10. Ethnomedicinal plants as anti-inflammatory and analgesic agents

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Abstract. The use of traditional medicine is expanding to newer horizons and plants still remain as the novel source of structurally important compounds that lead to the development of innovative drugs. India has about 45,000 plant species among which medicinal property has been attributed to several thousands. The traditional Indian system of medicine, the Ayurveda, mentions the use of plants in the treatment of various diseased conditions. Ethnobotanical research done in last few decades have revealed the anti-inflammatory and analgesic properties of plants cited in the traditional literature. Many herbal preparations are being prescribed as anti-inflammatory and analgesic in the traditional literature. The search for new anti-inflammatory and analgesic agents from the huge array of medicinal plant resources is intensifying. This is because such taxa may hold assurance for the discovery of novel therapeutic agents capable of suppressing, reducing or relieving pain as well as inflammation. This chapter reviews such plant species and their products that have shown experimental or clinical anti-inflammatory or analgesic activities.

**Introduction**

India harbours about 15% out of the 20,000 medicinal plants of the world, of which 90% of them are found growing wild in different climatic conditions [1]. The tribal and rural populations of India largely depend on medicinal plants for their health care as well as for their livestock. This attracted the attention of several botanists that lead to an array of reports on ethnomedicine [2]. Medicinal plants are the main sources of chemical substances with potential therapeutic effects. The use of medicinal plants for the treatment of many diseases is associated with folk medicine from different parts of the world. Naturally occurring compounds from plants, fungi and microbes are still used in pharmaceutical preparations in pure or extracted forms. A lot of compounds were characterized from plants. The research into plants with alleged folkloric use as pain relievers and anti-inflammatory agents is definitely a fruitful and logical research strategy in the search for new analgesic and anti-inflammatory drugs.

The term inflammation is derived from the Latin word – *Inflammare*, means burn. Any form of injury to the human body can elicit a series of chemical changes in the injured area. Earlier it was believed that inflammation was contemplated as a single disease caused by disturbances of body fluids. According to the modern concept, inflammation is a healthy process resulting from some disturbance or disease. The cardinal signs of inflammation are heat, redness, swelling, pain and loss of function. Inflammation usually involves a sequence of events which can be categorized under three phases viz. acute transient phase, delayed sub acute phase and chronic proliferate phase. In the first phase, inflammatory exudates develop due to enhanced vascular permeability and leads to local edema. It is followed by the migration of leukocytes and phagocytes from blood to vascular tissues which is the second phase, In the third phase, tissue degradation is followed by fibrosis.
Inflammation results in the liberation of endogenous mediators like histamine, serotonin, bradykinin, prostaglandins etc. Prostaglandins are ubiquitous substances that indicate and modulate cell and tissue responses involved in inflammation. These mediators even in small quantities can elicit pain response. Pain results in dropped muscular activities. In order to comprehend the inflammatory process, antagonists of mediators are generally employed in both Ayurveda and Allopathy treatment. Most of the anti-inflammatory drugs now available are potential inhibitors of cyclooxygenase (COX) pathway of arachidonic acid metabolism which produces prostaglandins. Prostaglandins are hyperalgesic, potent vasodialators and also contribute to erythema, edema and pain. Hence for treating inflammatory diseases analgesic and anti-inflammatory agents are required. These points to the utilization of plants possessing anti-inflammatory and analgesic properties. Now a days herbal drugs are routinely used for curing diseases rather than chemically derived drugs having side effects. The drugs used in inflammatory disorders may be either with analgesic and insignificant anti-inflammatory effects or with analgesic and mild to moderate anti-inflammatory activity. These drugs can cause gastric or intestinal ulceration that can sometimes cause secondary anaemia.

Inflammatory diseases include different types of rheumatic disorders such as rheumatic fever, rheumatoid arthritis, ankylosing spondylitis, polyarthritis nodosa, systemic lupus erythematosus and osteoarthritis. An array of drugs are available in the market to treat these disorders but only very few are free from toxicity. Gastrointestinal problems associated with the use of anti-inflammatory drugs are still an enduring dilemma of medical world. It is very important that profound research with ethnobotanical plants possessing anti-inflammatory and analgesic properties can definitely open up new vistas in inflammatory disorders. Purified natural compounds from plants can serve as template for the synthesis of new generation anti-inflammatory drugs with low toxicity and higher therapeutic value. This chapter reviews such medicinal plants with anti-inflammatory and analgesic properties which have been used by our ancestors to cure many of their ailments.

Plants with anti-inflammatory and analgesic activity

1. *Ananas comosus* (L.) Merr. (Bromeliaceae)

*Ananas comosus* (L.) Merril (Pineapple) has been used as a medicinal plant in several native cultures and its major active principle, Bromelain, has been known chemically since 1876. Bromelain is a general name for a family of sulphhydryl proteolytic compounds obtained from *Ananas comosus* L. It is
usually distinguished as either fruit bromelain or stem bromelain depending on its source. The primary component of bromelain is a sulphhydryl proteolytic fraction. It also contains peroxidase, acid phosphatase, several protease inhibitors and originally bound calcium. Eight basic proteolytically active components have been detected in the stem [3]. The two main components have been designated as F4 and F5. The proteinase, considered to be the most active fraction, has been designated as F9. It comprises about 2% of the total proteins. It is estimated that 50% of the proteins in F4 and F5 are glycosylated, whereas F9 was found to be unglycosylated. Since bromelain is derived from a natural source, different sources can exhibit variability in their physiological activity, even when their proteolytic activity is the same.

Bromelain seems to have both direct as well as indirect actions involving other enzyme systems exerting its anti-inflammatory effect. It inhibits the inflammatory pain in rats in a dose dependent manner [4]. It reduces pain and inflammation associated with surgery, arthritis, trauma or sports injury [5]. Bromelain was the most potent of nine anti-inflammatory substances tested on experimental rats [6]. Treatment with bromelain have been shown to decrease significantly the heat evoked immunoreactive substance released and subsequent edema in a rat model [7]. Bromelain is used as a digestive aid as it helps to heal and regenerate mucus lining of the stomach [8]. Bromelain interferes with the arachidonic acid cascade there by preventing the formation of pro-inflammatory eicosanoids [9]. Non-steroidal anti-inflammatory drugs inhibit COX, which is required for the synthesis of two prostaglandins, resulting in a decrease in both pro and anti-inflammatory prostaglandins. Rather than blocking the arachidonic acid cascade at the enzyme COX, bromelain may selectively decrease thromboxane generation and change the ratio of thromboxane/prostacycllin in favour of prostacyclin [3]. Bromelain has been shown to inhibit prostaglandins even though its action is significantly weaker [10]. The anti edema, anti-inflammatory and coagulation inhibiting effects are due to an enhancement of the serum fibrinolytic and fibrinogenolytic activity. It blocks synthesis and lowers serum and tissue levels of kinin compounds [11]. Bromelain has been shown to reduce edema, accelerate healing and lowers pain and inflammation after surgery in clinical trials [12]. A randomized, double blind, parallel group trial compared the efficiency and safety of an oral combination of bromelain with diclofenac in patients with osteoarthritis of the knee. From this study, Akhtar concluded that bromelain can be considered as an effective and safer alternative to non-steroidal anti-inflammatory drugs in the treatment of painful episodes of osteoarthritis [13].
2. *Boswellia serrata* Roxb. (Burseraceae)

*Boswellia serrata* Roxb has been used traditionally in Indian Ayurvedic medicine and is well known for its anti-inflammatory activity. The resinous gum of the bark is known as guggulu in Ayurveda and is also used in modern phytotherapy. It has been reported to be a powerful anti-inflammatory agent without the ulceration or irritation as observed in non-steroidal anti-inflammatory drugs [14]. *Boswellia* has been shown to possess sedative, analgesic [15,16], anti-inflammatory [17,18] and anticancer [19,20,21] effects. The resin obtained from the plant is recommended for rheumatoid arthritis, osteoarthritis, fibromyalgia and spondylitis. Patients treated with *Boswellia* reported decreases in knee pain, joint swelling and increases in knee flexion and walking distance [22,23]. Four pentacyclic triterpene acids including the bioactive compound β-boswellic acid which interferes with leukotriene biosynthesis have been isolated from *B. serrata*. It is a specific and dose dependent inhibitor of 5-lipoxygenase, 5-eicosatetraenoic acid and leukotriene B4 [24]. These chemical mediators of inflammation are implicated in the pathogenesis of many diseases including asthma [25], arthritis [26], colitis [27] and cancer [28]. *Boswellia* inhibits human leukocyte elastase (HLE) under *in vitro* conditions [29]. HLE inhibitor medications have been developed for the treatment of asthma, emphysema and cystic fibrosis [30]. Boswellic acids were found to be more potent inhibitors of human topoisomerases-I and II-α than chemotherapeutic agents that work largely by inhibition of these enzymes[31]. The mechanism of action of beta boswellic acid has been recently reported [32]. *B. serrata* extract can decrease the glycosaminoglycan degradation which keeps the cartilages in better condition thus preventing the progression of osteoarthritis [33]. The safety and efficacy of *B. serrata* extract in relieving osteoarthritis has been reported recently [16,34].

3. *Callophyllum inophyllum* L. and *Mesua ferrea* L. (Clusiaceae)

*Callophyllum inophyllum* L. and *Mesua ferrea* L. has been commonly used for the treatment of rheumatism, skin diseases, dysentery and bleeding piles [35]. The whole plant is medicinal and contains compounds such as xanthones, triterpenes, coumarins and glucosides. The anti-inflammatory effect of *C. inophyllum* was reported earlier [36]. Gopalakrishnan et al. reported the anti-inflammatory and Central Nervous System (CNS) depressant activities of xanthones from *C. inophyllum* and *M. ferrea* [37]. They have isolated different xanthones such as dehydrocycloguanandine, callophyllin–B, 6-deoxyjacareubin etc. All xanthones isolated produced signs of CNS depression characterized by ptosis, sedation, decreased spontaneous
motor activity and loss of muscle tone. The CNS depressant effect was predominant at a dose level of 200 mg/kg. Similar findings were reported on the pharmacological activity of the xanthones from *Garcinia mangostana* [38,39]. The xanthones of *Callophyllum* and *Mesua* have been found to produce significant anti-inflammatory activity in normal as well as adrenalectomised rats by both intra-peritoneal and oral routes. Usually the anti-inflammatory agents in clinical use exhibit analgesic and antipyretic properties along with ulcerogenicity and impairment of blood clotting as side effects. But the xanthones of *C. inophyllum* and *M. ferrea* did not possess any such properties and thus points to the possibility of developing anti-inflammatory drugs of future use.

4. *Calotropis gigantea* (L.) R. Br. (Asclepiadaceae)

*Calotropis gigantea* (L.) R. Br. is an important medicinal plant where all parts of the plant including the milky secretion have been claimed to possess varied medicinal uses [35,40,41,42]. It has been claimed to be useful in treating skin diseases and healing of wounds and ulcers [43,44]. Very recently, the plant is reported to possess analgesic and antipyretic activities [45]. The methanolic extract of *Calotropis gigantea* leaves revealed the anti-inflammatory activity in experimental rats using paw edema test [46]. Anti-inflammatory effects of aqueous extract of leaves and latex of *C. procera* were reported earlier [47,48].

5. *Calotropis procera* (Ak.) R.Br. (Asclepiadaceae)

*Calotropis procera* (Ait) R Br. is a well known medicinal plant in the traditional medicine system of India. It is used in the treatment of skin diseases, rheumatism and aches [49]. It has been reported to possess anti-inflammatory, analgesic and weak antipyretic activities [50,51,52]. The latex was reported to be as potent as standard anti-inflammatory drug phenylbutazone in inhibiting inflammatory response induced by different inflammatory agents in acute and chronic models [50]. The anti-inflammatory activity of the latex of *C. procera* and its methanolic extract against various inflammatory mediators as well as on leucocyte flux induced by carrageenan in rat paw edema model have been reported recently [53].

6. *Camellia sinensis* (L.) Kuntze (Theaceae)

*Camellia sinensis* (L.) Kuntze is one of the most commonly consumed beverages in the world. The established pharmacological activity of the green tea extracts are attributed to its high content of polyphenols/catechins, mainly epigallocatechin-3-gallate (EGCG) [54]. The potential effect of green tea in
arthritis on collagen type-II-induced arthritis in mice has been reported [55]. The anti-inflammatory effect of green tea polyphenols was reflected in a marked inhibition of the inflammatory mediators such as COX 2, interferon-γ and TNF-α in arthritic joints. Histopathological studies revealed a reduction in biochemical markers correlated with the marked reduction in inflammation in synovium. Studies have shown that most of the effects of green tea extracts are mimicked by its constituent polyphenol, EGCG [54,56]. Further studies have shown that EGCG inhibited the transcription factor, nuclear factor-kappa-B (NF-κ B) in conjunction with pro-inflammatory cytokines IL-1β-inducible nitric oxide synthase (Inos) and COX 2, resulting in reduction of nitric oxide and prostaglandin E2 (PGE2) in vitro [57,58]. It has also been identified that EGCG selectively inhibited the IL-1β-induced phosphorylation of c-Jun-N-terminal kinase (JNK) p46 isoform resulting in lower levels of phosphor-c-Jun and DNA-binding activity of activation protein-1 (AP-1), a transcription factor implicated in the inflammatory response in human OA chondrocytes [59].

The metalloproteinases (MMPs) produced by the activated chondrocytes in arthritic joints can result in cartilage degradation even though they are involved in remodeling [60]. In OA and RA joints, the levels of MMP1 and MMP13 were found to be significantly elevated [61,62]. Pretreatment of human OA chondrocytes with EGCG significantly inhibited the expression and activities of MMP-1 and MMP-13 in vitro [63]. EGCG was equally effective in inhibiting IL-1β-induced MMP-1, MMP-3 and MMP-13 in human tendon fibroplasts [64]. Catechins from green tea inhibited the degradation of human cartilage proteoglycan and type-II collagen and selectively inhibited the aggrecanases called a disintegrin and metalloproteinase with thrombospondin motifs (ADAMTS) -1, - 4 and -5 [65,66]. Further studies are required in this direction to investigate the anti-inflammatory effects of Camellia sinensis at the molecular level. Green tea catechins or related compounds could one day be useful as an ethnobotanical cure for the treatment of RA and OA [67].

7. Cannabis sativa L. (Cannabinaceae)

Cannabis sativa L. has been used in various preparations for their medicinal effects including anti-pyretic, anti-rheumatic, anti-allergic and analgesic purposes [68]. The traditional use of Cannabis as an analgesic, anti-asthmatic and anti-rheumatic drug is well established. Extracts of Cannabis have been shown to possess analgesic activity [69], and delta-1-tetrahydrocannabinol (delta-1-THC), the psychoactive component of Cannabis and cannabidiol (CBN), the bioactive compound, were shown to exhibit analgesic activity in vivo [70].
It is possible that the anti-inflammatory and anti-asthmatic properties of this herb are mediated through effects on arachidonate metabolism [71]. The constituents of Cannabis are known to stimulate [72] and inhibit [73] prostaglandin releases by influencing enzymes of the arachidonate pathway [74]. The anti-inflammatory potential of two extracts of Cannabis, pure cannabinoids and olivetol (a cannabinoid biosynthetic precursor) in two models of inflammation, in an attempt to separate on a structural basis, the peripheral from the central action of these phenolic drugs, have been studied [71]. It is possible that the cannabinoids and their extracts are inhibiting both PBQ induced writhing and TPA induced erythema by effects on arachidonate release and metabolism. Cannabinoids and olivetol have been shown to inhibit PG mobilization and synthesis [72,73]. Cannabinoids stimulate and inhibit phospholipase A2 (PLA2) activity [74] as well as inducing an inhibition of cyclooxygenase and lipoxygenase [75]. The activity of Cannabis herb or resin is complex, in which activities can be demonstrated on at least three major enzymes of the arachidonate cascade.

The results of the work reported by Formukong et al. [71] suggested that the response of the ethanolic extract cannot be solely due to cannflavon. Other structurally related phenolic extract cannot be solely due to cannflavon. Other structurally related phenolic substances may account for the higher activity seen either due to cumulative or synergistic effects upon cyclooxygenase. The activity of the petroleum ether extract is likely to be largely due to the presence of CBD and CBN. The cultivation of Cannabis plants rich in CBD and other phenolic substances would be useful not only as fiber producing plants but also for medicinal purposes in the treatment of certain inflammatory disorders.

8. **Centella asiatica** (L.) Urban

It belongs to the family Apiaceae and is commonly found in parts of Asia and the Middle East. Centella has been used in traditional medicine in Asia for 100 years [75]. The major bioactive constituents are triterpene saponins mainly asiaticoside, sapogenin, asiatic acid, madecassoside and madecassic acid [76]. It is believed to have beneficial effects in improving memory and treating mental fatigue, anxiety and eczema [77]. In Ayurveda, Centella is effectively used in the treatment of inflammation, anaemia, asthma, blood disorders, bronchitis, fever, urinary discharge and splenomegaly [78]. The aqueous extract of Centella possesses antioxidant, cognitive enhancing and antiepileptic properties [79]. The water extract of the plant was used to study the anti-inflammatory and analgesic activity in adult male rats. The extract elicited dose dependent anti-inflammatory activity at 2 mg/kg concentration. This study revealed that the extract is similar to
mefenamic acid and interestingly 10 mg/kg extract showed a significantly higher effect when compared to mefenamic acid. In the case of analgesic activity both hot plate and abdominal writhing test revealed positive effect and the mechanism might involve opioid receptors. The potency of antinoceception was less than morphine and aspirin at similar doses. Bioactive terpene acids such as asiatic acid and madecassic acid from the water-methanol extraction of Centella has been studied [80]. These compounds may be present in the extract which contributes to the anti-inflammatory and analgesic property in the study. These findings justify the traditional use of Centella in the treatment of inflammatory conditions.

9. Curcuma longa L. (Zingiberaceae)

Curcuma longa L. is a perennial herb distributed throughout tropical and subtropical regions of the world. It is widely cultivated in Asiatic countries, mainly in India and China. As turmeric powder it has been in continuous use for its flavouring, as a spice in both vegetarian and non-vegetarian food preparations and has digestive properties [80]. Traditional Indian medicine claims the use of turmeric powder against biliary disorders, anorexia, coryza, cough, diabetic wounds, hepatic disorder, rheumatism and sinusitis [81]. The active principle in turmeric powder is curcumin (diferuloyl methane) and was isolated in the 19th century from the rhizomes. It is with yellow colour and is responsible for the anti-inflammatory effects. In Hindu medicine turmeric powder has been extensively used for the treatment of sprains and swellings caused by injury [82]. The traditional medicine in China uses C. longa L. in abdominal pains. Religious ceremonies still use turmeric in many forms. The major components of turmeric are curcuminoids which include mainly curcumin (diferuloyl methane), dimethoxy curcumin and bisdimethoxycurcumin. These substances can be classified as Curcuminoids, the analogues of diarylheptanoids. The major constituent, Curcumin, is the most important fraction of C. longa L. and its chemical structure was determined by Roughley and Whiting [83]. Curcumin is insoluble in ethanol, alkalies, ketone, acetic acid and chloroform and is insoluble in water. In the molecule of curcumin, the main aliphatic, unsaturated and the aryl group can be substituted or not.

There is a great number of papers in the literature relating the activity of compounds extracted from C. longa L. being potent inhibitors of inflammation. The activity of curcumin and other semi synthetic analogues in experimental rats were demonstrated [84]. In Ayurveda, turmeric has been used for various medicinal conditions including rhinitis, wound healing, common cold, skin infections, liver and urinary tract diseases and as blood purifier [85,86]. It was found to be effective even when given by different routes of
administration, including topically, orally and by inhalation. Studies on anti-inflammatory activities included *in vitro*, animal and human models. The laboratory studies have identified a number of different molecules involved in inflammation that are inhibited by curcumin including phospholipase, lipoxygenase, cyclooxygenase-2, leukotriens, thromboxane, prostaglandins, nitric oxide, collagenase, elastase, hyaluronidase, monocyte chemoattractant protein-1 (MCP-1), interferon–inducible protein, tumour necrosis factor (TNF) and interleukin-12 (IL-12). The anti-inflammatory activity demonstrated in the experiment may be due to inhibition of a number of different molecules that play a role in inflammation.⁸⁶ In animal studies, oral administration of curcumin to rats decreased the levels of inflammatory glycoprotein with a reduction in paw inflammation [⁸⁶,⁸⁷]. Curcumin was also found to be inhibiting the carrageenan induced paw edema in mice and rats with an ED 50 dose 48 and 100.2 mg/kg respectively [⁸⁴].

Curcumin increases glutathione transferase activity which is involved in detoxification of carcinogens and increases mRNA transcription of transforming growth factor beta-1. Curcumin is a potent inhibitor of the common transcription factor NF-κB in several cell types [⁸⁸,⁸⁹,⁹⁰]. Others reported that curcumin inhibits or modulates upstream pathways of the arachidonic acid cascade by inhibiting the catalytic activities of phospholipases [⁹¹,⁹²,⁹³]. Curcumin also inhibited the incorporation of arachidonic acid into membrane lipids, PGF2 production, leukotriene B4 and leukotriene C4 synthesis as well as the secretion of collagenase, elastase and hyaluronidase by macrophages [⁹²]. IL-1β-induced up regulation of MMP-3 was inhibited by curcumin in a time dependent manner. In addition IL-1 β- induced decrease in type II collagen synthesis was also blocked by curcumin treatment. Based on this study it was concluded that curcumin antagonises crucial catabolic effects of IL-1 β- signalling that are known to contribute to the pathogenesis of osteoarthritis.

10. *Euphorbia heterophylla* L. (Euphorbiaceae)

*Euphorbia heterophylla* is a local medicinal plant commonly known as ‘spurge weed’. It is used in ethnomedicine for the treatment of constipation, bronchitis and asthma [⁹⁴]. It grows in semi humid places especially in cassava, cow pea and soyabean plantations. Phytochemical studies have revealed the presence of saponins, diterpenes and phorbolesters in the extracts. The anti-inflammatory activity of the aqueous and methanolic extract of *Euphorbia heterophylla* were evaluated by carrageenin induced rat paw edema test [⁹⁵,⁹⁶]. The aqueous extract of *Euphorbia* showed significant anti-inflammatory activity (P<0.001) comparable to the reference drug [⁹⁴]. But the methanolic extract did not show any appreciable anti-inflammatory activity. These studies were in
agreement with the earlier investigations [97] suggesting the presence of a flavanoid, quercetin, which is a known anti-inflammatory agent. The significant level of anti-inflammatory activity of the aqueous extract could be attributed to high amount of flavanoids present in the extract. This study justifies the traditional use of *Euphorbia* in the treatment of inflammatory disease conditions such as asthma.

11. *Gastrodia elata* Blume (Orchidaceae)

*Gastrodia elata* Blume is a very important traditional herbal medicine used to treat headache, migraine, dizziness, epilepsy, rheumatism, neuralgia, paralysis and other disorders [98]. Phytochemical studies of this plant have revealed the presence of several phenolic compounds [99]. Lee et al. [100] has identified eight compounds by structure activity guided separation. The compounds are 4-hydroxy benzaldehyde (1), 4-hydroxy bezyl alcohol (2), benzyl alcohol (3), bis(4-hydroxy phenyl) methane (4), 4(4’–hydroxybenzyl oxy) benzyl methyl ether (5), 4-hydroxy-3-methoxy benzyl alcohol (6), 4 hydroxy-3-methoxy benzaldehyde (7) and 4-hydroxy-3-methoxy benzoic acid (8). The anti-inflammatory and analgesic activities of these phenolic extracts were studied using animal models [100]. They suggested that these phenolic compounds inhibited COX activity and silica induced reactive oxygen species (ROS) generation in a dose-dependent manner. Among these phenolic compounds the compound (7) was the most anti-inflammatory and analgesic. Compound (7) significantly inhibited silica-induced ROS generation and compound (6) significantly increased 1,1-diphenyl-2-picryl hydroazyl (DPPH) radical scavenging activity. Compounds (1), (2) and (3) significantly inhibited the activity of COX. They concluded that phenolic compounds of *Gastrodia elata* are anti-inflammatory, which could be related to inhibition of COX activity and to anti-oxidant activity. Consideration of the structure-activity relationship of these compounds of *G. elata* on the anti-inflammatory action revealed that both C-4 hydroxy and C-3 methoxy radicals of benzyl aldehyde play an important role in anti-inflammatory activities [99].

12. *Harpagophytum procumbens* (Burch.) DC (Pedaliaceae)

*Harpagophytum procumbens* (Burch.) DC is commonly known as Devil’s claw and is a native of South Africa. The root tubers of the plant are used in herbal preparations [101]. Leung and Foster [102] reported three iridoid glycosides viz. harpagoside, harpagide and procumbide and are responsible for the anti-inflammatory and analgesic actions. These glycosides effectively reduced OA pain and was comparable with that of the analgesic/cartilage protective drug, Diacerhein [103]. *H. procumbens* at the rate of 600-120 mg/day was helpful in reducing low back pain [104]. The anti-inflammatory and analgesic effect of the aqueous extract of *H. procumbens*
was recently reported [105]. Research is going on in this line and new results are yet to come.

13. *Kalanchoe crenata* Andr. (Crassulaceae)

*Kalanchoe crenata* Andr. is commonly known as “never die” or “dog’s liver”. It has been traditionally used for the treatment of ear ache, small pox, head ache, inflammation, pain, asthma, palpitations, convulsion and general debility. Phytochemical studies using the aqueous and alcoholic extract of *K. crenata* revealed the presence of alkaloids and saponins [106]. Nguelefack et al. [107] demonstrated the antinociceptive activity of the ethanolic extract of *K. crenata* against acetic acid, formalin and hot plate as well as pain models induced by pressure. The anti-inflammatory property of the leaf extract of *K. crenata* was scientifically validated [108]. They reported the presence of sterols, flavanoids and saponins in the different extracts which were responsible for the acute and chronic anti-inflammatory activity against various phlogistic agents. The n-butanol fraction of the extract was capable of inhibiting edema induced by histamine, serotonin and formalin. Since n-butanol fraction of the extract significantly inhibited inflammation, it can be thought to possess antiproliferative and antiarthritis activities similar to that of diclofenac, a COX inhibitor. The non-steroidal anti-inflammatory activity of the extract prompted them to test for the ulcerogenic effect. Non-steroidal anti-inflammatory drugs are thought to impair the mucosal defense of the stomach and the intestine. They act by inhibition of COX and therefore inhibit the production of gastric prostaglandins which in turn leads to a reduction in the gastric mucus and an increase in mucosal permeability [109]. This can be attributed to the inhibition of COX. Hence, it was concluded from this study that the flavanoids in the n-butanol fraction was responsible for its pharmacological activities. Flavanoids have been reported earlier also for such similar activities [110,111].


*Mangifera indica* L. aqueous extract, known as Vimang in Cuba, is used to improve the quality of life in patients suffering from elevated stress. Garrido et al. [112] evaluated the analgesic and anti-inflammatory effects of *Mangifera indica* bark aqueous extract. Analgesia was determined using acetic acid induced abdominal constriction and formalin induced licking. Anti-inflammatory effects were studied using carrageenin and formalin induced edema. They reported polyphenols in the extract which might be responsible for the effect. Vimang at a concentration of 50-1000 mg/kg p.o exhibited a potent and dose dependent antinociceptive effect against acetic acid test in mice. It also dose dependently inhibited the second phase of formalin induced pain, but not in
the first phase. Edema formation was significantly inhibited both in carrageenin and formalin models. These inhibitions were similar to those produced by indomethacin and sodium naproxen p.o. The anti-inflammatory effects of mangiferrin in *M. indica* L. has also been reported earlier [113].

15. *Plumeria acuminata* W.T. Aiton (Apocyanaceae)

*Plumeria acuminata* W.T. Aiton belongs to the family Apocynaceae and is widely distributed in Southern parts of India. In traditional medicine system different parts of the plant have been used in a variety of diseases. The milky juice is employed for the treatment of inflammation and rheumatism. The leaves are reported to have anti-inflammatory and rubefacient in rheumatism and have strong purgative effect. The methanol extract of *Plumeria acuminata* exhibited significant anti-inflammatory activity on the tested experimental models in both acute and chronic inflammation models [114]. Preliminary phytochemical screening of the methanol extract revealed the presence of steroids, flavanoids, tannins, alkaloids and glycosides. The Methanolic extract produced significant (P<0.001) anti-inflammatory activity and the results were comparable to that of indomethacin as a standard anti-inflammatory drug. Their studies indicated that the extract acted in later phases probably involving arachidonic acid metabolites which produce an edema dependent on neutrophil mobilization [115].

16. *Ricinus communis* L. (Euphorbiaceae)

*Ricinus communis* Linn. is a small tree distributed throughout the tropics and warm temperate regions of the world [116]. In Indian traditional system of medicine different parts of this plant has been used to cure inflammation and liver disorders [40]. Various bioactivities of the plant such as hepatoprotective [117,118], hypoglycaemic [119], laxative [120], diuretic [121] and antibacterial [122,123] have been reported earlier. The plant was reported to contain flavanoids [124] and tannins [125]. The anti-inflammatory activity of the methanolic extract of *Ricinus communis* Linn. root was reported recently [126]. The methanolic extract at a dose of 250 mg/kg p.o exhibited significant (p<0.001) anti-inflammatory activity in carrageenin induced rat paw edema model and a higher dose of 500 mg/kg p.o also exhibited significant (p<0.001) activity in cotton pellet granuloma model in Wistar albino rats. Flavanoids have been reported to have anti-inflammatory and antiarthritic activity [127,128]. The anti-inflammatory activity of *Ricinus* can be attributed to the presence of phytochemicals such as flavanoids, alkaloids and tannins in the plant extract.
17. *Salix alba* L. (Salicaceae)

*Salix alba* L. is commonly known as the Willow tree and its bark contains heavy concentrations of salicin, a glycoside, which is the precursor of aspirin. In India willow has been used for centuries as a remedy for fever [129]. Willow is listed in the herbal remedies of ancient Egypt, in the Ebrus papyrus (1534 BC). It was in the mid 18th century the first written document on the analgesic property of willow was made [130]. Salicin is responsible for the anti-inflammatory and analgesic actions [131]. The consumption of herbal combination containing 100 mg willow bark for two months improved functioning via pain relief in OA. A trial study revealed that 1360 mg of willow bark extract per day (delivering 240 mg of salicin) for two weeks to be effective in treating pain associated with knee and hip [132]. A four week trial found that willow extract containing 240 mg of salicin was effective in reducing exacerbations of low back pain [133]. Some may develop stomach problems after the intake of willow extract, but the symptoms are less when compared to aspirin [134]. Those with ulcers and gastritis were advised to avoid willow extract [135].

18. *Sida cordifolia* L. (Malvaceae)

*Sida cordifolia* Linn is an extensively used herbal ingredient in the Ayurvedic system of medicine in the Indian subcontinent [40]. The anti-inflammatory and analgesic activities of the water extract of the plant in animal models were reported [136]. The whole plant extract in water has been used in the treatment of rheumatism [137]. Phytochemical analyses from time to time have revealed the presence of ephedrine, vasicinol, vascicinone and N-methyl tryptophan [138,139,140]. Sutradhar et al. [141] reported the anti-inflammatory and analgesic properties of the different extracts of *S. cordifolia* Linn. They used chloroform, methanol, ethanol, hexane, dichloromethane, butanol and diethyl acetate extracts. Chloroform, methanol, ethyl acetate and butanol extracts showed significant activity in experimental models. In addition another chemical constituent (5’ – Hydroxymethyl - 1’-(1,2,3,9-tetrahydro-pyrrolo[2,1-b] quinazolin -1- yl)-heptan-1-one) was reported [141] from the aerial parts of *Sida cordifolia*. They also investigated the anti-inflammatory and analgesic activity of the compound in mice and rat respectively. The bioactivity thus reported was due to the inhibitory effect of the compound by the inhibition of COX enzyme leading to the inhibition of prostaglandin synthesis.

19. *Silybum marianum* (L.) Gaertn. (Asteraceae)

*Silybum marianum* (L.) Gaertn. is an important medicinal plant commonly known as ‘Milk thistle’ or ‘St. Mary’s Thistle’. The anti-inflammatory
activity of this plant has been reported earlier [142]. The plant extract was reported to contain an important bioactive principle, sylimarin, which belongs to the flavanolignan group and possess anticancer, anti-inflammatory, antioxidant and immunomodulatory effects [143,144]. Even though the whole plant has been reported to possess anti-inflammatory activity, the activity of the dried leaf callus was also been reported recently [145]. They examined the anti-inflammatory activity of the methanolic extract of dried leaf callus using carrageenin and formalin induced rat paw edema models. The leaf and leaf callus of *Silybum marianum* (L.) Gaertn. inhibited the formation of paw edema to significant levels (74% and 93.9%) at a dose of 100 mg/kg when administered orally.

20. *Spilanthes acmella* Murr. (Asteraceae)

*Spilanthes acmella* Murr. is an indigenous herb growing as an annual throughout the tropics. The whole plant is claimed to possess medicinal properties. The flowers are chewed to relieve tooth ache and the crushed plant is used in rheumatism [146,40]. The plant is generally known as tooth ache plant [147]. Chakraborty et al. [148] evaluated the anti-inflammatory and analgesic activity of the aqueous extract of *S. acmella*. They reported the presence of flavanoids in the aqueous extract which was responsible for the significant anti-inflammatory and analgesic property of the plant. The extract produced dose dependent and significant inhibition of prostaglandins which are involved in the late phase of acute inflammation and pain perception [149]. Detailed studies using the extract may reveal the exact mechanism of action of the flavanoids responsible for the anti-inflammatory and analgesic activity.

21. *Tripterygium wilfordii* Hook F (Celastraceae)

*Tripterygium wilfordii* Hook F is a perennial vine like plant that grows in China and Thaïwan. The root of the plant is medicinal and is used for the treatment of inflammatory diseases like rheumatoid arthritis, asthma, nephritis etc for centuries ago [150]. The ethanolic and ethyl acetate extract of the plant is used in the treatment of rheumatoid arthritis [151]. They also reported a prospective, double blind placebo-controlled study of the ethanolic and ethyl acetate extract in patients with rheumatoid arthritis. Another report also substantiated the efficacy of the extract in both clinical manifestations and laboratory findings [152]. They concluded that the extract at dosages up to 570 mg/day was safe and doses >360 mg/day were associated with clinical benefit in patients with RA. The only toxic effect reported in this study was diarrhoea.
The anti-inflammatory effects of *T. wilfordii* was believed to be due to the presence of triptolide, the active ingredient [153]. Animal studies showed that triptolide inhibited the CIA in mice and rat [154,155]. A recent study has revealed that triptolide inhibited iNOS gene expression by down regulating NF-κ B-DNA binding activity and JNK pathway [156]. Triptolide was shown to inhibit LPS and cytokine induced expression of COX-2, MMP-3 and MMP-13 in articular chondrocytes [157] and IL-1, IL-17 and TNF-α induced expression of aggrecanase gene in human chondrocytes [158]. Another mechanism of anti-inflammatory effect may be by the suppression of adhesion molecules E-selectin, ICAM-1 and VCAM-1 [159]. These studies revealed a strong scientific explanation for the known beneficial use of *T. wilfordii* in rheumatoid arthritis.

22. *Uncaria tomentosa* (Willd.) DC. and *U. guianensis* J.F. Gmel (Rubiaceae)

*Uncaria tomentosa* (Willd.) DC. and *U. guianensis* DC commonly known as Cat’s claw is a Peruvian vine with medicinal properties that are well documented in alternative medicine literature. The anti-inflammatory activity of Cat’s claw extract was reported earlier [160,161]. In Peruvian medicinal system, the extract of both species has been used interchangeably to treat inflammatory and non-inflammatory conditions. The chemical composition of *U. tomentosa* and *U. guianensis* vary and accordingly the anti-inflammatory effects are independent of one another [160]. The anti-inflammatory activity of *U. tomentosa* is mainly due to the active constituent, pentacyclic oxindole alkaloid [161]. *U. guianensis* was found to be more potent in inhibiting TNF-α production by macrophages. [162] The safety and pharmacological profile of Cat’s claw in animal models using *in vitro* bioassays were reported by many workers [163,164]. Animal studies have suggested that cat’s claw extract is protective to the gastrointestinal tract and even protect the gut from the damaging effects of NSAIDs [162]. These studies revealed that cat’s claw extract was effective in inhibiting lipopolysaccharide induced free radical production followed by lipid peroxidation. They also showed that TNF-α production and iNOS expression via NF-κ B expression were also inhibited by the extract. A further study for the long term efficacy and safety of this extract is needed to develop an effective anti-inflammatory drug from this plant.

23. *Zingiber officinale* Roscoe (Zingiberaceae)

*Zingiber officinale* Rosc. is one of the most common constituents of diets world wide and is reported to possess antioxidant, anti-inflammatory, antiseptic
and carminative properties [165]. In folk medicine it has been used against pain, inflammation, arthritis, urinary infections and gastrointestinal disorders [166]. Ayurveda supports the use of ginger to treat inflammatory and rheumatic disorders. The major constituents of ginger include volatile oils, oleoresin (gingerol), linoleic acids and trace elements such as magnesium, phosphorus and potassium. Most of the pharmacological activities of ginger can be attributed to the presence of gingerol and its analogues found in the rhizome extracts [166]. Ginger oil contains a mixture of constituents like monoterpenes and sesquiterpenes which were reported to have anti-inflammatory and analgesic activities [166,167]. Ginger has been known to prevent relief in arthritis [168] and the intake of less than a tablespoon ginger every day for three months was enough to relieve pain in arthritis. The anti-inflammatory and analgesic properties of ginger essential oils have been reported recently [169]. The anti-inflammatory activity of the ginger essential oil was determined by pleuricy test using carrageenan (200 µg /cavity) in experimental mice. Ginger essential oil and indomethacin in 200 and 500 mg/kg was significant in proving anti-inflammatory activity. The experimental data suggested that ginger essential oil does not have influence on cells’ recruitment different to that observed for other essential oils [170]. Gingerol has been reported to have anti-inflammatory actions, which include suppression of both COX metabolites of arachidonic acid [171]. Anti-inflammatory activity of silica gel chromatography fractions of ginger have been reported [172]. Ginger extract administered daily for four weeks, either orally or intraperitoneally, caused significant reduction in prostaglandin E2 levels in experimental rats [171]. The efficiency of ginger in alleviating pain and associated symptoms in patients suffering from osteoarthritis has been reported recently [173]. According to them a highly purified and standardised extract of ginger had a statistically significant effect on reducing the symptoms associated with OA of the knee. There was a good safety profile also. The beneficial effects of ginger could be attributed to its ability to inhibit COX and LOX pathways resulting in the blockage of PGE2 and LTB4 production in affected joints [91,92,124]. The anti-inflammatory activity shown by ginger essential oil could be owing to the inhibition of prostaglandin release and hence ginger may act in a way similar to other non-steroidal anti-inflammatory drugs which interfere with prostaglandin biosynthesis. Ginger has been a common ingredient in arthritic formulas to encounter gastrointestinal adverse drug reactions due to aspirin and other non-steroidal anti-inflammatory drugs. A detailed study is needed to reveal the mechanisms of action of these compounds.
Table 1. List of some of the important anti-inflammatory and analgesic plants with their family and isolated compound.

<table>
<thead>
<tr>
<th>Name of Plant</th>
<th>Family</th>
<th>Isolated compound</th>
<th>Activity found</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Alchornea cordifolia</em></td>
<td>Euphorbiaceae</td>
<td>Quercitrin</td>
<td>Anti-inflammatory</td>
<td>Manga et al., 2004 [175]</td>
</tr>
<tr>
<td><em>Allium cepa</em></td>
<td>Liliaceae</td>
<td>Quercetin</td>
<td>Anti-inflammatory</td>
<td>Smith et al., 2003 [176]</td>
</tr>
<tr>
<td><em>Anacardium occidentale</em></td>
<td>Anacardiaceae</td>
<td>Epicatechin</td>
<td>Anti-inflammatory</td>
<td>Chatterjee and Pal, 1984 [177]</td>
</tr>
<tr>
<td><em>Ananas comosus</em></td>
<td>Bromeliaceae</td>
<td>Bromelain</td>
<td>Anti-inflammatory</td>
<td>Tassman et al., 1965 [178], Kelly, 1996 [3]</td>
</tr>
<tr>
<td><em>Apium graveolens</em></td>
<td>Apiaceae</td>
<td>Saponins</td>
<td>Anti-inflammatory</td>
<td>Sontakke et al., 2005 [135]</td>
</tr>
<tr>
<td><em>Aristolochia clematitidis</em></td>
<td>Aristolochiaceae</td>
<td>Aristolochic acid</td>
<td>Anti-inflammatory</td>
<td>Chavallier, 1996 [130]</td>
</tr>
<tr>
<td><em>Artemisia barlerieri</em></td>
<td>Asteraceae</td>
<td>Sesquiterpene lactones(Artemalin, Barelin, Barrelierin)</td>
<td>Anti-inflammatory</td>
<td>Zafra-Polo and Blazquez, 2006 [179]</td>
</tr>
<tr>
<td><em>Azadirachta indica</em></td>
<td>Meliaceae</td>
<td>Nimbidin</td>
<td>Anti-inflammatory</td>
<td>Shen, 1981 [180]</td>
</tr>
<tr>
<td><em>Berberis aristata</em></td>
<td>Berberidaceae</td>
<td>Berberine</td>
<td>Anti-inflammatory</td>
<td>Huang, 1999 [181]</td>
</tr>
<tr>
<td><em>Boswellia serrata</em></td>
<td>Boswelliaceae</td>
<td>Boswellic acid</td>
<td>Anti-inflammatory</td>
<td>Sontakke et al., 2005 [34]</td>
</tr>
<tr>
<td><em>Buddleja globosa</em></td>
<td>Buddlejaceae</td>
<td>Verbascoside, Luteolin – 7-</td>
<td>Anti-inflammatory</td>
<td>Backhouse et al., 2008 [182]</td>
</tr>
<tr>
<td><em>Calophyllum inophyllum</em></td>
<td>Guttiferae</td>
<td>(Xanthones) Dehydrocyclogomandrin, Calophyllin – B, Jacareubin</td>
<td>Anti-inflammatory</td>
<td>Gopalakrishnan et al., 1980 [37]</td>
</tr>
<tr>
<td><em>Canarium schweinfurthii</em></td>
<td>Burseraceae</td>
<td>Essential oil(ocetyl acetate, nerolidol)</td>
<td>Anti-inflammatory</td>
<td>Koudou et al., 2005 [183]</td>
</tr>
<tr>
<td><em>Cannabis sativa</em></td>
<td>Cannabaceae</td>
<td>Cannabinoids</td>
<td>Anti-inflammatory and analgesic</td>
<td>Formukong et al., 1988 [71]</td>
</tr>
<tr>
<td><em>Centella asiatica</em></td>
<td>Apiceae</td>
<td>Asiatic acid and Madecassic acid</td>
<td>Anti-inflammatory</td>
<td>Inamdar etal., 1996 [77]</td>
</tr>
<tr>
<td><em>Cucurbita andreana</em></td>
<td>Cucurbitaceae</td>
<td>Cucurbitacins</td>
<td>Anti-inflammatory</td>
<td>Jayaprakasham et al., 2003 [184]</td>
</tr>
<tr>
<td><em>Curcuma longa</em></td>
<td>Zingiberaceae</td>
<td>Curcumin</td>
<td>Anti-inflammatory</td>
<td>Kulkarni et al., 1991 [23], Kholi et al., 2005 [185]</td>
</tr>
<tr>
<td><em>Cyperus rotundus</em></td>
<td>Cyperaceae</td>
<td>β- sitosterol</td>
<td>Anti-inflammatory</td>
<td>Srimal andDhawan, 1983 [186]</td>
</tr>
<tr>
<td><em>Desmodium gangeticus</em></td>
<td>Fabaceae</td>
<td>Gangetic</td>
<td>Anti-inflammatory</td>
<td>Srimal andDhawan, 1983 [186]</td>
</tr>
<tr>
<td><em>Eupatorium arnotianum</em></td>
<td>Asteraceae</td>
<td>Flavanoids( nepetin, jacosadin, hispahudin)</td>
<td>Anti-inflammatory</td>
<td>Clavin et al., 2007 [187]</td>
</tr>
<tr>
<td><em>Foeniculum vulgare</em></td>
<td>Apiceae</td>
<td>Saponins</td>
<td>Anti-inflammatory</td>
<td>Sontakke et al., 2005 [135]</td>
</tr>
<tr>
<td><em>Garcinia mangostana</em></td>
<td>Guttiferae</td>
<td>Xanthones and xanthone – c-glucoside</td>
<td>Anti-inflammatory</td>
<td>Sankaranarayanan et al., 1979 [38], Bhattacharya et al., 1972 [188]</td>
</tr>
<tr>
<td><strong>Glycyrrhiza glabra</strong></td>
<td>Fabaceae</td>
<td>Glycyrrhizin</td>
<td>Anti-inflammatory</td>
<td>Huang, 1999 [181]</td>
</tr>
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</tr>
<tr>
<td><strong>Harpogophytum procumbens</strong></td>
<td>Pedaliaceae</td>
<td>Harpagoside</td>
<td>Anti-inflammatory</td>
<td>Leung and Foster, 1996 [103]</td>
</tr>
<tr>
<td><strong>Hibiscus vitifolius</strong></td>
<td>Malvaceae</td>
<td>Gossypin</td>
<td>Anti-inflammatory</td>
<td>Shen, 1981 [180]</td>
</tr>
<tr>
<td><strong>Kalanchoe crenata</strong></td>
<td>Crassulaceae</td>
<td>Flavonoids</td>
<td>Anti-inflammatory</td>
<td>Theophile et al., 2006 [109]</td>
</tr>
<tr>
<td><strong>Lycopersicon esculentum</strong></td>
<td>Solanaceae</td>
<td>Quercetin</td>
<td>Anti-inflammatory</td>
<td>Mitchell et al., 2007 [189]</td>
</tr>
<tr>
<td><strong>Madhuca longifolia</strong></td>
<td>Sapotaceae</td>
<td>Taxifolin</td>
<td>Anti-inflammatory</td>
<td>Huang, 1999 [181]</td>
</tr>
<tr>
<td><strong>Medicago sativa</strong></td>
<td>Fabaceae</td>
<td>Saponins</td>
<td>Anti-inflammatory</td>
<td>Sontakke et al., 2005 [135]</td>
</tr>
<tr>
<td><strong>Mesua ferrea</strong></td>
<td>Guttiferae</td>
<td>Mesua xanthone-A, Mesuaxanthone-B and Euxanthone</td>
<td>Anti-inflammatory</td>
<td>Gopalakrishnan et al., 1980 [37]</td>
</tr>
<tr>
<td><strong>Ricinus communis</strong></td>
<td>Euphorbiaceae</td>
<td>Flavonoids, alkaloids and tannins</td>
<td>Anti-inflammatory</td>
<td>Ilavarasan et al., 2006 [127]</td>
</tr>
<tr>
<td><strong>Sidia acuta</strong></td>
<td>Malvaceae</td>
<td>Cryptolepin</td>
<td>Anti-inflammatory</td>
<td>Bonjean et al., 1998 [190]</td>
</tr>
<tr>
<td><strong>Sida cordifolia</strong></td>
<td>Malvaceae</td>
<td>5-Hydroxy methyl-1'- (1,2,3,9 tetrahydro-pyrrolo[2,1-b] quinolin-1-yl)heptan-1-one</td>
<td>Anti-inflammatory</td>
<td>Suthradhar et al., 2006 [142]</td>
</tr>
<tr>
<td><strong>Solanum tilobatum</strong></td>
<td>Solanaceae</td>
<td>Solasodine</td>
<td>Anti-inflammatory</td>
<td>Immanuel et al., 2006 [192]</td>
</tr>
<tr>
<td><strong>Sphalanges acmella</strong></td>
<td>Asteraceae</td>
<td>Flavanoids</td>
<td>Anti-inflammatory and analgesic</td>
<td>Chakraborty et al., 2004 [149]</td>
</tr>
<tr>
<td><strong>Sulibium marianum</strong></td>
<td>Asteraceae</td>
<td>Silymarin</td>
<td>Anti-inflammatory</td>
<td>De La Puerta, 1996 [143]</td>
</tr>
<tr>
<td><strong>Zingiber officinale</strong></td>
<td>Zingiberaceae</td>
<td>Gingerol and triterpenes</td>
<td>Anti-inflammatory</td>
<td>Vendruscolo et al., 2006 [170]</td>
</tr>
<tr>
<td><strong>Salix alba</strong></td>
<td></td>
<td>Salicin</td>
<td>Anti-inflammatory and analgesic</td>
<td>Bradely, 1992 [132]</td>
</tr>
</tbody>
</table>
Summary and conclusion

In modern times the trend towards the use of alternative and complementary medicine is increasing and it offers unprecedented opportunities for the development of herbal medicine. Many of the Asian countries are taking full advantage of the links to the ancient cumulative wisdom of the traditional practitioners. Ethnobotanical knowledge of the past as well as present folk is of immense value to the development of newer drugs with virtually no or less adverse effects. Previous studies have contributed much in the understanding of the compound(s) responsible for the known anti-inflammatory and analgesic action, their mechanism of action and therapeutic values. Compounds such as Bromelain act as anti-inflammatory agent due to its fibrinolytic and fibrinogenolytic effects. Boswellic acids play a key role in inhibiting 5-HETE and leukotriene B4 which are involved in the pathogenesis of asthma and arthritis. Xanthones are also implicated in the anti-inflammatory and analgesic effects. Unlike other anti-inflammatory/ analgesic agents, xanthones were reported to have very less or no side effects such as ulcerogenicity and blood clotting. Green tea catechins are another useful candidate for the treatment of inflammatory diseases like RA and OA. Cannabinol and related compounds from Cannabis sativa are potent analgesic, antiasthmatic and anti-heumatic agents. Terpene acids such as madecassic acid and asiatic acid from Centella asiatica has been reported to be an effective analgesic and anti-inflammatory compound. Curcumin is the most important ethnobotanical drug isolated from Curcuma longa and is reported to have a variety of medical applications including anti-inflammatory activity. The pharmacological action of curcumin can be attributed to the inhibition of a number of inflammatory molecules including lipooxygenase, cyclooxygenase, TNF, IL-1, IL-2, leukotrienes and prostaglandins. Pathways of anti-inflammatory activity of curcumin have been studied by many workers and they come out with different views. However, curcumin is involved in one or the other pathway of inflammatory cascade and execute its effect. Gastrodia elata, an orchidacean member is used in ethnomedicine to treat a variety of disorders and eight structurally different phenolic compounds were identified. These compounds were involved in the inhibition of COX activity, which was attributed to the presence of C-3 and C-4 methoxy and hydroxyl radicals respectively in them. Yet another compound, Salicin, from Salix alba was also found to be very effective anti-inflammatory and analgesic agent and was proved better than aspirin. Gingerol and its analogues in Zingiber officinale are potent antioxidant, antinoceceptive and anti-inflammatory agents. Gingerol inhibits COX and LOX pathways, thus blocking the PGE-2 and LTB-4 production in affected areas.

Much of the current research trend is towards the isolation, purification, identification and characterization of active principle(s) from crude extracts.
of ethnomedicinal plants. However, there is a hidden fact that the different components present in the crude plant drugs may be more efficient and potent than any of the single purified compound which may help to nullify the toxic effects of individual constituents. Most of the commonly used modern medicines have originated from the plant sources. The incidence of arthritis and related diseases is increasing now due to the drastic changes that happened in the present life style. The quest for new botanicals as relief for these life style disorders would be a welcome step for the local and urban health care. Majority of the anti-inflammatory and analgesic compounds isolated from the above discussed medicinal plants are prone to some side effects for which addition of modern medicines or antidotes from plant sources are recommended. At the same time plants like *Bosewellia*, *Callophyllum* and *Mesua* yield such compounds free from side effects. The development of neutraceuticals from them could substitute the present generic market to a great extent.

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42. Oudhia, P. 2001, Calotropis gigantea: Useful weed, PankaLoudhia@usa.net. www.celestine India.com/Pankoudhia.