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Medicinal plants and their uses by a folk medicinal practitioner of Matlab Upazila in Chandpur district, Bangladesh

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Abstract
Background: Bangladesh is a small developing country with the majority population still residing in villages; most villages lack many modern amenities like proper drinking water facilities, sanitation, and conventional (allopathic) doctors and hospitals. On the other hand, although it is getting lost with possibly every passing day, villagers have a long history of traditional medicinal practitioners, who are also known as folk medicinal practitioners or Kavirajes (in Bengali). Kavirajes for the most part use medicinal plants, which are locally available for treatment and thus saves the villagers from costly conventional treatment, the medicines of which are neither readily available nor affordable. Once common, Kavirajes are fast disappearing along with loss of their folk medicinal knowledge. This loss is irreparable because plants and their phytochemicals still form the basis for discovery of modern drugs. For more than a decade, we had been conducting ethnomedicinal surveys among folk and tribal medicinal practitioners of Bangladesh.
Methods and Findings: Interviews were conducted of the only folk medicinal practitioner (FMP) in Matlab Upazila. Prior permission was obtained from the FMP. Interviews were conducted with the help of a semi-structured questionnaire, extensive discussions, and field trips to areas frequented by the FMP to collect medicinal plants. Information was noted carefully. Plants were pictured, and plant samples identified by a trained botanist following collection, drying and mounting onto herbarium sheets. We could obtain information on only ten formulations, which were used for treatment of respiratory disorders, gastrointestinal tract disorders, pain, dengue, diabetes, acne, fever, eye problems, jaundice, gonorrhea, sexual problems, and debility.
Conclusions: The richness of folk medicinal practice can be glimpsed from the diversity of illnesses treated with just twelve medicinal plant species. Some of these plants urgently need scientific attention before plants and FMPs disappear altogether. The phytochemicals present in the plants can be sources of potential drugs, lead compounds, or scaffolds for better drugs.

Keywords: Phytotherapy, folk medicine, Kavirajes, Chandpur, Bangladesh

Introduction
The relationship between humans and plants goes deeper than the simple dietary relationships. Besides forming a part of the human diet and supplier of oxygen without which humans will not be able to live, plants have also served and still serving human need for aesthetic purposes, habitat, maintaining carbon dioxide levels, and what may be one of the most important – the need for medicines. It can be safely assumed in the absence of historical records of human beings from their initial evolution, that the first human beings also suffered from diseases and possibly used plants to cure most, if not all diseases [1]. Naturally this gives rise to the question as to why plants? It could be the abundance of plant species, each species with its unique pharmacological properties and repertoire of phytochemicals, it could have been a learning lesson from the animal species, particularly the great apes, who can be observed even at this date to use plants as medicines [2, 3]. Needless to say, the use of plants for treatment of diverse diseases can be found in historical records since the invention of writing and continues to the present day [4, 5].
The ancient ways of using plants as medicines have been formalized and put forth in various ancient texts. Just taking India and Bangladesh into account, Ayurveda and Siddha way of treatment with mostly plant-based traditional medicines have existed in India from around four to five thousand years ago [6, 7].

Compilations of two of the most famous Ayurvedic physicians, Charak and Sushruta, are still extant and taught in Ayurvedic colleges in Bangladesh and India [8]. The Siddha system of medicine, which is considered as Tamil/Dravidian system of medicine and more ancient than the northern Indian Ayurveda (Aryan system) is the major traditional medicine system in practice in southern India [9]. The Unani system of medicine, which originated in Greece, was later expanded in the Middle East, Persia and India, also is taught in Indian and Bangladeshi Unani colleges and has its own pharmacopoeia. The Unani system was founded by Hippocrates in Greece, expanded by the Roman physician Galen, and further expanded by Rhazes and Avicenna in Persia [10]. The above does not take into account the other traditional medicinal systems that are being practiced in India and other countries of the world, among them one of the most famous being TCM or Traditional Chinese Medicine [11].

Folk medicine is another system of traditional medicine practiced in various countries of the world including Bangladesh. The major difference between folk medicine (FM) and systems like Ayurveda or TCM is that folk medicine can be practiced by any person without the necessity of any formal training or degree requirements. In Bangladesh, even a few years back, folk medicinal practitioners (FMPs) could be found by the dozens in both rural and urban areas. FMPs use mostly medicinal plants for treatment, but their modus operandi/formulations may also include animals, insects, minerals, amulets, and recitations from holy books. FMPs do not have any Government-approved pharmacopoeia; their practice is based on trial and error or transmitted orally through generations. Surprisingly, when we first started to study the practices of FMPs, we found that for the most part, their use of whole plants/plant parts can be justified by scientific reports, despite the fact that the FMPs rarely have even gone through high schools and can be said with certainty have no knowledge of the available scientific literature. Towards building up a database of the diverse formulations used by the FMPS, we started conducting ethnomedicinal surveys in various regions of the country; our survey also included tribal medicinal practitioners (TMPs), the difference between FMP and TMP is that the former caters to the mainstream Bengali-speaking population, while the latter serves their particular tribes [12-44]. The objective of the present study was to collect information from a FMP in Chandpur district, Bangladesh.

Methods

Information was collected from a FMP/Kaviraj practicing in village Charnaya, Matlab Upazila (sub-district), Chandpur district, Bangladesh. Prior informed consent was obtained from the FMP (male, age 72 years). Information was collected with the help of a semi-structured questionnaire, extensive discussions, and field trips to areas frequented by the FMP to collect medicinal plants. Information was noted carefully. Plants were pictured from several angles, and plant samples identified by a trained botanist following collection, drying and mounting onto herbarium sheets. It may be mentioned that the FMP was found after an extensive search of the area (comprising of several villages) and where even a decade ago, it would have been a realistic expectation to find at least 5-10 FMPs. In general, the ethnobotanical survey methods as described by Martin [45] and Maundu [46] were followed regarding interviews of the FMP and documentation of diseases treated and plant species used. Besides the FMP, there were extensive talks with the villagers to build up rapport and create a congenial condition for our visits. This rapport is necessary for a stranger to come and initiate work in rural areas, where an unknown person in recent years is more liable to be subject to suspicion than a general welcome. It also enabled us to question the villagers regarding whether they use the FMP's treatment and the effectiveness of treatment(s).

Results and Discussion

Chandpur district (Figure 1) is located in between 23°00' and 23°30' north latitudes and in between 90°32' and 91°02' east longitudes and has an area of 1704.06 square kilometers. It is comprised of eight Upazilas or sub-districts.

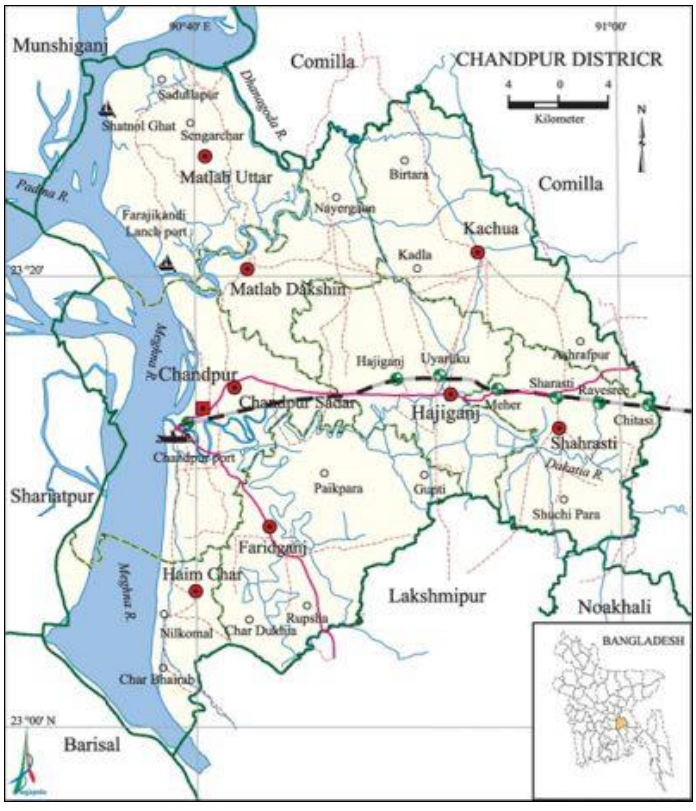

Fig 1: Map of Chandpur district (inset showing map of Bangladesh with Chandpur district depicted in yellow).

Agriculture forms the main source of income. The district forms a major center for hilsa fish (*Tenualosa ilisha*) trade, hilsa or ilish being the favorite fish of most Bangladeshis. The confluence of two major rivers of Bangladesh, namely the Padma and the Meghna rivers make Chandpur port an ideal place for selling and buying hilsa, more so because the fish caught from the Padma river is supposedly the best in taste according to fish lovers. A number of research stations and laboratories of the International Centre for Diarrhoeal Disease Research, Bangladesh (ICDDR, B) is located in Matlab, Chandpur district. The influx of foreign and local scientists and their field level research may be a reason for the absence of FMPs in and around villages in Matlab, the local people being able to check the diarrheal diseases affecting them and their children at ICDDR, B.

The various plants, formulations, and diseases treated as obtained from the FMP are shown in Table 1. An interesting feature is that different parts of a given plant was used to treat different diseases. Different parts of a same plant can contain different phytochemicals with differing pharmacological activities. The FMP's use of the plant showed that although illiterate, but possibly from practical uses, he was aware of different parts of the same plant possessing different disease-curing abilities.

Table 1: Information on plants, formulations and diseases treated as obtained from the FMP of Chandpur district.

Plant name	Family	Local name	Part(s) used	Disease(s) treated, formulations, and dosages
Justicia adhatoda L.	Acanthaceae	Bashok	Leaf	Bronchitis, asthma, fever, jaundice, and diabetes. Juice obtained from crushed leaves is mixed with water and three glasses of the mixture is taken daily for 3 weeks.
Allium sativum L.	Alliaceae	Roshun	Cloves making up the bulb	One to two cloves are taken raw every day for heart and respiratory problems.
Ipomoea aquatica Forssk.	Convolvulaceae	Kolmi shak	Leaf, stem	Gonorrhea, antidote to poisoning, to increase milk of nursing mother, low sperm count, and low semen volume. Leaves and stems are cooked and eaten. Alternately, leaves and stems are fried in oil or ghee (clarified butter) and taken with rice or bread.
Tamarindus indica L.	Fabaceae	Tetul	Fruit, bark, leaf	Ripe fruits are orally taken for indigestion. Dried bark is orally taken for loss of appetite and frequent thirsts. Leaves from young trees are orally taken for blood poisoning, pain, and blood dysentery.
Trigonella foenum-graecum L.	Fabaceae	Methi	Seed	Diabetes. Seeds (5-50 grams) are mixed with food (usually rice) or water and taken along with the meal. This is done once or twice daily.
Ocimum basilicum L.	Lamiaceae	Tulshi	Leaf	Cough, common cold. One cup amount of leaf juice is taken with ginger (rhizome of *Zingiber officinale*) and black pepper (dried fruit of *Piper nigrum*).
Azadirachta indica A. Juss.	Meliaceae	Neem	Leaf, bark, seed	Macerated leaf and bark are taken for dengue fever and stomach disorders. Seed oil is used topically to treat all kinds of skin disorders. Alternately, water in which leaves are boiled or soaked is also topically applied for skin diseases.
Syzygium aromaticum L.	Myrtaceae	Lobongo	Dried floral bud	Toothache. Crushed dry floral buds are taken with honey for seven days. Dried floral bud is also used as spice.
Phyllanthus emblica L.	Phyllanthaceae	Amloki	Fruit	Eye problems, coughs, skin disorders, and allergy. Green fruits are taken orally; alternately, dried fruits are soaked in water and taken daily till cure.
Piper nigrum L.	Piperaceae	Gol morich	Fruit	See *Ocimum basilicum*.
Plumbago zeylanica L.	Plumbaginaceae	Shada chita	Whole plant	See *Zingiber officinale*.
Zingiber officinale Roscoe	Zingiberaceae	Ada	Rhizome	See *Ocimum basilicum*. Low semen density, diabetes, debility, jaundice, coughs, mucus, and rheumatic pain. One teaspoonful of paste obtained from whole plants of *Plumbago zeylanica* and rhizomes of *Zingiber officinale* is taken twice daily for 6-7 days.

In total, the FMP used plants belonging to 12 plant species, which were in turn distributed into 11 families. Only the Fabaceae family had two different species, *Tamarindus indica* and *Trigonella foenum-graecum*. Fabaceae family comprises the most species after Orchidaceae and Asteraceae, and the Fabaceae and Poaceae family plants have been reported to be the most used in traditional medicines in Ethiopia [47]. Legumes belong to the Fabaceae family, and contain the highest number of medicinal species, as also reported from Thailand [48]. In the present survey, although the number of plants used were few, it is not surprising that the Fabaceae family contributed two plants versus one each for the other plant families.

The FMP used ten formulations of which two were polyherbal and the other eight monoherbal. Five of the formulations used leaves. In other studies in various parts of the world, it has been observed that leaves constituted the majority of traditional/indigenous medicinal formulations [49-51]. Quite possibly, the FMPs prefer leaves for their abundance and also causing least damage to plants if collected carefully. For the same reason, usually roots and whole plants are avoided for that totally destroys the plant. Interestingly, eight of the plants used by the FMP were cultivated and apart from *Plumbago zeylanica*, three other plants like *Azadirachta indica*, *Justicia adhatoda*, and *Ocimum basilicum* were also planted sporadically around homesteads. Using whole plants of *Plumbago zeylanica* is an example of wild plant loss mostly through over-collection, for the plant has now become a rare and endangered species in Bangladesh [52].

Leaves of *Justicia adhatoda* were used by the FMP for treatment of bronchitis, asthma, fever, jaundice, and diabetes. Interestingly, the plant is considered an important Ayurvedic plant and has been used from time immemorial for treatment of cold, cough, asthma, tuberculosis, fever, jaundice, and diabetes [53, 54]. Leaves reportedly contain the alkaloids vasicine, vasicinone, vasicinol, and adhatodine [55]. Vasicine possesses bronchodilatory activity and is potentially useful for coughs [55]. In the Unani system of medicine, the plant is known as 'Arusa', and used for upper respiratory tract infections ('Dama') like bronchitis and asthma. The plant is known in Arabic as 'Hashishatus-
sual', the word 'sual' meaning cough. Drug made from the plant is known in Unani medicine as 'Munaffis-e-balgham', meaning expectorant and good for treating cold, cough, asthma, and chronic bronchitis [56]. The hepatoprotective effect of leaves and flowers of the plant has been demonstrated in Swiss albino mice with CCl_4-induced liver injury [57]. Significant reduction of blood glucose and glycosylated hemoglobin have been reported with methanolic extract of leaves in Balb-C albino diabetic mice. Moreover, the extract further demonstrated antioxidant effects [58]. Hyperglycemia induces oxidative stress in diabetes mellitus leading to further diabetes-induced complications [59]; as such, leaves of the plant can have dual protective and synergistic beneficial effects in diabetes. Taken together, a rural FMP, who on top was illiterate and aged, used a plant to treat diseases, and every use of the plant *Justicia adhatoda* has been validated in scientific reports.

Allium sativum (garlic) cloves were used by the FMP for heart and respiratory problems. Garlic has turned into a folk medicine for heart disorders; one or two cloves are swallowed in the morning during breakfast. It is also used as a folk medicine for respiratory problems. Cloves crushed in mustard oil are warmed and rubbed onto the chest for respiratory disorders. It has been shown that garlic can reduce hypertension, lower cholesterol and clot formation. The sulfur compound present in garlic, allicin, is believed to be responsible for these beneficial effects [60]. Garlic has been shown to have cardioprotective effects against sodium fluoride-induced cardiotoxicity in male albino rats [61]. Ayurveda places significant importance on garlic as manifested in the following properties of garlic mentioned in Ayurvedic texts: Anulomana – redirects the flow of apanavata downwards, Brmhana –nourishing tonic, anabolic, Dipana – enkindles agni, Hrdaya – heart tonic, Jwaraghna – reduces fevers, Kasasvasahara –relieves coughs & breathing problems, Krimighna – eliminates worms & parasites, Medhya – brain tonic, nervine, Rasayana – rejuvenative, Sara –eases passage of stool, Sulaprasamana – relieves pain & spasm in the gut, Vajikarana –aphrodisiac, Visahara – clears toxicity [62]. It can be seen that Ayurveda recognizes the importance of garlic in alleviating both heart (Hrdaya) and respiratory disorders (Kasasvasahara). Time-released garlic powder tablets have been shown to reduce acute respiratory disease (ARD) mortality in school children aged 7-16 [63]. Garlic contains the sulfur compound alliin, which is broken down by the enzyme alliinase to the unstable compound allicin. Allicin breaks down to produce a number of sulfides like diallyl sulfide (DAS), diallyl disulfide (DADS), diallyl trisulfide (DATS), methyl allyl disulfide (MADS), methyl allyl sulfide (MAS), ajoene, and vinyl dithiins (2-vinyl-1,3-dithiin, 3-vinyl-1,2-dithiin), which are beneficial for asthma [64].

Ipomoea aquatica was used by the FMP to treat gonorrhea, antidote to poisoning, to increase milk of nursing mother, low sperm count, and low semen volume. The anti-bacterial activity of leaf extract of the plant against *Escherichia coli* and *Salmonella typhi* have been reported [65]. However, the effect of leaves on the causative agent for gonorrhea – *Neiserria gonorrhoea* remain to be elucidated and is an important research point considering the rise of antibiotic-resistant gonorrhea. In New Zealand white rabbits, lactation was considerably improved when the plant was used as feed instead of guinea grass [66]. The plant is used as an aphrodisiac in North-East India [67]. In Tangail district of Bangladesh, the Garo tribe as well as the mainstream Bengali-speaking population use the leaves and stems for female infertility, and for sexual disorders [24].

Various parts of the *Tamarindus indica* tree were used by the FMP for treatment of different diseases. Ripe fruits were orally taken for indigestion. Dried bark was orally taken for loss of appetite and frequent thirsts. Leaves from young trees were orally taken for blood poisoning, pain, and blood dysentery. In Unani medicine, the fruit pulp is used as a digestive and carminative [68]. In traditional medicinal systems of Africa, the fruits are used as laxative in Sudan and the Sahel; bark and leaves are used to treat wounds in central West Africa; bark is used to treat diarrhea in West African countries but leaves are used for the same purpose in East Africa [69]. A recent review has concluded from the available scientific literature that pulp, leaf, stem bark, and root extracts of the plant possess analgesic/antiinflammatory properties, which have been attributed to various factors like inhibition of a number of biological processes including cyclooxygenase-2 (COX-2) expression, inducible nitric oxide synthase (iNOS), 5-lipoxygenase biosynthesis, and tumor necrosis factor-α [75]. Fruit extract (aqueous) has been found to have analgesic activity properties as demonstrated in acetic acid-induced writhing, hot plate and formalin tests in rodent models. Since the opioid receptor antagonist naloxone modified the pain alleviating effects of the extract, it was concluded that the aqueous extract possessed potential antinociceptive activity at both the peripheral and the central levels, which were mediated via activation of the opioidergic mechanism [71].

The FMP used *Azadirachta indica* (neem) for treatment of dengue and skin problems. Macerated leaf and bark were taken for dengue fever and stomach disorders. Seed oil was used topically to treat all kinds of skin disorders. Alternately, water in which leaves were boiled or soaked was also topically applied for skin diseases. The inhibitory potential of crude aqueous extract of neem has been reported for serotype 2 dengue virus replication in only 2002 [72]; the FMP had been using neem for the last 40-50 years to treat dengue. Biflavonoids (kaempferol-3-*O*-rutinoside, rutin, hyperoside, and epicatechin present in the plant have been identified through computational and experimental approaches to inhibit dengue virus (DENV) serine protease enzyme, i.e. NS2B-NS3pro (non-structural protein 2B-non-structural protein 3) [73]. A very recent review has described various parts of neem including neem oil to be useful not only for acne but also for other inflammatory and oxidative stress-induced skin disorders [74]. Neem has reportedly more than 400 phytochemicals. The various skin or skin-related disorders that neem is used for both in conventional and traditional medicines include acne, eczema, impetigo, ulcers, pustules, snake and scorpion bites, chicken pox, measles, scaly scalp, psoriasis, pruritus, dermatophytosis, leprosy, pediculosis, and scabies [75].

Syzygium aromaticum dry floral buds (clove) were used for toothache by the FMP. The analgesic and antiinflammatory effects of hydroalcoholic extract of cloves in mice has been shown in hot plate and formalin tests [76]. Clove oil contains eugenol, which can act as an analgesic and anesthetic with most benefits obtained during toothache [77]. Fruits of *Phyllanthus emblica* (amla/amloki) were used by the FMP for eye problems, coughs, skin disorders, and allergy. It is said that the fruits have more medicinal properties in the dry state and since fresh fruits are not available throughout the year, dried fruits are soaked in water and the water used. Fruits are rich in antioxidants and are considered to be more antioxidant than vitamin C [78]. Natural products, because of their antioxidant nature can be beneficial in skin disorders through their antimicrobial, wound healing, and antiinflammatory properties [79]. The role of amla phytochemicals in alleviating eye problems, skin disorders, and allergy is yet to be determined; however, antioxidants/antiinflammatory phytochemicals in amla can be beneficial in eye disorders like conjunctivitis and inhibit progress of diabetic retinopathy [80]. Seeds of *Trigonella foenum-graecum* (methi) were used by the FMP for diabetes. Numerous reports exist on the anti-diabetic properties of fenugreek seeds. One review mentions the beneficial effects of methi in diabetes as reducing blood glucose, suppress glycosuria, reduce total cholesterol, reduce triglycerides, and counter hypoinsulinemia; a phytoconstituent of methi, trigonelline may be responsible for some of these beneficial effects [81].

Zingiber officinale or ginger (along with *Plumbago zeylanica*) were used by the FMP for treatment of low semen density, diabetes, debility, jaundice, coughs, mucus, and rheumatic pain. Hexane fraction of chloroform extract of ginger reportedly increased sexual stimulation index in mice; plasma dihydrotestosterone levels were also increased via an increase in cyclic GMP [82]. *Plumbago zeylanica* is used in Ethiopia for treatment of erectile dysfunction [83]. *Zingiber officinale* is a well-known plant and is used in diet-based therapy because of its anti-diabetic action and its complications. Ginger can act by increasing insulin sensitivity/synthesis, protecting β-cells of pancreatic islets, reducing fat accumulation, decreasing oxidative stress, and increasing glucose uptake by the tissues, as concluded in a recent review. Furthermore, ginger can act as a protective agent against diabetic nephropathy and diabetic cataract through its antioxidant and anti-glycation agent effect [84]. Ginger has also been found to reduce hyperglycemia-induced oxidative stress, inflammation, and apoptosis and protected rats against diabetic nephropathy [85]. Another review on *Plumbago zeylanica* concluded that the plant has antioxidant, antiinflammatory, and anti-diabetic properties, all three properties being beneficial in diabetic patients [86]. Plumbagin has been identified as at least one of the bio-active principles. When administered to streptozotocin (STZ)-induced diabetic rats, the compound reduced blood glucose, increased activity of hexokinase and caused reduction in glucose-6-phosphatase and fructose-1,6-bisphosphatase, and raised GLUT4 mRNA and protein expressions; all these factors contributing to alleviation of hyperglycemia [87].

Plumbago zeylanica showed hepatoprotective effect against paracetamol-induced hepatotoxicity in male Wistar albino rats. Paracetamol-induced elevated serum parameters like alkaline phosphatase, total bilirubin, direct bilirubin, and serum creatinine were reduced and extensive hepatic damage caused by paracetamol was reversed by decoction of the plant as shown by regeneration of hepatic tissues [88]. Ginger also has hepatoprotective activity. The hepatoprotective effects of ginger have been reported against mercury-induced hepatotoxicity in adult female Wistar rats [89]. Acetaminophen administration caused hepatic damage in rats as manifested by elevated plasma alanine aminotransferase (ALT), aspartate aminotransferase (AST), alkaline phosphatase (ALP), arginase activities, and total bilirubin concentration. Ginger administration lowered these elevated parameters and further decreased oxidative stress and decreased the histopathological changes in liver induced by acetaminophen [90]. One can then reasonably expect that since *Zingiber officinale* and *Plumbago zeylanica* are giving similar anti-diabetic and hepatoprotective effects, the FMP's use of the two plants would result in a synergistic action in the alleviation of diabetes and jaundice. A similar synergistic effect is possible with rheumatic pain. Leaf paste of *Plumbago zeylanica* is applied to rheumatic painful areas in India and Sri Lanka [91]. Antinociceptive and antiinflammatory effects have been observed for leaves of the plant and the bio-active component has been identified to be plumbagin [92]. The use of *Zingiber officinale* against rheumatoid arthritis has also been extensively reviewed [93]. Gingerols and other un-identified compounds possibly account for the anti-arthritic effect of ginger [94].

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