

1 **Botanical Allies: Exploring the Anti-Inflammatory Properties of Medicinal Plants**

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12 **Abstract**

13 Plants alongside being the primary source of food, played its role as a medicine as well.
14 Plants being rich in therapeutic potential due to their phytochemical profile have been in
15 medicinal use from ancient times and has always been an interest to clinical trials as well as
16 researches. Being less harmful and natural, plant derived medicines are a great alternative to
17 conventional medicines. The biological active compounds in plants i.e., phytochemicals are
18 capable of showing biological activities. One of the important properties of therapeutic plants
19 is their anti-inflammatory potential. Different plants from different regions of the world have
20 been proven to possess potential of reducing inflammation caused by different agents.
21 Inflammation is body's response to harmful stimuli. Plant derived medicine could be in form
22 of extract and powdered supplement. Extract of different parts of a therapeutic plant has been
23 helpful in treating induced inflammation in clinical trials along with conventional medicines
24 as well as alone. Plants having anti-inflammatory potential such as *Aegle marmelos*,
25 *Bryophyllum pinnatum*, *Albizia lebbeck*, *Cassia occidentalis*, *Cynodon dactylon* and *Zingiber*
26 *officinale* has been discussed in this chapter to emphasize their action against causative
27 agents.

28 **Key Words:** Therapeutic potential, phytochemical, clinical trials, anti-inflammatory,
29 conventional medicines

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34 **1. Introduction**

35 Plants have more than 500,000 species estimated globally. Each species has a unique variety
36 along with complex properties. People have been using plants for centuries for various
37 purposes, and curing diseases is the most important. It is said that more than 150,000 species
38 of plants have been studied which possess therapeutic effects. Due to the plant's complex
39 chemical profile, they can participate in biological activities. Plant-based medicines have
40 always been an interesting part of clinical research and drug industries. According to the
41 World Health Organization (WHO), around 65% of the population globally include plant-
42 based medicine in their health management. To attack pathogens and protection from
43 environmental stress, plants produce different chemical substances. These substances are the
44 result of secondary metabolism. Plants have great anti-inflammatory potential due to their
45 phytochemical constituents (Nunes et al., 2020). Inflammation can be described as a
46 protective reaction of the body that involves the onset of the immune system against
47 infection, harmful compounds, damaged cells, or exposure to harmful radiation to maintain
48 the body's homeostasis. Inflammation can be acute or chronic depending on the damage to
49 the body (Oronsky et al., 2022). Compared to conventional medicines, plant-based medicines
50 due to their phytochemical profile have helped treat and manage inflammation (Nunes et al.,
51 2020).

52 **2. *Aegle marmelos***

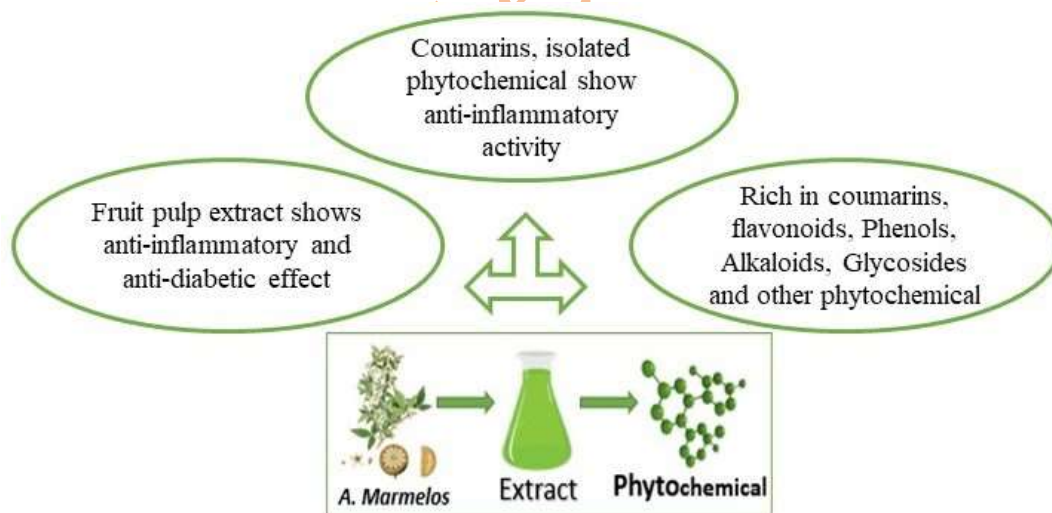
53 *Aegle (A.) marmelos* bearing numerous medicinal benefits of family Rutaceae usually known
54 as Bael, Japanese bitter orange, Bengal quince, golden apple, stone apple or wood apple, etc.
55 is a tree native to the Indian subcontinent and Southeast Asia. It also naturally grows in India,
56 Pakistan, Bangladesh, Sri Lanka, and Nepal. It is the only plant that belongs to the genus
57 *Aegle*. *A. marmelos* is a broad-leaved woody plant or small to medium-tall tree with a height
58 of 13 meters (Sharma et al., 2022a). The Bael tree has spiky stem branches that can be seen.
59 The alternating, usually trifoliate leaves have 3 to 5 leaflets per leaflet, each measuring 4 to
60 10 centimeters in length and 2 to 5 centimeters in width. When leaves are young, they are a
61 relatively lighter shade of green; as they mature, they turn a dark green color. The tree has
62 thick, peeling bark with limbs that are frequently spiky. There is a gum discharge from the
63 injured bark that thickens in the presence of air. The Bael flower has a greenish-white hue. It
64 is characterized by a fragrant aroma and an actinomorphic, bisexual, ebracteate, hypogynous
65 stalk. 10 flowers are seen in lateral panicles that are located in the leaf axil. The Bael fruit has
66 a mostly yellowish green color and is 5.3–7.2 cm in diameter. Its approximate weight is 77.2
67 g, its volume is 73.7 mL, and its sphericity is 93.72 ± 2.78 percent. The fruit's pulp has a

68 yellow color and is sticky. It has a few spots on the outside and a large number of firm seeds
69 with white thread-like hairs covering their outside surface. Every part of this tree at a certain
70 maturity and age provides various medicinal benefits, making it a pharmacologically
71 important plant (Sharma et al., 2022a).

72 2.1 Phytochemical Constituents and Anti-inflammatory Mechanism

73 This native tree has several coumarins, glycosides, carotenoids, polyphenols, flavonoids,
74 pectins, triterpenes, alkaloids, tannins, sterols, saponins, psoralen, and essential oils granting
75 medicinal properties to the plant (Sharma et al., 2022a). Extract derived from *A. marmelos*
76 leaves and fruit has shown anti-inflammatory activity by inhibiting mediators in vitro.
77 Coumarin, a special phytochemical isolated from *A. marmelos*, has been scientifically proven
78 to have significant anti-inflammatory potential compared to commercial medicines (Tiwari et
79 al., 2023). Crude extract, methanolic extract, and coumarin-enriched extract of *A. marmelos*
80 fruit pulp have shown remarkable anti-inflammatory effects along with anti-diabetic potential
81 by inhibiting responsible enzymes in vitro and silico. Extract of *A. marmelos* leaves has been
82 proven to treat acute inflammation in carrageenin-induced rat paw edema model,
83 administered orally (200mg/kg B.) (Ramadoss & Vishnupriya, 2023).

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Figure 1: Anti-inflammatory mechanism of *A. marmelos*

87 3. *Bryophyllum pinnatum*

88 *Bryophyllum (B.) pinnatum* of family Crassulaceae, is widely naturalized in Australia,
89 topical eastern Africa (Madagascar), New Zealand, Asia (e.g., India, Taiwan, Indonesia, and
90 New Guinea), the Caribbean, south-eastern USA (i.e., Florida) and the Pacific (i.e., the
91 Galapagos Islands, Melanesia, Polynesia, and Hawaii). It has many common names such as

92 Pan photo, Resurrection plant, Leaf of life, Life plant, Live leaf, green mother of millions,
93 Air plant, Canterbury bells, Cathedral bells, good luck leaf, Curtain plant, and Mexican love
94 plant, etc. 60-120cm tall plant with broad and scalloped margin oppositely arranged leaves
95 (Mule et al., 2020). The leaves decussate and are 10–20 cm long. Surrounding the 3 to 7-
96 foliate upper leaf is a lengthy petiole. With red ribbons scalloping them, they have a dark
97 green color. Latent buds that can form into healthy plantlets with an acute tip are present in
98 the 30-35 cm long, 2-4 cm petiole, and 7-8 X 3-5.5 cm blades. On the leaves are vegetative
99 buds that are rooted. The *Paniculate terminale* has a length of 10–40 cm. Flowers in the
100 shape of pendulous bells cover the ground. With follicles in the petals and calyx, oblong
101 stamens, and oval-shaped nectar scales, the calyx tube is 2-4 cm long. The smooth, ellipsoid
102 seeds are plentiful and found in the four-septate fruit pod. November to March is when the
103 plant produces the most. The aftertaste of this is spicy, astringent, acidic, and sweet
104 (Selvakumar, 2022).

105 **3.1 Phytochemical Constituents and Anti-inflammatory Mechanism**

106 Phenols, alkaloids, flavonoids, saponins, tannins, carotenoids, glycosides, sitosterol,
107 anthocyanin, malic acid, terpenoids, quinines, tocopherol, lectins, coumarins and the key
108 component are Bufadienolides-Bryophyllin A (bryotoxin)¹⁵; Bryophyllin B, are present in
109 air plant (Kumar et al., 2020). *B. pinnatum* leaves extract, flowers, seeds, and recent studies
110 have shown that its root powder has anti-inflammatory potential due to its phytochemical
111 profile, strong enough to inhibit the mediators (Selvakumar, 2022; Singh et al., 2022; Latif et
112 al., 2020). *B. pinnatum* decreases the potency of tissue necrosis factor by inhibiting
113 cyclooxygenase enzyme. Leaf and flower aqueous extract helped to reduce inflammation in
114 carrageenan-caused paw edema when tested in rats. Leaves methanolic distillate remarkably
115 inhibits edema in comparison to standard drugs (Selvakumar, 2022; Singh et al., 2022; Latif
116 et al., 2020).

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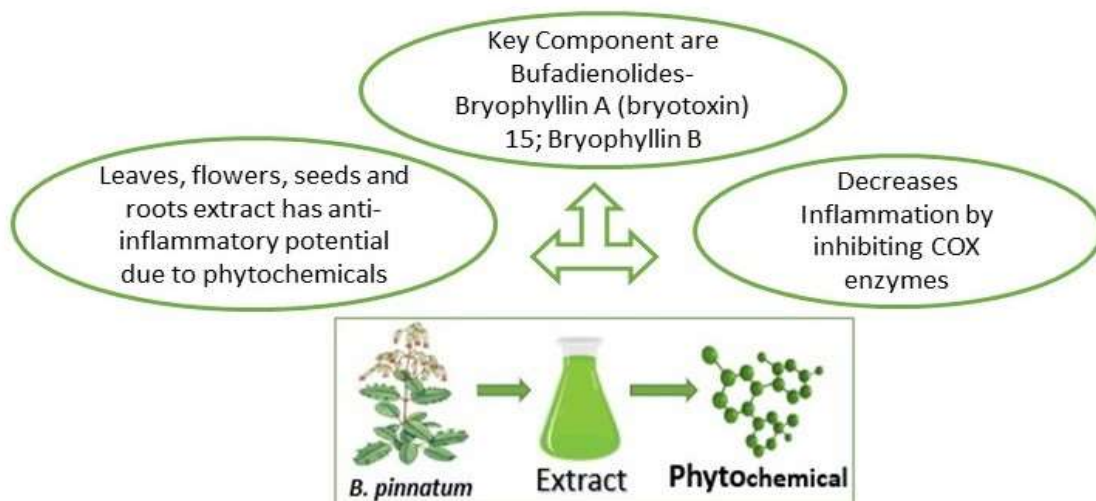


Figure 2: Anti-inflammatory mechanism of *B. pinnatum*

4. *Albizia lebbek*

Albizia (A.) lebbek is indigenous to the Indian subcontinent and Myanmar is a plant belonging to the family Fabaceae. It is generally grown and naturally grows in more humid and warm areas, including Australia. It has many usual names such as siris, Indian siris, East Indian walnut, Broome raintree, lebbek, lebbek tree, fry wood, Koko, and woman's tongue tree etc. (Sharma et al., 2022b). Many medical systems, including Ayurveda, Sidha, and Unani medicine, advocate it. It has a wide range of traditional applications; among them, the majority involve treating respiratory disorders (16%), skin disorders (11%), gastrointestinal disorders, and oral disorders (7%). Within all of these traditional and ethnomedical contexts, the plant is commonly used to treat a variety of ailments, including ulcers, scorpion stings, leprosy, boils, bronchitis, diarrhea, and gum inflammation (4.88%), piles (4.27%), parasitic infestation and snakebite (3.66%), and abdominal tumors, arthritis, cough, dysentery, night blindness, and poisoning (2.44%). With 33.33% of all plant parts utilized, the bark is the most commonly used. It is followed by leaves, flowers, seeds, roots, bark, stems, and pods (16.67%) (Balkrishna et al., 2022). Genus *Albiza* also has a common name i.e., Siris, because of the rattle sound produced by seeds inside the pods. 18-30 m tall tree (50cm-1m in diameter trunk), bipinnate leaves (7.5–15 cm long with 1 to 4 pairs of pinnae, each pinna with 6–18 leaflets) and very fragrant white flowers (numerous 2.5–3.8 cm long stamens). The fruit is in form of pod 15–30 cm long and 2.5-5.0 cm broad, containing six to twelve seeds (Sharma et al., 2022b).

142 **4.2 Phytochemical Constituents and Anti-inflammatory Mechanism**

143 The phytochemical profile of *A. lebbeck* consists of alkaloids, anthraquinones, essential oils,
144 flavonoids, glycosides, phenolics, phytosterol, tannins, saponins, steroids, and triterpenoids.
145 Its seeds are a good source of protein 2.272%, lipids 0.27%, fatty acid (linolenic acid, oleic
146 acid, palmitic acid, and steric acid), tetradecane, hexadecane, phytol, nonadecane, eicosane,
147 vitamin E, stigmastadiene, and octadecane (Sharma et al., 2022b). All parts of the plant
148 performed anti-inflammatory action when tested. Aqueous leaf extract of *A. lebbeck* by
149 inhibiting protein denaturation, showed anti-inflammatory activity (Kamala & Valarmathi,
150 2020). In animal models, the anti-inflammatory effect of *A. lebbeck*'s various solvent extracts
151 on acute as well as chronic inflammation and effect of the extract in carrageenan-induced
152 edema has been studied. Drug extract has shown remarkable potency in anti-inflammatory
153 activity and has shown effects on adjuvant arthritis by eliminating paw edema (Balkrishna et
154 al., 2022).

155 **5. *Cassia occidentalis***

156 *Cassia (C.) occidentalis* is known as *Senna occidentalis* as well. A weed linked to the breed
157 Fabaceae. *Senna occidentalis* is indigenous to the humid and warm areas of America and
158 naturalized in Australia, southern and eastern USA, and eastern Africa (Khurm et al., 2021).
159 It has various common names such as Coffee senna, ant bush, arsenic bush, negro coffee,
160 Nigerian senna, septic-weed, sicklepod, stinkweed, stinking pea, stinking weed, styptic weed,
161 etc., (Pawade & Jane, 2020). Its leaves, stems, and roots have all been widely used in
162 traditional medicine to treat urinary tract, liver, and flu conditions as well as as a laxative,
163 painkiller, and vermifuge. Sometimes, the seeds are roasted and used to make drinks that
164 resemble coffee. Additionally, Laboratorio Pernambucano Ltd. (LAPERLJ) marketed the
165 extractives of *C. occidentalis* L. leaves, stems, and roots under the trade name "*Cassia*
166 *virginica*" in Brazil. These products were intended to treat fever, TB, flu, and other illnesses,
167 as well as to function as a diuretic (Sayed et al., 2023). 1-2 m tall stinking shrub which has
168 soft bushy branches and stem. 3-7 pair pinnate leaves, commonly elliptic to egg-shaped
169 leaflets. Yellow coloured flowers are attached on the end of branchlets in 2-4 groups and each
170 flower has 6 fertile stamens. This weed is broadly scattered all over the humid region of the
171 earth (Pawade & Jane, 2020)

172 **5.1 Phytochemical Constituents and Anti-inflammatory Mechanism**

173 *Senna occidentalis* phytochemical profile shows presence of flavonoids, alkaloids, glycosides
174 and terpenoids in high amount. While saponins, phenol, tannins, and steroids are present in
175 moderate amounts. Its phytochemical screening also shows the presence of vitamins such as

176 vitamin A, vitamin B, vitamin B1, vitamin B2, vitamin B3, vitamin C, vitamin D, vitamin E
177 and vitamin K (Ujah et al., 2022). Some noteworthy components are aloe-emodin,
178 chrysophanol, nerolid, apigenin, 1-methoxy naphthalene and quinine. Investigation has
179 shown that *Senna occidentalis* extract has anti-inflammatory ability by blocking the activity
180 of cyclooxygenase-2 (COX-2) protein and lipoxygenase (LOX) protein. *Senna occidentalis*
181 extracts in vitro, displayed anti-inflammatory action by hindering the making of pro-
182 inflammatory cytokines such as interleukin-1 β and tumor necrosis factor-alpha. This happens
183 might be because of the plant's capability of altering the action of enzymes associated with
184 inflammation, such as cyclooxygenase-2 (COX-2) and lipoxygenase (LOX) (Shyheed et al.,
185 2023).

186 **6. *Cynodon dactylon***

187 This grass belongs to the family Poaceae. *Cynodon (C.) dactylon* is found worldwide (New
188 Zealand, Europe, Africa, Australia and in many countries of Asia). It was brought to
189 America. It is commonly called as Couch grass and Bermuda grass. It is not an Indigenous
190 plant of Bermuda but aggressively grows there and is called as crabgrass. Various common
191 names are dhoob, ethane grass, dubo, Bahama grass, durva grass, dog grass, dog's tooth
192 grass, devil's grass, grama, Indian doab, wire grass, arugampul, scutch grass, etc. (Das et al.,
193 2021). *C. dactylon* is described as having a strong, sharp flavor and a pleasing scent in the
194 Unani medical system. In addition to their cardioprotective qualities, the plant's rhizomes and
195 aerial parts have diuretic, antidiabetic, antibacterial, antimicrobial, antioxidant, and wound-
196 healing qualities. *C. dactylon* is used by traditional healers to treat gonorrhoea, diarrhea,
197 conjunctivitis, anuria, and stomachaches. It also makes the blood pure (Amritkar et al., 2023).
198 1-30 cm tall, generally tinged purple coloured and flattened stem with grey green colour short
199 and rough-edged blades. Seed heads are attached at the top of stem in form of cluster of 2-6
200 spikes. Root system is very deep. Usually, root mass is not greater than 60 cm in depth. But
201 in case of drought and fertile soil root system can go over 2 metres in depth (Das et al., 2021).

202 **6.1 Phytochemical Constituents and Anti-inflammatory Mechanism**

203 This widely spreading grass bears a good phytochemical profile consisting of glycosides,
204 alkaloids, terpenoids, flavonoids, saponins, resins, triterpenoid esters, tannins, carbohydrates,
205 phytosterols, proteins, phenols, reducing sugars, fixed as well as volatile oils (Savadi et al.,
206 2020). Aqueous and alcoholic extract of couch grass has experimentally shown good anti-
207 inflammatory action by inhibiting protein denaturation. Alcoholic extract showed better
208 action as compared to aqueous extract in vitro. In carrageenan-caused edema in paws of rat,
209 *C. dactylon* extract showed anti-inflammatory action by inhibiting histamine and serotonin.

210 Anti-inflammatory action is due to the reduced pharmacological activity of histamine. The
211 high flavonoid content of this grass can reduce the synthesis of prostaglandins (Akhlaq et al.,
212 2024).

213 **7. *Zingiber Officinale***

214 The plant *Zingiber (Z.) officinale*, Zingiberaceae is used as a spice in food all around the
215 world. Ginger is a perennial plant native to tropical Asia that is grown in tropical regions of
216 Australia, Brazil, China, India, Jamaica, West Africa, and some areas of the United States.
217 Chinese and Ayurvedic medicine have traditionally used ginger rhizome as an antipyretic,
218 antiemetic, and anti-inflammatory (Kumari et al., 2020). Ginger has been utilized as an herb
219 for thousands of years because of its wide range of phyto-therapeutic properties. In
220 Ayurveda, ginger is called Mahaashdi, which suggests that it improves internal functions
221 and helps flush the body of toxins. Moreover, the components of this substance have been
222 shown to treat the symptoms of arthritis, muscle aches, chest pain, lower back pain, stomach
223 pain, and menstrual pain, indicating that ginger is a pain reliever. Other illnesses that can be
224 treated with ginger include upper respiratory tract infections, coughs, and bronchitis. The
225 rhizome is advised for use in treating joint issues because it can also lower inflammation
226 (Edo et al., 2024).

227 **7.1 Phytochemical constituents and Anti-inflammatory mechanism**

228 The components of ginger are diverse and can differ based on the region of origin and
229 the state of the rhizomes, but here is a summary of the main ones that have been linked to the
230 crude drug's pharmacological effects. Gingerol is the main pungent ingredient in ginger
231 (phenylalkylketones or vanillyl ketones); significant concentrations of other gingerol analogs,
232 including shogaols, paradol, and zingerone, are also present in rhizome extracts. It seems that
233 gingerol and shogaol are the main pharmacological components of ginger (Sindhoora &
234 Bhattacharjeenbsp, 2020). Ginger has been found to inhibit prostaglandin biosynthesis and
235 interfere with the inflammatory cascade and the vanilloid nociceptor (Pazmzndi et al., 2024).
236 There is a long history of using ginger as an anti-inflammatory, and numerous of its
237 ingredients have been shown to have anti-inflammatory qualities. Ginger extract derived from
238 *Z. officinale* inhibits the induction of various genes that are implicated in the inflammatory
239 response, such as those that encode chemokines, cytokines, and the inducible enzyme
240 cyclooxygenase-2. This discovery provided evidence that ginger modulates biochemical
241 pathways activated in chronic inflammation (Azeez & Lunghar, 2021).

242

243 **Table 1. Showing phytochemical profile of anti-inflammatory potential-rich plants**

Phytochemical	<i>A.marmelos</i>	<i>B. pinnatum</i>	<i>A. lebbeck</i>	<i>C. occidentalis</i>	<i>C. dactylon</i>	<i>Z. officinale</i>
Alkaloids	+	+	+	+	+	+
Glycosides	+	+	+	+	+	+
Flavonoids	+	+	+	+	+	+
Terpenoids	+	+	+	+	+	+
Phenols	+	+	+	+	+	+
Saponins	+	+	+	+	+	+
Tannins	+	+	+	+	+	+
References	Sharma et al., 2022a	Kumar et al., 2020	Sharma et al., 2022b	Ujah et al., 2022	Savadi et al., 2020	Christine et al., 2021

244 **8. Conclusion**

245 Although the body naturally responds to injury or infection with inflammation, persistent
 246 inflammation can result in several illnesses. These illnesses can give birth to serious health
 247 issues if left unchecked. Plants are rich in miraculous components which offer a bunch of
 248 therapeutic services. In this review, numerous therapeutic plants with anti-inflammatory
 249 qualities have been investigated, including *A. marmelos*, *B. pinnatum*, *A. lebbeck*, *C.*
 250 *occidentalis*, *C. dactylon*, and *Z. officinale*. *A. marmelos*, often referred to as Bael, the
 251 abundance of phytochemicals found in *A. marmelos*, such as tannins, flavonoids, and
 252 coumarins, is thought to be responsible for its anti-inflammatory qualities. *B. pinnatum* is
 253 distinguished by its capacity to multiply from leaf buds. This succulent's leaves are rich in
 254 bioactive substances with notable anti-inflammatory properties, such as glycosides,
 255 triterpenoids, and flavonoids. Because *B. pinnatum* reduces swelling and inflammation. *A.*
 256 *lebbeck* is utilized in traditional medicine for its leaves, bark, and seeds. The saponins,
 257 tannins, and flavonoids found in *A. lebbeck* are primarily responsible for its anti-
 258 inflammatory properties. *Cassia occidentalis*, often referred to as coffee senna, this plant is
 259 used for its strong anti-inflammatory qualities in its seeds, leaves, and roots. The plant's anti-
 260 inflammatory properties are facilitated by the presence of tannins, flavonoids, and
 261 anthraquinones. Bermuda grass, *C. dactylon* is valued for both its medicinal and robust
 262 qualities. Phytochemicals found in the grass, including glycosides, alkaloids, and flavonoids,

263 have anti-inflammatory properties. *Z. officinale* commonly called as ginger, is well-known
264 for its therapeutic and culinary applications. Strong anti-inflammatory bioactive substances
265 like paradol, shogaol, and gingerol are found in the rhizome. The potential of ginger to lower
266 inflammation in diseases like rheumatoid arthritis, osteoarthritis, and gastrointestinal issues
267 has been thoroughly investigated. Ginger has anti-inflammatory properties that are mediated
268 by suppression of pro-inflammatory cytokines and inhibition of the COX and lipoxygenase
269 pathways. All these plants have been in medicinal practices from ages.

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