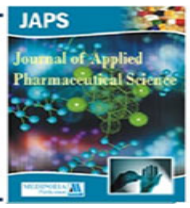
Journal of Applied Pharmaceutical Science

Available online at www.japsonline.com



ISSN: 2231-3354
Received on: 22-02-2012
Revised on: 03-03-2012
Accepted on: 13-03-2012

A review on Phytochemical and Pharmacological studies of Kundur (*Boswellia serrata* Roxb ex Colebr.) -A Unani drug

Mahe Alam, Hakimuddin Khan, L. Samiullah and K.M. Siddique

Mahe Alam, Hakimuddin Khan, L. Samiullah
Regional research Institute of Unani Medicine, Bhadrak-756100, Odisha, India

K.M. Siddique
Central council for Research in Unani Medicine, Janakpuri-58, New Delhi, India

For Correspondence
Dr. Mahe Alam
Regional Research Institute of Unani Medicine (RRIUM) Motel Chhak, Mahta Sahi, Bhardak-756100, Orissa, INDIA

ABSTRACT

Oleo-gum resin of *Boswellia serrata* Roxb ex Colebr. (Burseraceae) called *Kundur* in Unani system of Medicine is a prime ingredient in modern quality perfumes. The gum is popularly used in Indian Systems of Medicine (Unani, Ayurvedic & Sidha) for the last several centuries in curing various aliment especially rheumatism and skin diseases. *Kundur* is one of the popular drugs for various ailments such as dysentery, dyspepsia, lung diseases, haemorrhoids, rheumatism, urinary disorders and corneal ulcer in Unani system of medicine for the last several years. It is also an ingredient in certain compound formulations *viz*: *Majoon Kundur*, *Majoon Murawwah-ul-Arwah*, *Dawa-ul-Kibrit* and *Habbe Suzak* of Unani medicine used in renal disorders. The studies carried out on *Kundur* (*Boswellia serrata* Roxb) reveal that Oleo-gum resin exhibits potent Anti-fungal, Anti-complementary, Juvenomimetic and Anti-carcinogenic properties. Investigations on *Kundur* also revealed its beneficial effects in Immunomodulation, Bronchial asthma, Polyarthritis, Hepatitis C-virus, Colitis and Crohn's disease.

Phytochemistry and pharmacology on *Kundur* (Oleo-gum resin) of *Boswellia serrata* Roxb has been reviewed in this paper with the view to justify its recorded uses in Unani System of Medicine on scientific lines.

Keywords: Kundur, Boswellia serrata, Unani drug, Phytochemistry.

INTRODUCTION

Boswellia serrata Roxb ex Colebr (Kundur) belonging to family Burseraceae, is commonly known as ‘Salai’ or ‘Salia’ in Orissa. The tree is commonly found in West Asia, Oman, Yemen, South Africa, Southern Arabia and many parts of India (Western Himalayas, Rajasthan, Gujarat, Maharashtra, Madhya Pradesh, Bihar, Orissa). A medium to large sized, deciduous tree; up to 18m in height and 2.4m in the girth (normally 1.5m); The bark of this plant is thin, greenish grey, yellow or reddish and finally turning to ash colour, peeling off in smooth, exfoliating papery flakes; blaze pinkish and exuding small drops of resin (Saxena & Brahmam, 1994). The leaves alternate, imparipinnate, 30-45 cm long, ex-stipulate and crowded at the end of the branches. The leaflets are 2.5-6.3 x 1.2-3.0cm, ovate or ovate-lanceolate, 8-15 in number, nearly sessile with short toothed, mostly pubescent. The flowers are bisexual, small, white in axillary racemes or panicles at the tip of the branches. The calyx is small cupular and 5-6 lobed. The petals are 0.5-0.8 cm oblong-ovate with basal disk. (Dymock *et al*., 1972; Anonymous, 1988). The fruits are cotyledous, trifed, 1.25 cm long, trigonous, splitting into three valves. Seeds are heart-shaped and attached to the inner angle of the fruit, compressed, pendulous.

OLEO-GUM-RESIN

It is an exudate, which comes out from cortex after an injury or natural crack in the bark. It is fragrant, transparent and golden yellow. After solidification it turns into brownish yellow tears or drops and crusts. Its size varies from pea size to walnut size. The smell is agreeable. The oleo-gum-resin is tapped by shaving off a thin band of bark about 20 cm wide and 30 cm long, at a height of 15 cm from the base of the tree. This initial blaze should be made to a depth of about half the thickness of the bark, *viz*. up to 0.75 cm. Tapping should start from November and stopped before the monsoon. The number of blazes required depends upon the girth of the tree. For a tree of 90 cm girth, one blaze may be made, and for every increase of 50 cm girth one more blaze may be added. Blazes may be made horizontally leaving approximately equal space between them. The length or height of the blaze is to be increased by about 1.6 cm in fortnightly and 0.81. cm in weekly freshening every time on the upper edge. The surface already blazed or freshened may not be scraped. For continuous tapping on a 3-year cycle, the bole may be divided into three zones, each one being tapped for one year. For making another horizontal row of blazes in the subsequent year 7.5 cm space may be left above the blazed portions. The horizontal blazes of the subsequent years should be alternating or staggering with the preceding ones. Again alternating the blazes within the same zone, the blazed portions may be given complete rest for six years during which period the wounds heal up and are ready for fresh tapping.

The oleo-gum-resin is scrapped off and collected in a circular tray suitably placed around the trunk. It is collected in a semi-solid state and the vegetable impurities are manually removed. It is then kept in baskets up to 30 days on a cemented and sloping floor, whence the fluid portion containing the volatile oil is collected and used in paints and varnishes. The remaining semi-solid to solid part is mainly gum-resin which is thoroughly dried and sometimes treated with soapstone powder to make it brittle. It is then broken into small pieces, cleaned and graded for marketing.

Following kinds of oleo-gum-resin (*Kundur*) have been described in Unani literature:-

1. *Kundur-unsa* (Female), Deep pale tears 2. *Kundur-zakar* (Male) Yellow tea 3. *Kundur Mudahraj* Artificial tears 4. *Kishar Kundur (Karfa*) (It contains bark or scurf tears) and 5. *Kundur Dukak* Dust of gum According to Unani philosophers *'Kundur zakar'* mentioned at serial number 2 above, is red in colour, considered the best in quality and can be stored up to 20 years. It is also mentioned that the *Kundur unsa* is white and mostly found in India. Usually the gum is white or yellow in colour but when old, it become ruby or blackish-red or some time golden colour. The smell of '*Kundur-Zakar'* is very similar to the smell of Mastagi (*Pistacia trebinthus* Linn.). The purity can be checked by the burning of the gum which gives the flames, while adulterated gum gives only smoke. (Afaq & Siddiqui, 1984; Ghani N, 1917; Ibne Sena, 1912; Azam Khan, 1895; Nadkarni, 1976; Anonymous, 1988) *Kundur* is being used for various ailments such as dysentery, dyspepsia, lung diseases, haemorrhoids, rheumatism, urinary disorders and corneal ulcer in Unani system of medicine for the last several years (Azam, 1885; Ghani, 1917; Ibne Sina, 1912). It is also an ingredient in certain compound formulations viz: *Majoon Kundur*, *Majoon Murawwah-ul-Arwah*, *Dawa-ul-Kibrit* and *Habbe Suzak* of Unani medicine used in renal disorders (Nigrami, 1995; Lubhaya, 1979). Oleo-gum resin of *Boswellia serrata* Roxb (*Kundur)* possesses Anti-fungal (Garg, 1974), Anti-complementary (Kapil and Moza, 1992), Juvenomimetic (Dennis *et al.*, 1999) and Anti-carcinogenic properties (Huang *et al.*, 2000). Investigations on *Kundur* revealed its beneficial effects in Immunomodulation (Sharma *et al.*, 1996), Bronchial asthma (Gupta *et al.*, 1998), Polyarthritis (Sander *et al.*, 1998), Hepatitis C-virus (Hussein *et al.*, 2000), Colitis (Gupta *et al.*, 2001) and Crohn's disease (Gerhardt *et al.*, 2001)

MIZAJ (TEMPERAMENT)

The temperament (*mizaj*) of *Kundur* (*Boswellia serrata*) is mentioned as Hot^{1} Dry^{2} temperament.

Action (*Afal*)

Kundur (Oleo-gum resin of *Boswellia serrata*) is recorded as *Dafe humma* (Antipyretic), *Dafe khafqan* (Palpitation), *Dafe Tafun* (Antiseptic), *Mudire haiz* (Emmenagogue), *Muhallile auram* (Anti-inflammatory), *Muhallile reyah* (Carminative), *Muhallile Khoone Munjamid* (Thrombolytic), *Muharrike dam* (Haemodynamic), *Muhazil* (Antiobesity), *Muqavvie bah* (Aphrodisiac), *Muqavvie Qalb* (Cardiotonic), *Qatile kirm* (Antihelmenthic), and *Tiryaq* (Antidote) in classical Unani texts

***Istemal* (Therapeutic uses)**

Kundur (Oleo-gum resin of *Boswellia serrata*) is used for the treatment of *Amraze jild* (Skin diseases), *Atshak* (Syphilis), *Nafe kasrate boul* (Polyuria), *Nafe suzak* (Gonorrhoea), *Nafe Ziabetes* (Diabetes), *Simane mufrat* (Anti-obesity), and *Wajaul mufasil* (Arthritis), (Sheerazi, 1913; Ibne Rushd, 1980, Ibne Sina, 1912, Azam Khan, 1314; Singh D., 1949; Ghani N., 1917 Kirtikar & Basu, 1995; Varier's, 1994; Nadkarni, 1976; Asolkar, L.V., 1992; Chopra, R. N., 1986; Dymock, 1976; Anonymous, 1988;)

PHYTOCHEMICAL STUDIES

The chemistry of *Kundur* (oleo gum resin) of *Boswellia serrata* is now thoroughly worked out. Sample of oleo gum resin analysed by Imperial Institute London showed following composition:-Moisture – 10 – 11%, volatile oil 8 – 9% resin 55 – 57%, Gum 20 – 23%, Insoluble matter 4 – 5%. (Try and find some recent reference for analysis of *Kundur*. The constituents can be grouped as under: A: Oil, B. Terpenoids and Gum

A. Oil

The fixed oil is usually pale yellow in colour and has an agreeable odour. Essential oil is obtained in yield of up to 16% oleo-gum-resin by steam distillation. The specific gravity of essential oil is 0.8470; $[\alpha]_D^{28^0}$, $+24^0$; $n_D^{28^0}$, 1.4574; acid value, 0.76; ester value, 8.5; ester value after acetylation, 42.8; and iodine

value, 182 (Anonymous, 1984). α and β–pinenes were reported as the main constituents of oil (Pearson and Singh, 1918) . Simonson (1922) studied the low boiling fractions of the oil and found α-thujene and major constituent α–pinenes and β–phellandrene in small quantities. High boiling fractions worked out in detail by the presence of terpenol, methyl chavicol and sesquiterpenes as the major components. On the basis of spectral data and interconversion isolation of acetyl-β-boswellic acid has also been reported. The methods for separation of essential oil, resin & gum, characteristics and uses of essential oil. (Winterstein *et al.,* 1932). The physico-chemical characteristics of oil are quite variable because of the diversified sources. The constituents of the oil are α-pinene dipentene, phellendrene, cadinene, camphene, *p*-cymene, *d*-borneol, verbenone and verbenol. Girgune *et al.,* (1979) have reported the presence of α-thujene (50%), α-pinene 6.2%, d-limonene (4.5%), p-cymene (14%), cadinene (4%), geraniol (0.8%) and elemol (1.3%) as the main constituents of the essential oil. The α and β-pinenes, and d-emonene as the major constituents. In the presence of terpinyl acetate 3.5%, methyl chavical 2%, linalool 1.5% and terpinol 1% is reported (Anonymous, 1988). Composition of essential oil prepared by steam distillation (Abdel Wahab S. M. *et al.,* 1987).

B. Terpenoids

Three triterpene acids, α, β and γ--boswellic acids by the use of barium hydroxide as precipitant. The constitution of α & β Boswellic acids have been described (Simpson *et al.,* 1938, 1941). Ruzicka *et al.,* 1940 converted α-boswellic acid into β-amyrin. They prepared surfactants from these acids. Bilhma *et al.,* 1942 have assigned the position of –COOH group in β-boswellic acid. Ruzicka *et al.,* 1944 carried out various reactions in the ring A & B of the Boswellic acid and its derivatives. Beton *et al.,* 1956 have described the chemistry of triterpene and related compounds with special reference to isolation of β-boswellic acid. A review with emphasis on Boswellic acid and abietic acids have been written by (Sharma *et al.,* 1962; Budzikiewiz *et al.,* 1963) which describes the NMR and Mass spectrometry of triterpenes. β-sitosterol from the bark of *B. serrata* has been isolated (Beri *et al.,* 1963, 1964). Critical examination of the non volatile fraction of the resin has been done by (Pardhy *et al.,* 1978) and has led to the isolation of terpene acids and several neutral products including methyl chavicol, α- and 3-amyrins and a new diterpene alcohol serratol, four tetracyclic triterpene acids and four pentacyclic triterpene acids *viz.* 3-α-acetoxytirucall-8, 24-dien-2l-oic acid ($C_{32}H_{50}O_4$, m.p.220^0), 3-ketotirucall-8, 24-dien-21-oic acid ($C_{30}H_{46}O_3$, m.p.212^0), 3-α-hydroxytirucall-8, 24-dien-21-oic acid, 3-β-hydroxytirucall-8, 24-dien-21-oic acid ($C_{30}H_{48}O_3$, m.p.198^0), β-boswellic acid, acetyl-β-boswellic acid ($C_{32}H_{48}O_4$, m.p.253^0), acetyl-11-keto-β-boswellic acid ($C_{32}H_{48}O_5$, m.p.271^0) and 11-keto-β-boswellic acid ($C_{30}H_{46}O_4$, m.p.195^0). Two new triterpenoids, 2α-3α-dihydroxy-urs-12-ene-24-oic acid and urs-12-ene-3α, 24-diol, have been isolated from the gum resin of *boswellia serrata* (Babita Mahajan, 1995). Non aqueous titrimetric method was developed by (Gupta *et al.,* 1984) for the estimation of total triterpene acids present in different forms of *B. serrata* on the basis of β-boswellic acid which constitutes more than 30% of the total triterpene acids. Total triterpene acids include β-boswellic, 11 ketoboswellic and acetyl 11-keto β-boswellic acids. Estimation of triterpene acids alone or in combination of two was done using functional groups analysis. The functional groups analyzed were acetyl and hydroxyl groups at 3 position and keto group at the 11-position.

C. Gum

Analysis of Oleo-gum resin yielded: Moisture 10-11%, volatile oil 8-9% resin 55-57%, Gum 20-23%, insoluble matter 4-5%, (Fowler *et al.,* 1921, 1925) have given methods of separation of the oleo gum resin into its various constituents and have also examined gum enzymes as diastase and oxidase. The gum contains 0.16% of nitrogen. Malandkar, 1925 has hydrolyzed the gum by heating it with 3% H_2SO_4 for 8 hours and identified sugars as arabinose, xylose and galactose. Sharma *et al.,* 1980 revealed that the emulsion prepared from *B. serrata* was slightly better than those prepared with acacia gum. Emulsifying properties of Na-□-Boswellata, which was found suitable for the preparation of emulsions for internal administration has been reported. Tablets prepared with 9% *B.serrata* mucilage were comparable to those prepared with 5% Acacia mucilage. Ashis *et al.,* 1992 isolated 4-O-methyl-glucuronoarabinogalactan from the water soluble protein of gum resin.

PHARMACOLOGICAL STUDIES

Analgesic and Psychopharmacological effects

The *Boswellia serrata (Kundur)* exhibited marked analgesic activity in experimental animals in addition to its sedative effect. *Boswellia serrata (Kundur)* have found that it produces reduction in the spontaneous motor activity and causes ptosis in rats (Menon & Kar 1969).

Anti-complementary activity of boswellic acids (BA) –an inhibitor of C3-convertase

Boswellia serrata (Kundur) is found to possess anti-complementary activity. It inhibited *in vitro* immunohaemolysis of antibody-coated sheep erythrocytes by pooled guinea-pig serum. The reduced immunohaemolysis was found to be due to inhibition of C3-convertase of the classical complement pathway. The threshold concentration for inhibiting C3-convertase was found to be 100 micrograms. However, higher concentrations of BA showed constant inhibitory effects on immunohaemolysis. BA also exhibited weak inhibitory effects on individual components of the complement system. In vivo administration of BA also showed the inhibitory effect on guinea-pig serum. (Kapil A. & Moza N., 1992)

Antifungal activity of *B. serrata*

Boswellia serrata yield 0.6 percent of essential oil upon hydrodistillation. The oil has weak antifungal activity against human pathogens, and highly effective against plant pathogens, where it inhibited the tested organisms *viz. Pytophothora parasifica.* (Garg S.C. *et al.,* 1974).

Anti-hyperlipidmic Activity

Serum cholesterol and triglycerides levels, deposits of fat, in different organs and area of body of the rabbit, fed on high cholesterol and saturated fat containing diet, was noted and found the deposits in various organs including iris was significantly less marked in the Salai gum treated group. The protective effect was established, whereas, several effects was also confirmed in the other experiments. The effect was probably at the biosynthesis level. This mechanism of action was studied by incorporating the U-C14 acetate in cholesterol biosynthesis. They also suggested that Salai gum is mainly effective in checking the rats of biosynthesis and partly effective in enhancing the excretion of cholesterol (Zutshi *et al*., 1980). The alcoholic extract, tested at different dose level in 25-50 mg/kg. p.o. doses, shows anti-hyperlipidemic activity on hypercholesterolinic animals decrease the 30-50% in cholesterol level and 20-60% triglycerides level.

Anti-artherosclerotic agent

The anti-artherosclerotic activity was taken up in rabbits fed on the diet containing cholesterol and saturated fat. Four groups of rabbits (five in each group) were employed and kept on high liquid diet for three months. DAESG treatment was started on day 50 in one group, day 90 in second and continued up to day 150. The other two served as controls. Serum cholesterol and triglycerides levels, deposits of fat in different organs and areas of the body including that in iris was significantly less marked in DAESG treated group as compared to control. Anti-artherosclerotic studies made on rabbits fed on high lipid diet for three months showed that treatment with DAESG decreased serum cholesterol and triglyceride levels by 32-46% and 53-62% respectively, monitored at weekly intervals. DAESG treatment showed both prevention and reversal of artheroscelortic process as was evident from the start of high lipid diet (Atal *et al*., 1980, 1981).

Anti-inflammatory and Anti-arthritic activities

Anti-inflammatory and anti-arthritic activities have been tested against carrageen in-induced paw oedema adjuvant arthritis in rats. DAESG treatment caused inhibition of the carrageen in induced rat hind paw oedema by 39.75% and 65-73%, administered orally (p.o) in dose ranges of 50-200 mg per kg^{-1} and interaperitoneal (i.p.) in dose range of 50-100 mg per kg respectively compared to 47% inhibition seen with phenylbutazone (50 mg/kg^{-1} p.o.). The anti-inflammatory effect was equally well marked in adrenalectomized rats. In the anti-arthritic study on the mycobacterial adjuvant-induced poly-arthritis in rats, salai guggal showed 34% and 49% inhibition of paw swelling with 50 and 100 mg per kg (p.o.) doses respectively as compared to controls. Phenyl butazone in doses of 50 and 100 mg per kg (p.o.) showed 26% and 60% inhibition respectively. (Atal, *et al*., 1980-1981)

The *in vivo* effect of a herbal based, non-steroidal anti-inflammatory product salai guggal, prepared from the gum resin exudates of *Boswellia serrata* active principle 'boswellic acids" on glycosaminoglycan metabolism has been studied in male albino rats. The biosynthesis of sulfated glycosaminoglycan evaluated by the uptake of [35S] sulfate, and the content of glycosaminoglycan were measured in specimens of skin, liver, kidney and spleen. Statistical analysis of the data obtained with respect to the boswellic acids and salai guggal were compared with those of ketoprofen. A significant reduction in glycosaminoglycan biosynthesis was observed in rats treated with all of the drugs. Glycosaminoglycan content was found to be decreased in the ketoprofen-treated group, where as that of the boswellic acids or salai guggal treated groups remained unaltered. The catabolism of glycosaminoglycan was followed by estimating the activities of lysosomal glycohydrolases, namely be glucuronidase, beta-N-acetylglucosaminidase, cathepsin B1, cathpsin B2 at cathepsin D, in tissues and by estimating the urinary excretion and hexosami and uronic acid. The degradation of glycosaminoglycan was found to be reduced markedly in all drug-treated animals as compared to controls. The potential significance of boswellic acids and salai guggal was discussed in the light of changes in the metabolism of glycosaminoglycan. (Reddy, G.K. *et al.*, 1989).

Curcumine from *Curcuma longa* and the gum resin of *Boswellia serrata*, which was demonstrated to act as anti-inflammatory in in-vivo animal models, was studied in a set of in vitro experiments in order to elucidate the mechanism of their beneficial effects. Curcumine inhibited the 5-lipoxygenase activity in rat peritoneal neutrophils as well as the 12-lipoxygenase and the cyclooxygenase activities in human platelets. In a cell free peroxidation system curcumine exerted strong antioxidative activity. Thus, its effects on the dioxygenases is probably due to its reducing capacity. Boswellic acids was isolated from the gum resin of *Boswellia serrata* and identified as the active principles. Boswellic acids inhibited the leukotriene synthesis via 5-lipoxygenase, but did not affect the 12-lipoxygenase and the cyclooxygenase activities. Additionally, boswellic acids did not impair the peroxidation of arachidonic acid by iron and ascorbate. The data suggest that boswellic acids are specific, non-redox inhibitors of leukotriene synthesis either interacting directly with 5-lipoxygenase or blocking its translocation. (Ammon, H.P. *et al*., 1993; Singh, G. B., 1992)

Anti-microbial and anti-oxidant effect

The essential oil of *Boswellia serrata* was analysed by GC and GC-MS, and their antimicrobial and anti-oxidant activity tested. The volatile oil exhibited considerable inhibitory effect against all tested organisms. The oil also demonstrated anti-oxidant activity comparable with alpha-tocopherol and butylated hydroxytoluene (BHT). (Baratta M. T. *et al*., 1998) Extracts of gum resins was found to be active against six text organisms-*Staphylococcus aureus, Escherichia coli, Klebsiella species, Pseudomonas aeruginosa, Proteus mirabilis* and *Bacillus subtilis*. (Mishra *et al.*, 1980)

Anti-tumor and anti-carcinogenic activities

Boswellin (BE), a methanol extract of the gum resin exudates of *Boswellia serrata*, contains naturally occurring

triterpenoids, beta-boswellic acid and its structural related derivatives. Topical application of BE to the backs of mice markedly inhibited 12-O-tetradecanoylphorbol-13-acetate (TPA) - induced increase in skin inflammation, epidermal proliferation, the number of epidermal cell layers and tumor promotion in 7, 12-dimethylbenz[a] anthracene (DMBA)-initiated mice. Feeding 0.2% of BE in the diet to CF-1 mice for 10-24 weeks reduced the accumulation of parametrial fat pad weight under the abdomen, and inhibited azoxymethane (AOM)-induced formation of aberrant crypt foci (ACF) by 46%. Addition of pure beta boswellic acid, 3-O-acetyl-beta-boswellic acid, 11-keto-beta-boswellic acid or 3-O-acetyl-11-keto-beta-boswellic acid to human leukemia HL-60 cell culture inhibited DNA synthesis in HL-60 cells in a dose dependent manner with IC50 values ranging from 0.6 to 7.1 microM. These results indicate that beta-boswellic acid and its derivatives (the major constituents of Boswellin) have anti-carcinogenic, anti-tumor and anti-hyperlipidemic activities. (Huang, M.T. *et a.l*, 2000).

Effects of *Boswellia serrata* in Chronic colitis

Patients studied were suffered from chronic colitis characterized by vague lower abdominal pain, bleeding per rectum with diarrhoea and palpable tender descending and sigmoid colon. The inflammatory process in colitis is associated with increased formation of leukotrienes causing chemotaxis, chemokinesis, synthesis of superoxide radicals and release of lysosomal enzymes by phagocytes. The key enzyme for leukotriene biosynthesis is 5-lipoxygenase. Boswellic acids were found to be non-redox, non-competitive specific inhibitors of the enzyme 5-lipoxygenase. The gum resin of *Boswellia serrata* was studied for the treatment of this disease. Thirty patients, 17 males and 13 females in the age range of 18 to 48 years with chronic colitis were included in this study. Twenty patients were given a preparation of the gum resin of *Boswellia serrata* (900 mg daily divided in three doses for 6 weeks) and ten patients were given sulfasalazine (3gm daily divided in three doses for 6 weeks) and served as controls. Out of 20 patients treated with Boswellia gum resin 18 patients showed an improvement in one or more of the parameters; including stool properties, histopathology as well as scanning electron microscopy, besides haemoglobin, serum iron, calcium, phosphorus, proteins, total leukocytes and eosinophils. In the control group 6 out of 10 patients showed similar results with the same parameters. Out of 20 patients treated with Boswellia gum resin 14 went into remission while in case of sulfasalazine remission rate was 4 out of 10. In conclusion, this study shows that a gum resin preparation from *Boswellia serrata* could be effective in the treatment of chronic colitis with minimal side effects. (Gupta I. *et al*., Jul. 2001)

Effects of *Boswellia serrata* gum resin in bronchial asthma

The gum resin of *Boswellia serrata*, known in Ayurvedic system of medicine as Salai guggal, contains boswellic acids, which have been shown to inhibit leukotriene biosynthesis. In a double-blind, placebo-controlled study forty patients, 23 males and 17 females in the age range of 18-75 years having mean duration of illness, bronchial asthma, of 9.58 +/- 6.07 years were treated with a preparation of gum resin of 300 mg thrice daily for a period of 6 weeks. 70% of patients showed improvement of disease as evident by disappearance of physical symptoms and signs such as dysponea, rhonchi, number of attacks, increase in FEV subset l, FVC and PEFR as well as decrease in eosinophilic count and ESR. In the control group of 40 patients 16 males and 24 females in the age range of 14-58 years with mean of 32.95 +/- 12.68 were treated with lactose 300 mg thrice daily for 6 weeks. Only 27% of patients in the control group showed improvement. The data show a definite role of gum resin of *Boswellia serrata* in the treatment of bronchial asthma. (Gupta *et al*., 1998; Miller *et al*., 2001).

Effects of Boswellic acids extracted on autoimmune encephalomyelitis

Mixed acetyl boswellic acids, pentacyclic triterpenes extracted from the gum resin of *Boswellia serrata* Roxb., significantly inhibited the ionophore-stimulated release of the leukotrienes (LT) B4 and C4 from intact human polymorphonuclear neutrophil leukocytes (PMNLs), with IC50 values of 8.48 micrograms/ml and 8.43 micrograms/ml, respectively. Purified acetyl-11-keto-beta-boswellic acid was about three times more potent as inhibitor of the formation of both LTB4 (IC50 = 2.53 micrograms/ml) and LTC4 (IC50=2.26 micrograms/ml) from human PMNLs in the same assay. The comparative agent MK 886 (3-[1-(4-chlorobenzyl)-3-t-butyl-thio-5-isopropylindol-2-yl-]-2, 2-dimethylpropanoic acid, L-663, 536, CAS 118, 414-82-7) was about 10 to 100-fold more active than the boswellic acids in inhibiting. The formation of 5-lipoxygenase products in human PMNLs, with IC50 values of 0.0068 microgram/ml (LTB4) and 0.49 microgram/ml (LTC4). After daily intraperitoneal dosage the extract of mixed acetyl boswellic acids (20 mg/kg) significantly reduced the clinical symptoms in guinea pigs with experimental autoimmune encephalomyelitis (EAE) between days 11 and 21. However, the inflammatory infiltrates in the brain and the spinal cord were not significantly less extensive in the treated animals than in the respective control group. The multiple intraperitoneal application of boswellic acids did not inhibit the ionophore-challenged *ex vivo* release of leukotrienes B4 and C4 from PMNLs separated from the blood of guinea pigs with EAE. The boswellic acids have been characterized as selective, non-redox and potent inhibitors of the biosynthesis of leukotrienes in vitro. (Wildfeuer A. *et al*., 1998)

Effects of *Boswellia serrata* gum resin in ulcerative colitis

Ulcerative colitis is a chronic inflammatory disease of the colon where leukotrienes are suggested to play an important role for keeping inflammation active. Boswellic acids, the biologically active ingredients of the gum resin of *Boswellia serrata* (Sallai guggal), have been shown to be specific, nonredox and noncompetitive inhibitors of 5-lipoxygenase, the key enzyme of leukotriene biosynthesis. In patients suffering from ulcerative colitis grade II and III the effect of *Boswellia serrata* gum resin preparation (350 mg thrice daily for 6 weeks) on stool properties,

histopathology and scan microscopy of rectal biopsies, blood parameters including Hb, serum iron, calcium, phosphorus, proteins, total leukocytes and eosinophils was studied. Patients receiving sulfasalazine (1gm thrice daily) served as controls. All parameters tested improved after treatment with *Boswellia serrata* gum resin, the results being similar compared to controls: 82% out of treated patients went into remissions in case of sulfasalazine remission rate was 75%. (Gupta *et al*., Jan. 1997).

Effects of *Boswellia serrata* in Polyarthritis

Boswellia serrata are used in India for the treatment of chronic polyarthiritis. Employing the main constituents of both plants i.e. curcumine and bosellic acids, their effects on the pathways of arachidonic acid cascade in stimulated polymorphnuclear neutrophiles (PMNL) and platelets have been studied. Extracts from the resin of *Boswellia serrata* in a dose related manner inhibited formation of 5-lipoxygenase products in PMNL. A similar effect was observed employing boswellic acids EC50 being 2-7 micro M. Curcuma exhibited an antioxidative effect in Fe/ascorbate-induced peroxidation of arachiodonic acid. Moreover, curcumine inhibited the formation of cyclooxygenase and 5-lipoxygenase as well as 12-lipoxygenase products. (Ammon H.P.T. *et al*., 1992)

Effect of *Boswellia serrata* in hepatitis C-virus (HCV)

The methanolic and water extract of *Boswellia species* used in traditional medicine were screened for their inhibitory effects on hepatitis C-virus (HCV) protease (PR) using in vitro assay methods. The methanolic extract showed significant inhibitory activities. (Hussein G. *et al*., 2000).

Effect of *Boswellia serrata* on liver and cardiac function

Efficacy of six different gums *Acacia* ((A), *Tragacanth* (B), *Butea monosperma* (C), *Boswellia glabera* (D), *Balsamoderon mukul* (E), and *Melia azadirachta* (F),were investigated for various biochemical parameters :ALAT, ASAT, LDH, CK, bilirubin ,and albumin in serum of rabbits. The serum level of transaminases showed a significant increase with all gums A, C, D, E and F while the effect of gum B was not significant. The serum level of LDH was reduced with gums A, B, C, D and F. the serum level of CK was decrease with gums A, B, C, and E. The serum albumin level was not affected significantly by the gums investigated. The bilirubin level was elevated with gums A, E and F while it was decreased with gums B and C. (Rasheed *et al*., 1993)

Effect on the gonads of male Dysedercus of *Boswellia serrata* oil

Topical application of the essential oil from *B .serrata* on the freshly moulted fifth insets nymphs resulted in production of super nymphus adult nymphs. In the resultant from both spermatogenesis were seriously affected. Thus the essential oil can act as a effective insect growth regulation (Rao *et al.*, 1989).

Immunomodulatory effect of *Boswellia serrata*

Boswellic acid, a mixture of pentacyclic triterpene acids (BA) from *Boswellia serrata*, was investigated for their effect on cell mediated and humoral components of the immune system and the immunotoxicological potential. A single oral administration of BA (50-200 mg/kg) inhibited the expression of the 24hr delayed type hypersensitivity (DTH) reaction and primary humoral response to SRBC in mice. The secondary response was appreciably enhanced at lower doses. In a multiple oral dose schedule Ba (25, 50 and 100 mg/kg) reduced the development of the 24h DTH reaction and complement fixing antibody titres and slightly enhanced the humoral antibody synthesis. In concentrations greater than 3.9 micro g/mL BA produced almost similar and dose related inhibition of proliferative responsiveness of splenocytes to mitogens and alloantigen. Preincubation of macrophages with different concentrations of BA enhanced the phagocytic function of adherent macrophages. Prolonged oral administration of BA (25-100 mg/kg/dx 21 days) increased the body weight, total leukocyte counts and humoral antibody titers in rats. It is not found to be cytotoxic or to cause immunosuppression (Sharma M.L. *et al.*, 1996; Dandekar *et al.*, 1993).

Inhibitory activity of human leukemia HL-60 cells in culture

Four major tritperpene acids including beta-boswellic acid, 3-O-acetyl-beta-boswellic acid, 11-keto-beta-boswellic acid, and 3-O-acetyl-11-keto-boswellic acid were isolated from the gum resin of *Boswellia serrata* and examined for their in vitro antitumor activity. They inhibited the synthesis of DNA, RNA and protein in human leukemia HL-60 cells in a dose dependent manner with IC50-values ranging from 0.6 to 7.1 microM. Among them, 3-O-acetyl-11-keto-beta boswellic acid induced the most pronounced inhibitory effects on DNA, RNA and protein synthesis with IC50 values of 0.6, 0.5 and 4.1 microM, respectively. Its effect on DNA synthesis was found to be irreversible. This compound significantly inhibited the cellular growth of HL-60 cells, but did not affect cell viability. (Shao *et al*., 1998) Acetyl-11-keto-beta-boswellic acid (AKBA) is a pentacylic triterpene isolated from *Boswellia serrata*, AKBA treated cells showed morphological changes like membrane blebbing and subsequent flow cytometric analysis of propidium-iodide stained cells indicated that the cells underwent apoptosis. This was confirmed by flow cytometric detection of sub-G1-peaks in AKBA treated cells. As inhibitors of topoisomerases are known to be potent inducers of apoptosis. The effect of AKBA on topoisomerase 1 from calf thymus in vitro was examined. In a DNA-relaxation assay with OX174RF DNA, AKBA inhibited topoisomerase 1 and IC50 being 20 micro M. This suggests that induction of apoptosis in HL60 and CCRF-CEM by AKBA might be topoisomerase 1. (Hoernulein *et al.*, 1996/97)

Inhibition of 5-LO by boswellic acids

Boswellic acids represent the active principle of *Boswellia serrata* gum resin with antiphlogistic and antirheumatic properties. Among the Bas, 11-keto-beta-BA was the most potent. The presence of a carboxylic function and an 11-keto function has been reported to be crucial for the 5-lipoxygenase inhibiting property of this unique pentacyclic triterpene derivative. (Satyahi, *et al*., 1994/2000) Pentacyclic triterpenes from the 11-keto-boswellic acid

series were identified as the active principal ingredients of *Boswellia* resin, inhibiting the key enzyme of leukotriene biosynthesis, 5-lipoxygenase (5-LO). Of the genuine boswellic acids hitherto characterized, 3-O-acetyl-11-keto-beta-boswellic acid, AKBA proved to be the most potent inhibitor of 5-LO. In the course of purification of further boswellic acid derivatives from *Boswellia* resin, degradation of the natural compound 3-O-acetyl-11-hydroxy-beta-boswellic acid to the thermodynamically more stable product 3-O-acetyl-9, 11-dehydro-beta-boswellic acid was observed. The metastable intermediate of this conversion, under moderate conditions of workup in methanolic solutions, was identified as 3-O-acetyl-11-methoxy-beta-boswellic acid (Schweizer, 2000).

Juvenomimetic activity of *Boswellia serrata*

The essential oil from the gumoleoresin of *Boswellia serrata* showed juvenomimetic activity when tested at 1:10-4:50 acetone dilution on Dysdercus similes V instar nymphs. Its terpene constituents were characterized by GLC and GC-MS analysis (Dennis *et al*., 1999).

Table. 1: evidence based scientific validation of (*boswellia serrata)* kundur.

Therapeutic Uses and Actions	Unani & other alternative medicine References	Scientific References
Antiseptic	Ibne Sina, 1912; Azam Khan, 1314; Anonymous, 1988; Varier's, 1994; Kirtikar & Basu, 1995;	Mishra *et al*, 1980; Baratta M. T. *et al*, 1998; Garg *et al*, 1974
Anti fungal, anti microbial	Ibne Sina, 1912; Azam Khan, 1314; Anonymous, 1988; Varier's, 1994; Kirtikar & Basu, 1995	Mishra *et al*, 1980; Baratta *et al*, 1998; Garg *et al*, 1974
Anti-inflammatory	Ibne Sina, 1912; Azam Khan, 1314; Ghani, N.; 1917; Kirtikar & Basu, 1995; Varier's, 1994; Nadkarni, 1976; Asolkar, L.V., 1992; Anonymous, 1988	Menon & Kar 1969
Arthritis	Azam Khan, 1314; Ghani, N., 1917; Asolkar, L. V., 1992; Varier's, 1994; Anonymous, 1988	Ammon *et al*, 1992; Atal, *et al*, 1980-1981; Reddy *et al*, 1989; Ammon *et al*, 1993; Singh 1992;
Anti-obesity	Ghani, N., 1917; Nadkarni, 1970	Zutshi *et al*, 1980
Asthma	Kirtikar & Basu, 1995; Varier's, 1994	Gupta *et al*, 1998; Miller *et al*, 2001
Cardiotonic	Ibne Sina, 1912; Azam Khan, 1314; Ghani, N., 1917; Ibne Rushd, 1980; Asolkar, L.V., 1992	Rasheed *et al*, 1993
Anticonvulsant	Kirtikar & Basu, 1995; Chopra, R.N., 1986; Varier's, 1994;	Wildfeuer *et al*, 1998
(Gastropathy)	Ibne Sina, 1912; Azam Khan, 1314; Ghani, N., 1917; Ibne Rushd, 1980	Gupta *et al*, Jan. 1997; Gupta *et al*, Jul. 2001
Aphrodisiac	Azam Khan, 1314; Ghani, N., 1917	Rao *et al*, 1989

CONCLUSION

This review literature provides evidence based scientific validation (Table –1) to some of the therapeutic uses and actions described for *Kundur* in classical texts of Unani medicine. It clearly reveals that phyto-chemicals particularly secondary metabolites reported so far from Oleo-gum resin *(Kundur)* of *Boswellia serrata* and related pharmacological activities justify its recorded therapeutic actions in Unani literature. For example: antifungal (Garg 1974) and antimicrobial (Mishra *et al.,* 1980) activities reported from essential oil provides clear cut evidence for its recorded use as *Dafe Tafun* (Antiseptic) in Unani system of medicine. Similarly there are clear evidences that *Kundur* is one of the potential antiinflammatory and anti arthritic drug popularly used for the treatment of arthritis in Unani system of medicine since long (Table -1). It is further suggested that phytochemical and pharmacological studies on some of the less known or controversial Unani drugs may be taken up on priority basis not only to scientifically validate therapeutic actions/uses recorded, but revive the faith and confidence of Unani practitioners in its actions to serve the large strata of the rural society.

ACKNOWLEDGMENT

The authors are thankful to department of Ayurveda, Yoga & Naturopathy, Unani, Siddha and Homoeopathy (AYUSH), Ministry of Health and Family Welfare, Govt. of India, and Director General, Central Council for Research in Unani Medicine (CCRUM), New Delhi and Department of Ilmul Advia (Pharmacology) Faculty of Medicine, Jamia Hamdard, New Delhi, for providing financial support.

REFERENCE

Abdel Wahab S M., Aboutabl E A., El-Zalabani S. M., Fouad H A., Depooter H L, El-Fallaha B. The essential oil of olibanum. Planta Med. 1987; 53 (4): 382-384.

Abdul Hakeem. Bustanul Mufradat Taraqqui Urdu Publications, Lucknow (1311 H.) 261.

Afaq S H., Siddiqui M M H., Pharmacognosy, phytochemistry, pharmacology & clinical studies of Unani medicinal plants, Kundur (Boswellia serrata) & Guggul (Commiphora mukul), A.K. Tibbiya College, Aligarh Muslim University, Aligarh, India (1984)

Ammon H PT., Safayhi H., Mack T, Sabieraj J. Potent inhibitors of prostaglandin and/or leuckotriene synthesis from turmeric and salai guggal. International Seminar–Traditional Medicine, Calcutta. 1992; 52-53.

Ammon M T., Safayhi H., Mack T., Sabieraj J. Mechanism of anti-inflammatory actions of curcumine and boswellic acids. Journal of Ethnopharmacology. 1993; 38(2, 3): 113-119.

Anonymous. The Wealth of India, Vol- II, Publication and Information Directorate, CSIR, New Delhi (1988) 203-209.

Ashis K Sen., Sr, Asit K Das., Nilima Banerji. Isolation and structure of a 4-O-methyl-glucuronoarabino-galactan from *Boswellia serrata*. Carbohydrate Research. 1992; 223: 321-327

Asolkar LV Kalkar K K and Charke O J. 2nd Supplementary to Glossary of Indian Medicinal Plant with Active Principals, Vol. I, CSIR, New Delhi (1992) 134-135.

Atal CK., Gupta OP., Singh GB. Salai guggal an anti-arthritic and anti-hyperlipidaemic agent. Br. J. Pharm. 1981; 74: 203

Atal, C. K. Singh, G.B. Batra, S. Sharma S.. Gupta O. P. Salai guggalex Boswellia serrata a promising anti-hyperlipidemic and ant-iarthritic agent. Ind. J. Pharm. 1980; 12: 56.

Azam Khan. Muheet-e-Azam. Vol. IV, Part-II, Darmataba Nizami, Kanpur (1314 H.) 129-132.

Babita Mahajan, Taneja S C., Sethi V.K., Dhar K. L. Two terpenoids from Boswellia serrata gum resin. Phytochemistry., 1995; 39, 453-455.

Baratta M. T., Dorman H. J. D., Deans S. G., Figueiredo A. C., Barroso J. G. Ruberto G. Antimicrobial and antioxidant properties of some

commercial essential oils. Flavour and Fragrance Journal. 1998; 13(4), 235-240.

Beri R M, Karnik M G. Chemistry of *Boswellia serrata* bark. Indian Forest Leaflet. 1964; 175: 1-7.

Beri R M, Karnik M G. Phytosterol: beta-*sitosterol from boswellia Serrata* Roxb.**.** Curr. Sce. 1963; 32: 324

Beton J L, Halsall T G, Jones E R H. The chemistry of triterpenes and related compounds. Part XXVIII. β-Boswellic acid. J. Chem. Soc. 1956; 2904-9.

Bilham P, George A R, Kon Walter C. J. Ross. Sapogenins. Part XII. The position of the carboxyl group in certain triterpene acids. J. C hem. Soc. 1942; 35-42.

Budzikiewiz H, Wilson J J, Djerassi C. Mass spectrometry in structural and stereochemical problems. XLVI the mass spectrometric fragmentation of steroidal ethylene ketals and ethylene thioketals. J. Am. Chem. Soc. 1963; 85; 3688-99.

Chopra RN, Nayyar SL, and Chopra IC. Glossary of Indian Medicinal Plants, PID, CSIR, New Delhi (1986) 39.

Dandekar T., Dandekar G. Immunotherapeutical potential of Ayurvedic drugs; Medicines and Foods, The Ethnopharmacological Approach, 2nd European Colloquium on Ethnopharmacology, Heidelberg, Germany 1993; 81.

Dennis T.J., Kumar A., Srimannarayana G., Raghunathrao D. Juvenomimetic activity of the gumoleoresin of *Boswellia serrata*. Fitoterapia. 1999; 70: 308-310

Dymock W., Warden C. J. H. and Hopper D. Pharmacographia Indica Vol. III, B. P. Singh, Dehradun (1976) 295-304

Fowler G J, Malandkar M A. A Suggested Method for the Extraction of Turpentine, Resin and Gum from the Gum-oleo-resin of *Boswellia serrata* without the use of Solvents. J. Ind. Inst. Sci. 1921; 4: 27.

Fowler G J, Malandkar M A. An Examination of Some Gum-Enzymes, II. Chemical Constitution of the Gum from *Boswellia serrata*. J. Ind. Inst. Sci. 1925; 8; 221-239.

Garg S.C. Antifungal activity of some essential oils. Ind. J. Pharmacol. 1974; 36: 47-47.

Gerhardt H., Seifert F., Buvari P., Vogelsang H., Repges R. Effect of *Boswellia serrata* extract in Crohns disease. *Z.* Gastroenterol. 2001; 39(1): 11-7.

Ghani MN. Khazainatul Advia. 1st ed Vol. III, Munshi Naval Kishore, Lucknow (1917) 371-374.

Girgune JB, Garg BD. Chemical investigation of the essential oil from *Boswellia* serrata Roxb. J. Sci. Res. 1979; 1: 119–122.

Gupta I., Gupta V, Parihar A., Gupta S., Ludtke R., Safayhi H., Ammon H.P. Effect of *Boswellis serrata* gum resin in bronchial asthma. Eur. J. Med. Res. 1998; 3: 511-514.

Gupta I, Parihar A, Malhotra P, Gupta S, Ludtke R, Safayhi H., Ammon H.P. Effect of *Boswellis serrata* in chronic colitis. Planta Med. 2001; 67: 391-395.

Gupta I., Parihar A., Malhotra P., Gupta S., Ludtke R., Safayhi H., Ammon H. P. Effects of *Boswellia serrata* gum resin in ulcerative colitis, Eur. J. Med. Res., 1997; 2(1): 37-43.

Gupta R K., Gupta V N., Gupta V K., Atal C K. Non aqueous method for estimation of total triterpene acids in salai guggal and its different forms. Indian Drugs. 1984; 21: 523-5.

Hoernlein R.F., Rlikowsky Th., Ethrer C., Niethammer D., Sailer E.R., Dannecker G.E., Ammon H.P.T. Acetyl-11-keto-beta-boswellic acid (Akba) induces apoptosis in HL-60 and CCRF-cum cells and inhibits topoisomerase. Phytomedicine. 1996/97; 3: 191

Huang M. T., Bacdmaev V., Ding V., Liu Y., Xie J. G., Ho C.T. Anti-tumor and anti-carcinogenic activities of triterpenoid, beta-boswellic acid. Biofactors. 2000; 13(1-4): 225-30.

Hussein G., Miyashiro H., Nakamura N., Hattori M., Kakiuchi N., Shimotohno K. Inhibitory effects of Sudanese medicinal plant extracts on hepatitis C virus (HCV) protease. Phytotherapy Research. 2000; 14(7): 510-516.

Ibne Rushd. Kitabul Kulliyat (Urdu). Central Council for Research in Unani Medicine, Ministry of Health and Family Welfare, Govt. of India (1980) 52, 112-113, 292.

Ibne Sina. Al-Qanoon Fit Tib (Tibb-e-Islami Ka encyclopaedia) Vol. II, translated by Syed Husain Kantoori, Nigar-e-Ashayat Main Chamber, Lahore (1912) 199.

Kapil A., Moza N. Anticomplementary activity of boswellic acid an inhibitor of C3-convertase of the classical complement pathway. Int. J. Immunopharmacol. 1992; 14: 1139-1143.

Kirtikar KR, Basu BD. Indian Medicinal Plants. Vol. I, International Book Distributors & Publishers, 9/3, Rajpur Road, 1st Floor, Dehradun India (1995) 5 20-523.

Lubhaya R. Delhi Ke Muntakhab Murakkabat, Goswami Pharmacy, Gali Qasimjan, Delhi India. (1979) 80.

Malandkar M A. Chemical Constitution of the Gum from *Boswellia serrata.* J. Ind. Inst, Sci. 1925; 8: 240-243.

Menon M. K., Kar A. Analgesic and psychopharmacological effects of the gum resin of *Boswellia serrata*. Planta. Med. 1971; 333-341.

Miller A. L. Effects of *Boswellia serrata* on asthma, Altern. Med. Rev. 2001; 6(1): 20-47.

Mishra V., Kandya A. K., Mishra, G. P. Screening of some medicinal plants for antimicrobial activity. Bull. Bot. Soc. Univ. Sagar. 1980; 27: 57-59.

Nadkarni K M. Indian Materia Medica. Vol-I, Popular Prakashan, Bombay (1976) 211-212.

Nigrami SMH. Unani Advia Murakkaba, Khalil Ahmad Mahmood Nagar, Lucknow India (1995) 110-303.

Pardhy R S, Bhattacharyya S C. Tetracyclic Triterpene Acids from the Resin of Boswellia serrata Roxb. Ind. J. Chem. 1978; (16B): 321.

Pearson RS, Singh P. Ind. Forest. Records. Published by Govt. of India. (1918) 6: 321.

Rao Raghunatha D., Amarjit Kaur. Effect of the essential oil from the gum oleoresin of *Boswellia serrata* Roxb. on the gonads of male Dysdercus similes F. Current Science. 1989; 58: 822-824.

Rasheed A., Alam M., Tufail M., Khan, F.Z. Effect of different gums on some of the liver and cardiac functions in rabbits. Hamdard Medicus. 1993; 36(4): 36-39.

Reddy G. K., Chandrakasan G., Dhar S. C. Studies on the metabolism of glycosaminoglycans under the influence of new herbal anti-inflammatory agents. Biochem. Pharmacol. 1989; 15:38 (20): 3527-34.

Ruzicka L, W. WirzHelv. Zur Kenntnis der triterpene (Mitteilung) Umwandlung der α- Boswellinsanure in β-Amyrin. Chim. Aeta. 1940; 23: 132-5.

Ruzicka L, Jeger O, Ingold W. Zur Kenntnis der Triterpene. (91 Mittelung) Umsetzungen in den Ringen A and B bei β-Boswellinsaure. Helvetica Chimica Act. 1944; 27: 1859-1867.

Safayhi H, Boden S E, Schweizer S, Ammon H P. Concentration dependant potentiating and inhibitory effects of Boswellia extracts on 5-lipoxygenase product formation in stimulated PMNL. Planta Med. 2000; 66(2): 110-3.

Safayhi H, Sailer E R, Rall B, Ammon H P T. Structure requirements for 5-Lo inhibition by boswellic acids. European Journal of Pharmaceutical Sciences. 1994; 2(1-2): 101.

Sander O., Herborn G., Rau R. Resin extract of *Boswellia serrata* is useful supplement to established drug therapy of chronic polyarthritis, Results of a double-blind pilot study. Z. Rheumatol. 1998; 57(1): 11-6.

Schweizer S., VonBrocke A.F.W., Boden S.E., Bayer E., Ammon H.P.T., Safayhi H., Workup- dependent formation of 5-lipoxygenase inhibitory boswellic acid analogues. Journal of Natural products. 2000; 63 (8): 1058-1061.

Sharma M. L., Kaul A., Khajuria A., Singh S., Singh G. B. Immunomodulatory activity of Boswellic acids (pentacyclic triterpene acids) from *Boswellia serrata.* Phytotherapy Research. 1996;10(2): 107-112.

Sharma M, Gliek R E, Mumma R O. The Nuclear Magnetic Resonance Spectra of Pentacyclic Triterpenes. J. Org. Chem. 1962; 4512-4517.

Sharma M.L, Kaul A. Khajuria A., Singh S., Singh G.B. Immunomodulatory activity of boswellic acid (pentacyclic triterpene acids) from *Boswellia serrata*. Phytother. Res. 1996; 10: 107-112.

Sharma R A, Verma K C. Studies on gum obtained from Boswellis serrata Roxb. Indian Drugs. 1980; 17: 225-7.

Simonson J L and Owen L N. The Terpenes. University Press, Cambridge (1942) 2.

Simpson JCE, George A R K. The triterpene group. Part I. β-Boswellic acid. J. Chem. Soc. 1941; 793-4.

Simpson J C. E, Norman E. Williams. The triterpene group. Part I. β-Boswellic acid. J. Chem. Soc. 1938; 686-688.

Singh D. Unani Dravya Guna. Vigyan, Satyabhambai Pandurang Nirmay Sagar Press, Mumbai (1949) 76-7.

Singh G. B., Surjeet S., Bani S., Kaul A. Boswellic acids - a new class of anti-inflammatory drugs with a novel mode of action. International Seminar Traditional Medicine, Calcutta. 1992; 81-82.

Varier PK. Vaidyaratnam. Arya Vaidya Sala. Indian Medicinal Plant, Orient Longman Ltd., 160, Anna Salai, Madras (1994) 1, 297-300.

Wildfeuer A., Neu I. S., Safayhi H., Metzger G., Wehrmann M., Vogel, U., Ammon H. P. Effects of Boswellic acids extracted from a herbal medicine on the biosynthesis of leukotrienes and the course of experimental autoimmune encephalomyelitis. Arzneimittel forschung., 1998; 48(6), 668-74.

Winterstein A, Stein G. Untersuchungen in der Saponinreihe. X. Mitteilung, Zur Kenntnis der Mono-oxy-triterpensäuren. *Hoppe-Zyler's* Z. Physiol. Chem. 1932; 208: 9-25.

Zutshi U, P. G. Rao, Samagat Kaur, G. B.Singh C. K. Atal. Mechanism of cholesterol lowering effect of Salai guggal ex-Boswelliaserrata. Ind. J. Pharm. 1980; 12: 59.

Zutshi U., Siddiqui M., Singh G. B., Atal C. K. Mechanism of Action of Salai Guggul as Antilipidmic, Agent Souvenier, 13th Indian Pharmacological Society, Conference. 1980; 1-31.