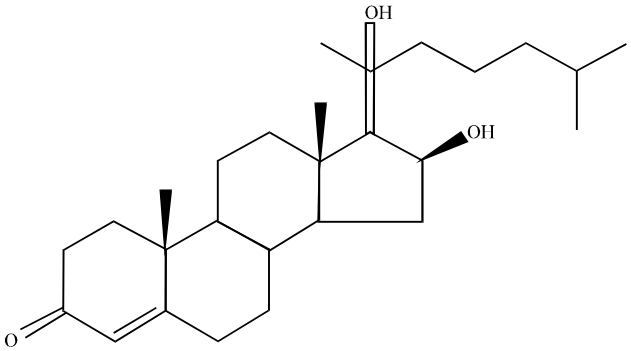


Fig. 8: Guggulsterol-III (Patil *et al.*, 1972)

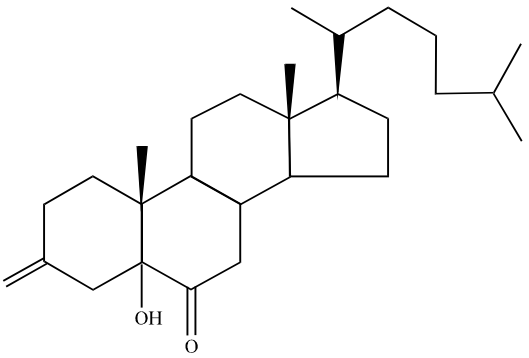


Fig. 9: Guggulsterol-IV (Purushothaman and Chandrasekharan, 1976)

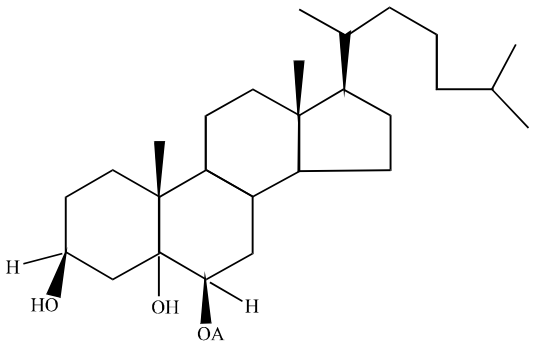


Fig. 10: Guggulsterol-V (Purushothaman and Chandrasekharan, 1976)

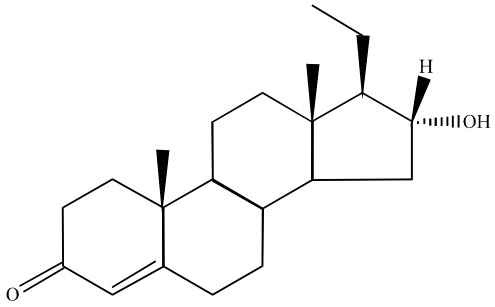


Fig. 11: Guggulsterol-VI{16-α- hydroxy-4-pregnen-3-one}(Bajaj and Sukh, 1982)

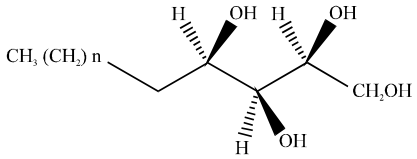


Fig. 12: Guggultetrol-18(D-xylo-octadecane-1,2,3,4-tetrol) n = 2 (Kumar and Dev, 1987)

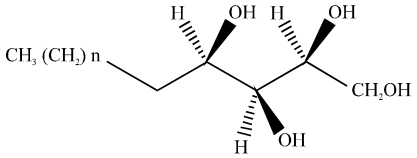


Fig. 13: Guggultetrol-20 (eicon-1 , 2, 3,4-tetrol) (Kumar and Dev, 1987)

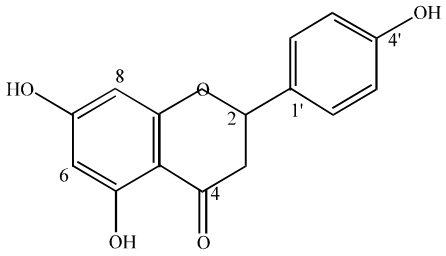


Fig. 14: Naringenin (Fatope *et al.*, 2003)

A search was done on these two tetrols (Fig. 12, 13), but no references describing biological activity were found (Dev, 1983).

**Naringenin:** Naringenin (Fig. 14) can efficiently prevent the accumulation of plasma lipids and lipoproteins. Naringenin has hepatoprotective efficacy. It is flavonoids which display anti-inflammatory, antihistaminic, antibacterial and antiviral properties (Kay, 1996).

**Cembranoids:** Yu *et al.* (2009) studied the Effect cembranoids (Fig. 15) of *Commiphora mukul* and observed that the cembranoids did not show a noticeable effect on FXR, but lowered the cholate (1)-activated rate of human pancreatic IB phospholipase A2 (hPLA2), which controls gastrointestinal absorption of fat and cholesterol (Yu *et al.*, 2009).

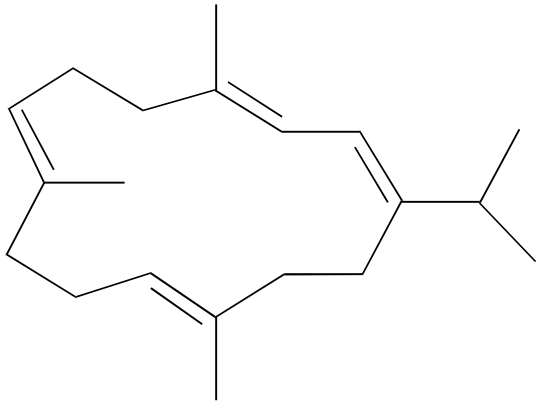

Fig. 15: Cembranoids

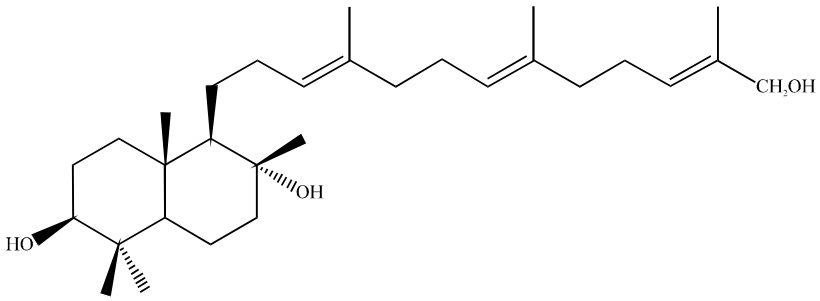


Fig. 16: Myrrhanol A (Kimura *et al.*, 2001; Matsuda *et al.*, 2004)

**Myrrhanol A:** Myrrhanol A (Fig. 16), a triterpene of *Commiphora mukul* gum resin displayed a potent anti-inflammatory effect on exudative pouch fluid, angiogenesis and granuloma weights in adjuvant-induced air-pouch granuloma of mice. Researchers noted that the effects were more marked than those of hydrocortisone (Kimura *et al.*, 2001). A petroleum ether extract of the oleo-gum resin of *Commiphora molmol*, dosed at 500 mg $kg^{-1}$ produced a significant inhibition of carrageenan -induced inflammation and cotton pellet granuloma, as well as significant antipyretic activity in mice (Tariq *et al.*, 1986). Myrrhanol A, is significantly reduces pain and stiffness in patients with osteoarthritis.

**α-pinene:** The bicyclic monoterpenes α-pinene (Fig. 17) showed considerable antifungal activity (Lis-Balchin *et al.*, 1999; Aligiannis *et al.*, 2001; Mourey and Canillac, 2002; Delaquis *et al.*, 2002; Kim *et al.*, 2003; Martins *et al.*, 2003; Staniszewska *et al.*, 2005). However, there is no clear consensus yet as to which pinene isomer is more antimicrobially active (Griffin *et al.*, 1999; Hammer *et al.*, 2003).

Eugenol (Fig. 18) is known to inhibit lipid peroxidation by acting as a chain-breaking antioxidant (Nagababu and Lakshmaiah, 1992; Fujisawa *et al.*, 2002). The lipid peroxidation may play a very important role in cell proliferation especially in tumours (Udilova *et al.*, 2003) thus; lipid peroxidation control could be a mechanism of action of eugenol as an anti microbial agent. Eugenol is involved in cytotoxic process and can cause apoptotic cell death (Yoo *et al.*, 2005). Eugenol inhibited the mutagenicity of aflatoxin B1 and N-methyl-N'-nitrosoguanidine (Francis *et al.*, 2004).

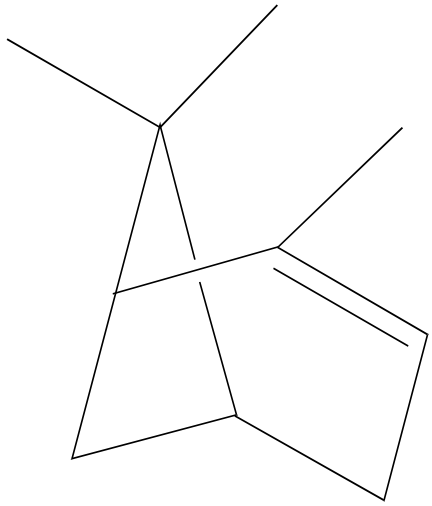

Fig. 17: $\alpha$-pinene (Saxena and Sharma, 1998)

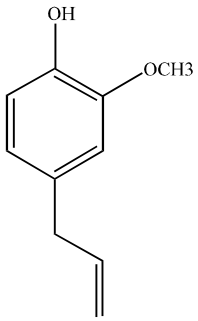


Fig. 18: Eugenol (Saxena and Sharma, 1998)

**Ellagic acid:** Ellagic acid (Fig. 19) has antioxidant, anti-mutagen and anti-cancer properties. Studies have shown the anti-cancer activity on cancer cells of the breast, oesophagus, skin, colon, prostate and pancreas. More specifically, ellagic acid prevents the destruction of P53 gene by cancer cells. Ellagic acid can bind with cancer causing molecules, thereby making them inactive.

Ahn *et al.* (1996) studied on the effects of dietary ellagic acid on rat hepatic and esophageal mucosal cytochromes P450 and phase II enzymes. They showed that ellagic acid causes a decrease in total hepatic mucosal cytochromes and an increase in some hepatic phase II enzyme activities, thereby enhancing the ability of the target tissues to detoxify the reactive intermediates. Ellagic acid showed also a chemo-protective effect against various chemically induced cancers (Ahn *et al.*, 1996). A study by Thresiamma *et al.* (1996) indicate that oral administration of ellagic acid by rats can circumvent the carbon tetrachloride toxicity and subsequent fibrosis of the liver. Ellagic acid has also antiviral and antibacterial activities (Thresiamma *et al.*, 1996). In plants, ellagic acid is bound to a sugar molecule to form ellagitannin, a potent antimicrobial agent. This molecule may have evolved to protect plants from infections and parasites, but there is some evidence that ellagic acid might serve antiviral and antibacterial functions.

**L-arabinose:** L-Arabinose (Fig. 20) found in plant, has no reported biological activity, but makes the bean pods a good source of sugar (Kay, 1996).

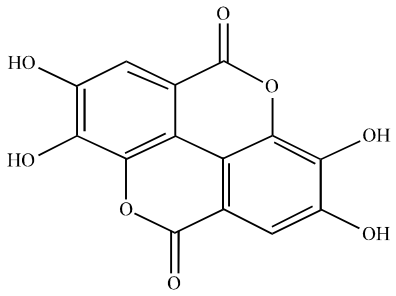


Fig. 19: Ellagic acid (Kakrani, 1981)

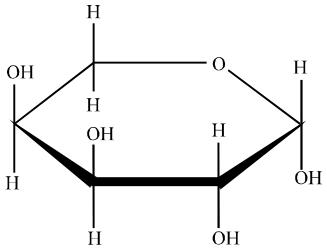


Fig. 20: L-arabinose (Bose and Gupta, 1964a)

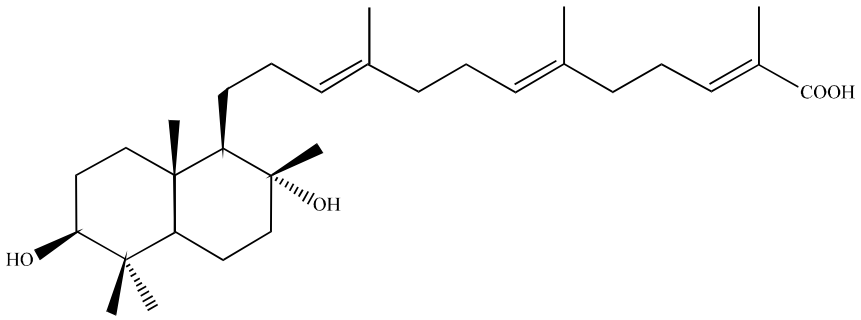


Fig. 21: Myrrhanols B

**Myrrhanols B, myrrhanones A, myrrhanones B:** Matsuda *et al.* (2004) studied on absolute stereo structures of polypodane- and octanordammarane-type triterpenes with nitric oxide production inhibitory activity from guggul-gum resins. They observed that the several triterpenes (Fig. 21-23) constituents showed inhibitory effects on nitric oxide production and induction of inducible nitric oxide synthase.

**Muscanone:** Fatope *et al.* (2003) were isolated a new antifungal flavanone, muscanone (Fig. 24) along with known naringenin from *Commiphora wightii* which show the antifungal activity against *Candida albicans*. Muscanone inhibited the growth of Candida albicans at 250 μg $mL^{-1}$ (Fatope *et al.*, 2003).

**Diayangambin:** De Leon *et al.* (2003) studied on diayangambin (Fig. 25) have immunomodulatory and anti-inflammatory efficacy *in vitro* and in vivo condition. They observed that Human mononuclear cell proliferation was inhibited by diayangambin with an $IC_{50}$ value

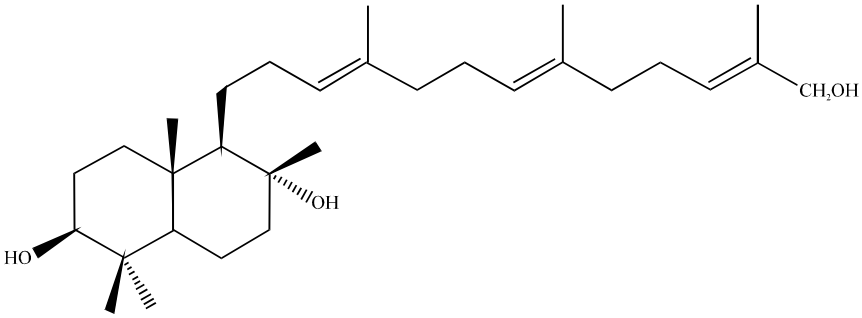


Fig. 22: Myrrhanones A

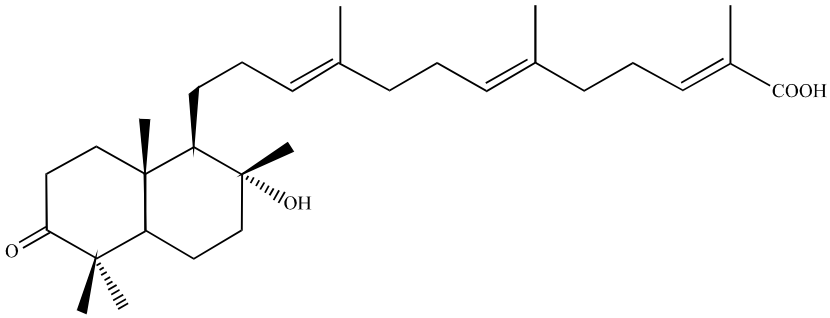


Fig. 23: Myrrhanones B (Kimura *et al.*, 2001; Matsuda *et al.*, 2004)

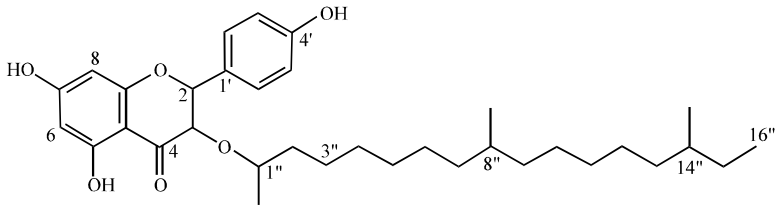


Fig. 24: Muscanone (Fatope *et al.*, 2003)

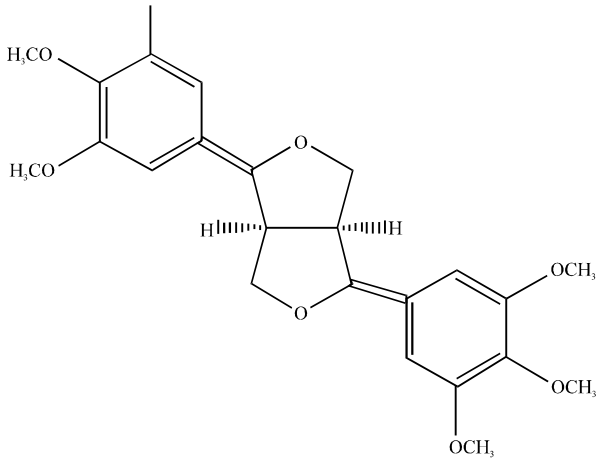


Fig. 25: Diayangambin ((Matsuda *et al.*, 2004)

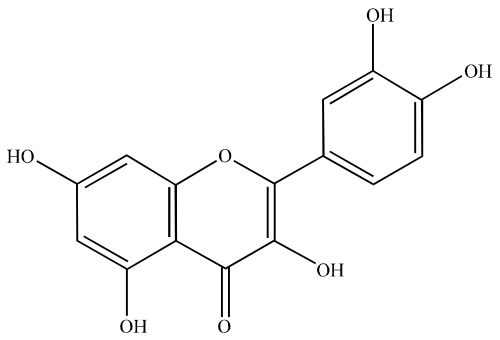


Fig. 26: Quercetin

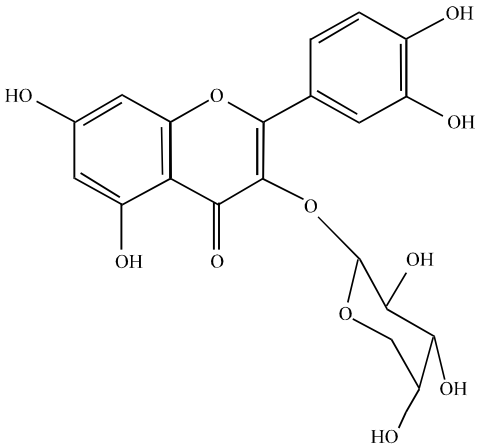


Fig. 27: Quercetin-3-O-α-L-arabinoside

of 1.5 (0.5-2.8) micro M. In addition, the compound reduced for 40.8% prostaglandin E 2 generation in stimulated RAW 264.7 macrophage cell line at 10 micro M and *In vivo*, a clear reduction of ear swelling was observed when diayangambin (40 mg $kg^{-1}$) was administered orally to 2,4-dinitrofluorobenzene-treated mice. The inhibition of swelling was associated with a reduction of leukocyte infiltration determined as myeloperoxidase activity. In the carrageenan mouse paw edema model, diayangambin significantly suppressed inflamed paw volume and prostaglandin E 2 levels. So, they conclude that the potential interest of diayangambin in the treatment of immune and inflammatory responses (De Leon *et al.*, 2002).

**Quercetin:** The major flavonoid components of the flowers of *Commiphora mukul* were identified as quercetin (Fig. 26), quercetin-3-O-α-L-arabinoside (Fig. 27), quercetin-3-O-β-D-galactoside (Fig. 28), quercetin-3-O-α-L-rhamnoside (Fig. 29), quercetin-3- O-β-D glucuronide (Fig. 30) (Kakrani, 1981). The flavonoid pelargonidin-3, 5-di-O-glucoside (Fig. 31) is an anthocyanidin also isolated from *C. mukul* flowers. Some studies have also reported that, *in vitro*, quercetin (Fig. 26) can inhibit various cytokines, including tumour necrosis factor β (TNFβ) (Manjeet and Ghosh, 1999; Nair *et al.*, 2006). Quercetin aglycone was the most effective inducer of the anticarcinogenic phase II marker enzyme, Quinone Reductase (QR), in mouse Hepalclc7 cells. Of the glycosides, only quercetin-4'-glucoside was able to induce QR activity in this assay (Williamson *et al.*, 1996).

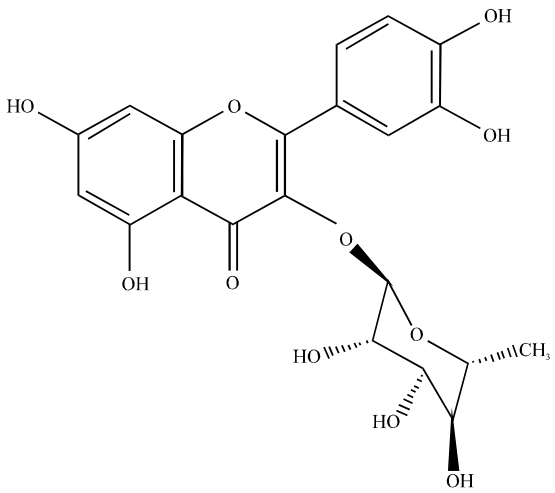


Fig. 28: Quercetin-3-O-β-D-galactoside

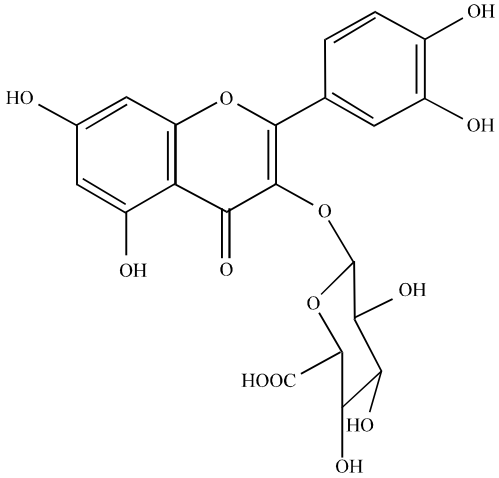


Fig. 29: Quercetin-3-O-α-L-rhamnoside

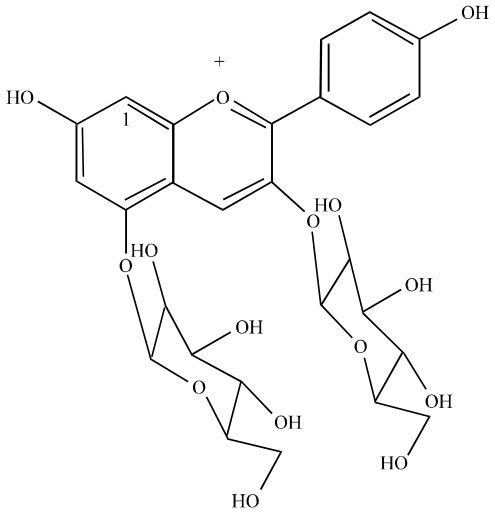


Fig. 30: Quercetin-3-O-β-D-glucuronide

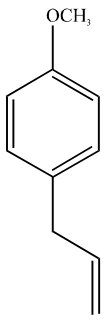


Fig. 31: Pelargonidin-3,5-di-O-glucoside (Kakrani, 1981)

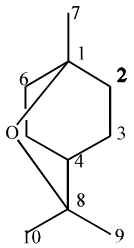


Fig. 32: Methyl chavicol (Saxena and Sharma, 1998)

Quercetin has a range of activities. It has been shown *in vitro* to act as an antioxidant (Filipe *et al.*, 2004), inhibit LDL oxidation (Formica and Regelson, 1995; Yamamoto *et al.*, 1999; Janisch *et al.*, 2004), inhibit the nitric oxide pathway (Chan *et al.*, 2000; Mu *et al.*, 2001), have anti-inflammatory activity, possibly due to an influence on the production of eicosanoids, including leukotrienes and prostaglandins (Formica and Regelson, 1995) and also cytokines (Wadsworth and Koop, 1999), have potential as an anti-cancer agent through interaction with type II oestrogen binding sites (Shenouda *et al.*, 2004), inhibition of tyrosine kinase (Huang *et al.*, 1999), up-regulation of tumour suppressor genes (Nair *et al.*, 2004; Van Erk *et al.*, 2005) induction of apoptosis (Mertens-Talcott and Percival, 2005; Mertens-Talcott *et al.*, 2003) and inhibition of tumour necrosis factor-alpha (Wadsworth *et al.*,2001), have antihistamine activity (Marozzi *et al.*, 1970).

**Methyl chavicol:** Methyl chavicol (Fig. 32), also known as estragole (Lewinsohn *et al.*, 2000).

**1, 8-cineole:** Santos and RAO (2000) were studied on anti-inflammatory and antinociceptive effects of 1,8-cineole (Fig. 33) a terpenoid oxide present in many plant essential oils. They observed that 1,8-Cineole (cineole), a terpenoid oxide present in many plant essential oils displays an inhibitory effect on some types of experimental inflammation in rats, i.e., paw edema induced by carrageenan and cotton pellet-induced granuloma. Cineole also inhibits in mice, the acetic acid-induced increase in peritoneal capillary permeability and the chemical nociception induced by intraplantar formalin and intraperitoneal acetic acid (Santos and Rao, 2000).

**β-sitosterol:** The structures of β-sitosterol (Fig. 34) and cholesterol are quite similar. It is reasonable that β-sitosterol can inhibit the absorbing of cholesterol in the body (Miettinen and Gylling, 2002) and thus reduce the cholesterol levels in the plasma (MacLatchy and Van Der Kraak, 1995). The liver function activity (GDP, GOP) can improve with β-sitosterol (Zak *et al.*,

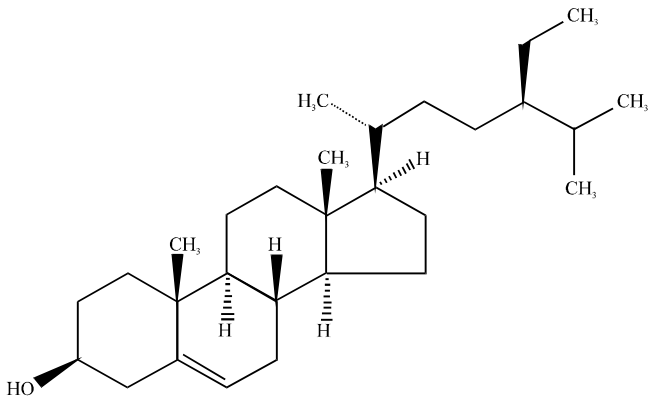


Fig. 33: 1,8-cineole (Saxena and Sharma, 1998)

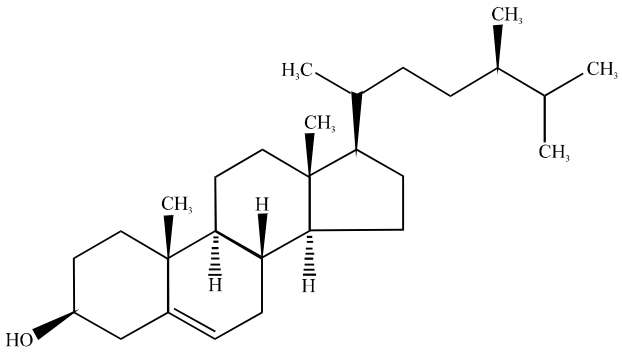


Fig. 34: β-sitosterol (Amjad and Mashooda, 1967)

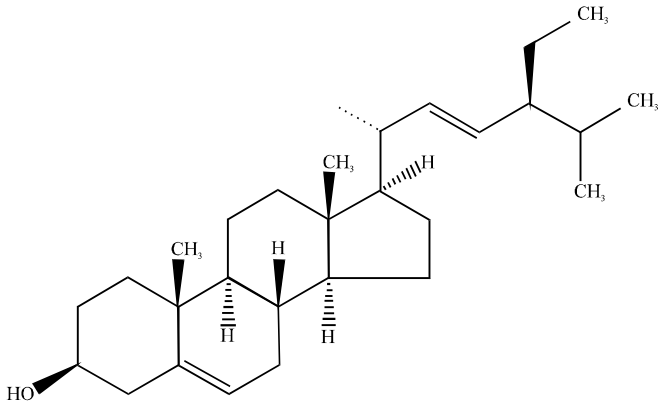


Fig. 35: Campesterol (Kakrani, 1982)

2005). β-sitosterol can reduce prostate cancer and colon-cancer cell growth (Awad and Fink, 2000). β-sitosterol has been reported that it has *in vivo* topical anti-inflammatory properties in acute TPA-induced ear oedema in mice but not in the chronic one (Gomez *et al.*, 1999).

**Stigmasterol and campesterol:** The most commonly found phytosterols are campesterol (C28) (Fig. 35) and stigmasterol (C29) (Fig. 36) (Pegel, 1980; Ostlund, 2002). Phytosterols are incorporated in a variety of food products (functional foods (Vorster *et al.*, 2003) due to their

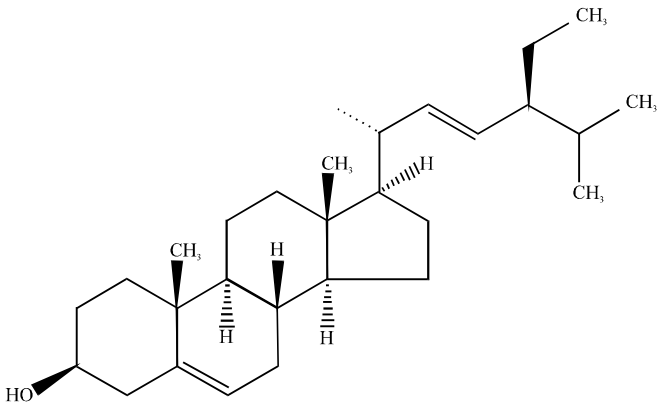


Fig. 36: Stigmasterol (Kakrani, 1982)

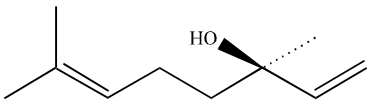


Fig. 37: (±)-linalool

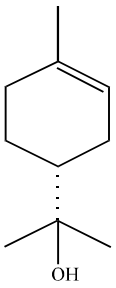


Fig. 38: α-terpineol (Saxena and Sharma, 1998)

cholesterol-lowering effect, hence providing protection against cardiovascular disease (Tapiero *et al*., 2003). Stigmasterol was found to markedly inhibit tumor promotion in two-stage carcinogenesis in mice (Yasukawa *et al*., 1991; Kasahara *et al*., 1994) and to exhibit significant inhibitory effect on HIV reverse transcriptase (Akihisa *et al*., 2001). A mixture of stigmasterol and sitosterol were shown to possess anti-inflammatory activity after topical application (Gomez *et al*., 1999).

**(±)-linalool and α-terpineol:** Linalool (Fig. 37) and α-terpineol (Fig. 38) exhibited strong antimicrobial activity against periodontopathic and cariogenic bacteria and their concentration should be kept below 0.4 mg $mL^{-1}$ (Park *et al*., 2012).

**Mansumbinoic acid and mansumbinone:** Research on anti-inflammatory activity of *C. mukul*. They observed that two octanodammarane triterpenes and mansumbinoic acid (Fig. 39) mansumbinone (Fig. 40) exhibited significant anti-inflammatory activity. The effect of mansumbinoic acid to reduced the joint swelling (Duwiejua *et al*., 1993; Sosa *et al*., 1993). Rahman *et al*. (2008) studied on antibacterial terpenes from the oleo-resin of *Commiphora molmol* (Engl.). They observed that two octane-dammaranes; mansumbinone and 3,4-seco-mansumbinoic

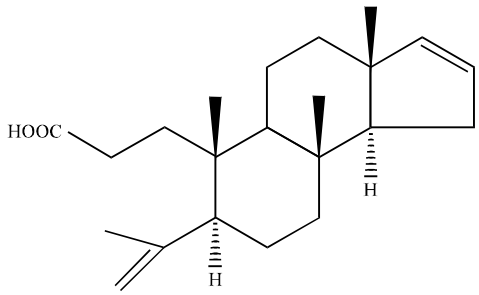


Fig. 39: Mansumbinoic acid

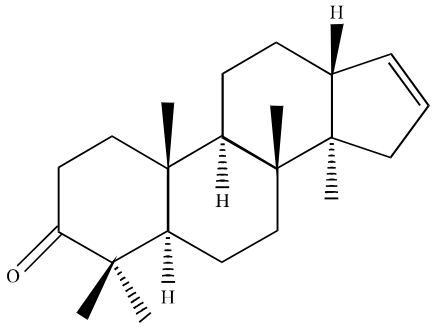


Fig. 40: Mansumbinone (Duwiejua *et al*., 1993)

acid and two sesquiterpenes; beta-elemene and T-cadinol were show the antimicrobial activity against a number of *Staphylococcus aureus* strains: SA1199B, ATCC25923, XU212, RN4220 and EMRSA15. The 3,4-seco -mansumbinoic acid were show the highest Minimum Inhibitory Concentration (MIC) against *Staphylococcus aureus* SA1199B (4 $mL^{-1}$) (Rahman *et al*., 2008).

## CONCLUSION

Pharmacological effects of *Commiphora mukul* have been studied in various laboratories. *C. mukul* is a most food and feed plant, produced a broad range of bioactive chemical constituent via their so called secondary metabolism. Bioactive compounds are often characterized as both poisonous and medicinal and a beneficial or an adverse result may depend on the amount eaten and context of intake.

Pharmacological studies on *C. mukul* have been studied in various laboratories. *C. mukul* can be regarded as plant of high medicinal value as it is an active source of number of bioactive compounds such as guggulsterone, eugenol, ellagic acid, quercitin, stigmasterol and campesterol. Studies showed that these bioactive compounds possess immense utility. Guggulsterones may be able to suppress carcinogenic growth in head and neck cells from smokeless (chewing) tobacco. Eugenol also known as lipid peroxidation may play a very important role in cell proliferation especially in tumours. Ellagic acid possesses antioxidant, anti-mutagen and anti-cancer properties. Studies have shown the anti-cancer activity on cancer cells of the breast, oesophagus, skin, colon, prostate and pancreas. Quercitin has been shown *in vitro* to act as an antioxidant inhibit LDL oxidation, inhibit the nitric oxide pathway have anti-inflammatory activity. In today's era deadly

disease as cancer, tumor has become epidemic. Plants, gift of nature still possess unexplored potential. Studies on *C. mukul* have shown a light in treating such diseases through natural means.

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