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# *Tamarindus indica* – A Review of Explored Potentials

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**Abstract**

Tamarind (*Tamarindus indica*) is a potential medicinal plant bearing fruits and belonging to the leguminous family. It is found indigenous to subcontinent and has been widely cultivated in India since long period of time and commonly named as "imli" in Urdu and Hindi. Tamarind is a slowly growing, long lived massive tree that can attain the height of 24 to 30 m even under very unfavorable climatic conditions. Generally two different types of tamarind are found in our country among which, one is sweeter and the other is bitter in taste. Tamarind can grow in varied climatic conditions and environmental modifications. Appropriate warmth, proper sunlight and adequate moisture are the key ecological features for its maximum yield. Tamarind is known to have anthranilate, p-cymene, linalool, limonene, 6,10,14-trimethylpentadeca-5,9,13-trien-2-one, caryophyllene, diphenyl-ether, longifolene, vitamin C, dietary fibers, tartaric acid, tannin, pectin, cellulose, reducing sugars, carbohydrates, proteins and fats along with phosphorous, potassium, calcium, sodium, iron and zinc. Some important phytochemicals of this plant include phenolic compounds, cardiac glycosides, L-(-)mallic acid, tartaric acid, mucilage, arabinose, xylose, pectin, galactose, glucose and uronic acid. Tamarind has wide range of applications starting from culinary uses to religious purposes including medicinal potentials owing to excellent therapeutic effects. Tamarind has number of pharmacological activities because of anti-microbial and anti-oxidant effects and laxative properties. It is used to treat abdominal pains, deep wounds, intense fever, severe malaria, blood related diseases, dysentery, diarrhea and cardiovascular disorders. Tamarind is also used as anti-venomous, anti-diabetic, anti-asthmatic, hepato-protective, analgesic, anti-inflammatory and parasitic potentials.

**Key words:** Anti-venomous, hepato-protective, anti-inflammatory, p-cymene, cardiac glycosides, mucilage, dysentery, caryophyllene

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## 1. Botany

### 1.1 Introduction

Tamarind (*Tamarindus indica*) is a fruity plant belonging to the leguminous family [1]. It has been cultivated on the Indian subcontinent for so long and also reported to be indigenous there [2], where it is called as "imli" in Hindi and Urdu [3]. The genus Tamarindus has only a single species so it is monotypic taxon that is *Tamarindus indica* L. commonly "Tamarind". It grows wild in Africa as well as in Cameroon, Sudan, Tanzania and Nigeria. *Tamarindus indica* have different varieties and they can be separated into two i.e., sweet and acidic. Acidic type tamarind are generally found in many countries, thus easily grows into sunny, warm locations. While sweet type varieties are not easily available [4]. Tamarind self-pollinates easily but cross pollination is much more effective. Pollination that's occur by honeybees is attracted to the nectiferous flowers. *Tamarindus indica* is known by different names in the world. Its English name is "tamarind" based on Arabic name of that plant "tamr al-hindi" means the date of India.

Similar names are found all over Europe, e.g., Estonian, Swedish and Russian. In Italian and Spanish, it is called as "tamarindo" while "tamarin" is its Greek name. A slight variation of sounds is found in its Turkish name that is "demirhindi". Tamarind is a long-lived, slow growing, massive tree which reaches a height of 24-30 m (80 or even 100 ft) under favorable conditions [5]. In some regions, the reddish flesh type is consider as superior in quality and separated from the brown-fleshed type that is ordinary. There are two types of tamarinds that are sweeter in taste. Makham waan of Thailand is one of them and other is Manila Sweet administered by the United States, Department of Agriculture's Subtropical Horticulture Research Unit, Miami. The majority of essential oil is concentrated in leaves. In the leaf oil of tamarind, thirteen components were identified in which 24.4% limonene and 40.6% benzyl benzoate were most prominent [6].

**1.2 History/Origin**

It is believed that tamarind is indigenous to East Africa, but now grows broadly all around the Indian subcontinent, the West Indies and Southeast Asia. That's why it is also called as "date of India". Tamarind is related with the wedding of the Indian God Krishna which is celebrated by a feast in November, in Hindu mythology. The British in Goa kept a tamarind in one year in Victorian times, while wandering into the local quarter to keep them free from badgering. Since local people trusted that the new cases were possessed by malicious evil spirits. This earned the colonials the nickname "tamarind heads" or "Lugimlee", and it has fixed to this day. The history of tamarind is very old. Tamarind finds its mention between 1200 and 200 B.C. in Indian Brahmasamhita scriptures. During sixteenth century, it was introduced into America and it is widely grown in Mexico.

It was cultivated in Egypt before 400 B.C. It is suggested that tamarind brought to South East Asia from India by Arab and Persian merchants [7]. There is a superstition because of the caustic effect that fallen leaves have on fabrics in damp weather. So it is considered harmful to tie a horse or to sleep beneath the tree. Some African tribes honor the tamarind tree as holly. The tree represents the dwelling-place of the Rain God to certain Burmese, while some belief that the tree increases the temperature in its instant area. Hindus before eating the fruits of the mango may marry a tamarind tree to a mango tree. Tamarind bark soaked with corn in Nyasaland for domestic fowl and belief that, it will cause them to return home when they are stolen or stray. In Malaya, at the birth of an infant a little tamarind and coconut milk is placed in the mouth, while the fruit and bark are given to elephants to make them wise [5-8].

**1.3 Demography/Location**

Tamarind is grown in a variety of climatic and environmental conditions. Moisture, light and warmth are the key ecological requirements for its cultivation. So that's why it is grown unattended in the backyards or roadsides. Tamarind is sensitive to frost and drought resistant. Now in 54 countries of the world, tamarind is cultivated in which 18 are native and 36 are other countries. Tamarind is grown widely in the following countries: Cameroon, Cambodia, China, Central African Republic, Colombia, Cuba, Ethopia, Egypt, Guinea, Kenya, Afghanistan, Australia, Bangladesh, Brazil, Malaysia, Mexico, Pakistan, Sri Lanka, Thailand and India. But the world largest producer of tamarind is India [9]. The global statistics for the production of tamarind are hard to obtain. But it is considered that the world's largest producer of tamarind products is India. It is particularly abundant in the Indian States of Andhra Pradesh, Madhya Pradesh, Bihar, Tamil Nadu, Karnataka and West Bengal. In India tamarind naturally regenerates on forestlands and wastelands [9]. In recent studies, it is found that Thailand has become a major producer of tamarind, with sour and sweet cultivars in production. In Thailand, total planted area of tamarind is (105,785 ha) or 661,158 rai while the production area is (60,451 ha) or 377,816 rai. The important area for tamarind is the Western countries. Traditionally, India has exported processed tamarind pulp to these countries. The yearly fare to the US surpasses 10,000 tons earning about Indian Rs 100 million (US$ 2,165,000) [9].

**1.4 Botany, Morphology and Ecology**

Tamarind is evergreen, large, long-lived tree, 20 to 30 meter tall with a thick trunk upto 1.5 to 2 meter across and upto 8 meter in circumference. The trunk forks at about 1 meter above ground and is multistemmed with widely spreading branches that formed the rounded crown drooping at the ends. The bark is rough, scaly and brownish-grey in colour. Young twigs are puberulent and slender [10]. The leaves are pinnate and 3-6 inches (7.5 to 15 cm) in length each having 10-20 pairs of oblong leaflets half to 1 inch (1.25 to 2.5 cm) long and feathery foliage. Flowers attractive pale yellow or pinkish. Pedicel is 6-10 mm long slim articulate below the calyx. It is glabrous, bracts concave and 6-8 mm. long. Calyx is 1.3 cm long [11]. Flowers are inconspicuous, one inch wide, borne in small racemes. They are 5-petalled, yellow with red or orange streaks. The flower buds are markedly pink because of the outer color of 4 sepals. When the flower opens, sepals shed. Tamarind requires full sun and heat. It prefers deep loamy soil. Soil should be well drained. It grows in pH level around 4.5–9. It is a light depending tree and grows very slowly. It develops in tropical and subtropical regions. The ideal average temperature of tamarind is 25ºC. It is considered as an ideal tree for semiarid regions. It may tolerate 5 to 6 months in dry conditions but does not survive at low temperatures [12]. The tamarind tree shows resistance against heavy winds and can bear violent cyclones and typhoons [13].

**2. Chemistry**

Tamarind is an impressively sweet smelling plant. Tamarind ecotypes have been described on the basis of their flavor and other phenotypic characters. Mostly tamarind contains Limonene, linalool, p-cymene and anthranilate. However, the compounds like Longifolene, Diphenyl-ether, Caryophyllene and 6,10,14-trimethylpentadeca-5,9,13-trien-2-one are also present in its essential oils [14]. The tamarind is very important due to its nutritional value. It is also a good source of vitamin C, dietary fiber and an excellent source of folates [15].

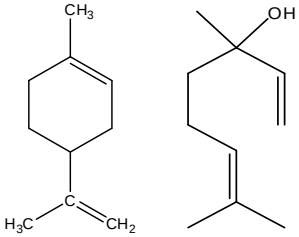
**2.1 Chemical Composition**

The tamarind fruit contains seeds and pulp. Both dry and ripened forms of its fruit mainly contain tartaric acid, pectin, tannin, reducing sugars, cellulose and fiber. The seeds also contain fat, protein, carbohydrates and sugars. Both pulp and seeds are good sources of calcium, potassium, phosphorous and contain other minerals like zinc, iron and sodium [10]. The other components of tamarind are also described in detail in this review. The fruit of tamarind is the most common and valuable part of the tamarind tree that is

used. The pulp constitutes 30 to 50% of the ripened fruit [16] while the shell and fibre accounts for 11 to 30% and the seed about 25 to 40% [16]. The dried tamarind pulp of commerce contains 8 to 18% tartaric acid (2, 3-dihydroxy butanedioic acid–$C_4H_6O_6$, a dihydroxy carboxylic acid) and 25 to 45% reducing sugars, of which 70% is glucose and 30% fructose [10]. Tamarind pulp is rich in minerals such as potassium 62 to 570 mg per 100 g; calcium 81 to 466 mg per 100 g, phosphorus 86 to 190 mg per 100 g and iron 1.3 to 10.9 mg per 100 g. According to some scientists, magnesium content is high 25.6 to 30.2 mg per 100 g, as is sodium 23.8 to 28.9 mg per 100 g, whereas copper (0.8 to 1.2 mg per 100 g) and zinc (0.8 to 0.9 mg per 100 g) are low [17]. It is also excellent in riboflavin and a good source of niacin and thiamin while it contains low amount of vitamin C and vitamin A [16].

**2.2 Phytochemistry**

Phytochemical studies of *Tamarindus indica* showed the existence of many active components, like phenolic compounds, L-(-)mallic acid, cardiac glycosides, mucilage, tartaric acid and arabinose, pectin, xylose, glucose, galactose and uronic acid. The ethanolic extract of *Tamarindus indica* exhibit the presence of fatty acids and many essential elements like calcium, arsenic, cadmium, iron, copper, manganese, magnesium, sodium, phosphorus, potassium, zinc and lead [18]. The leaf oil has thirteen components. The benzyl benzoate and limonene are most important components. Phytochemical studies of *Tamarindus indica* root bark exhibited presence of β-sitosterol, eicosanoic acid, n-hexacosane, 21-oxobehenic acid, octacosanyl ferulate and (+)-pinitol. The (+)-pinitol bioactive compound in this plant is investigated for the first time. The volatile components of fruit pulp were furan derivatives which are about 44.4% and carboxylic acid are 33.3% of total volatiles. The main fatty acids of seeds were oleic acid, palmitic acid, eicosanoic acid and linoleic acid. Unsaponifiable matter of *Tamarindus indica* seed oil showed presence of β-sitosterol, β-amyrin, compesterol and seven hydrocarbons. The aerial parts of the plant have showed the presence of acetic acid, tartaric acid and succinic acid, pectin, gum, tannins, sugar, flavonoids, alkaloid, sesquiterpenes and glycosides [19]. *Tamarindus indica* pericarp and seeds contain phenolic antioxidants such as procyanidin trimer, procyanidin dimer, procyanidin B2, epicatechin, apigenin and catechin along with naringenin, taxifolin and eriodictyol. The seeds of *Tamarindus indica* only constitute procyanidins, procyanidin hexamer, oligomeric procyanidin tetramer and procyanidin pentamer with relatively lower contents of procyanidin B2 epicatechin [4]. The pulp comprises of organic acids like acetic acid, tartaric acid, citric acid, malic acid, formic acid and succinic acid; also including amino acids; invert sugar are 25 to 30% proteins, pectin, fats, pyrazines (trans-2-hexenal) and thiazoles (2-methylthiazole, 2-ethylthiazole) as fragrant and seed polysaccharides are present with main chain containing of β-1,4-connected glucose molecules together with galactose and xylose (α-1,6); lipids with fatty oils; total protein and some keto acids. In the plant leaves, two triterpenes, lupeol and lupanone has been found [20].




Limonene Linalool

Table 1: Fatty acid composition of tamarind fatty acid oil [21]

| Fatty Acids | Composition % |
|---|---|
| Palmitic Acid | 14-20 |
| Stearic Acid | 6-7 |
| Oleic Acid | 15-27 |
| Linoleic Acid | 36-49 |
| Arachidic Acid | 2-4 |
| Behenic Acid | 3-5 |
| Linolenic Acid | 3-8 |

**3. Postharvest Technologies**

The harvesting time of tamarind fruit is in between January to April. In general proper storage practices include controlled temperature, controlled relative humidity, circulation of air and adequate ventilation and avoiding product mixtures. It is advised to store tamarind by making its pastes or in juice form. It can be stored by mixing it with sea salt and putting it into earthen ware vessels and jars [22]. The pulp was stored in different commonly available packaging materials like polypropylene, porcelain pot, polyethylene and aluminium foil box at room temperature (35°C) and low temperature (5°C). The changes in different physicochemical characteristics like pH, titratable acidity, reducing sugar and moisture contents were recorded at 15 days interval during 45 days of storage. During room temperature storage, it was found that the titratable acidity, moisture contents and reducing sugars increased in all packaging materials while pH decreased. In polyethylene and aluminium foil box, the extent of increase was found less dominant. These parameters has same trend at low temperature but the extent of increase was less as compared to room temperature (35°C).

Low temperature storage was found favorable for its preservation. Polyethylene and aluminium foil box was found more suitable for tamarind storage [23]. The important step in packing is grading for color, size, shape, maturity and defects. The effectiveness and efficiency of sorting lead the quality standard of the product and packing lines [24] which in turn finds the marketability of the product. Manual sorting is also done but it is costly in terms of time and labor. The absence of trained workers is also the reasons that manual arranging may become ineffective and cause harm. Electro-optical technique is one of the most

successful and practical technique for nondestructive quality evaluation and arranging of agricultural products [25]. This technique is used to detect shape, size, color, uniformity, external defects, disease and foreign materials. It has been utilized for postharvest grading for an expensive assortment of agricultural items including tamarind. Tamarind natural product is a non-climacteric [26], so that's why it will not ripen any further after harvest.

**4. Processing**

Tamarind like many other plants is consumed in a variety of ways and used for various purposes. In addition to fresh pods, other common processed forms of tamarind include fruit, which is used for culinary purposes. It can be stored in a variety of ways but traditional methods for preserving tamarind include storage in salt [22]. Tamarind can be stored as a separated dry pulp or with the shell. The firmly bundled pods can be stored at 20°C for some weeks. The mature tamarind pulp is compressed and packed in plastic bags or palm leaf mats. The paste form of tamarind can be stored at 20°C for an effective period of time. It can be stored and frozen for one year and refrigerated for upto six months. The pulp remains good for about one year, under dry conditions after that it becomes almost black. Especially in humid weather, the pulp becomes sticky and soft as pectolytic degradation occurs and absorbed moisture [27]. Pod yield neutralizes at about IS years and continues for upto 50 or 60 years. By finger pressing when a loose and hollow sound is produced, it means tamarind fruits are mature and ready for harvesting. The shell becomes brittle when the pulp shrinks with maturity. The maturity of the fruit is also indicated by the testa color change.

However, it is not always the only indication that whether the fruits are ready for harvesting, because the testa color changes slowly as the pods ripe. Even on the same tree, individual fruits mature at different times, forming harvesting selective. At different stages of ripeness, pods are harvested according to their uses. Usually immature green fruits for flavoring are harvested prior to use. The ripe fruits of sour tamarind are usually gathered, in most countries by shaking the branches and collecting the fruits that have fallen while the remainder is left to fall naturally when it ripe. The price of sweet tamarind fruits are higher in market, hence they are picked by hand carefully. To increase the marketability and to avoid damaging of the pods of both types sour and sweet, clipping harvesting should be exercised [28]. Normally, fruits are left to ripen on the tree, so that about 20% moisture content is reduced before harvesting. The pods may remain hanging on the tree for almost one year, if un-harvested even after flowering and sometimes to the next flowering period [29]. Fruits are often harvested for immediate processing by pulling the pod from the stalk, which is left with the long, longitudinal fibers attached. In humid climates, fungi and beetles readily attack ripe fruit, and that's why they should be harvested before fully ripe.

**5. Value Addition**

Tamarind is of immense food value. Tamarind is used in preparing charu, pickles and juices. Number of medicinal uses linked with tamarind like digestion and maintaining body temperature. Beside these, tamarind seed powder is also used as cattle feed. Tamarind contains two main types; sweet and sour. Sweet tamarind is usually harvested in fully ripened form and mostly consumed fresh, while the sour type is processed into a range of value added products [30]. Some of the most common products produced from tamarind include pulp, juice, powder, pickles, chutney, sugar coated candies, sauces and tamarind kernel powder (TKP). TKP is an important sizing material for textile industry and jute. Tamarind seeds are gaining importance as a rich source of valuable amino acids and proteins. In India, pulp is eaten with sugar and even in raw form. The pulp is removed from pod and used to make jams, juices, candies and syrups. Tamarind leaves are also an important source of food and used as flavoring agent. Tamarind pulp powder is one of the most important food products. It is prepared by the following steps like concentrating, drying and then milling the pulp. Tamarind is also used to prepare Ade which is tamarind refreshing drink. Ade is mainly used in Philippines and some tropical American countries. Inspite of wide range of industrial and domestic uses, tamarind is also used in number of pharmaceutical products and medicines owing to excellent therapeutic potentials.

**6. Uses**

*Tamarindus indica* (Fabaceae) is a common tree, mainly found in West Africa, with a good potential to contribute to local health care. It is also used as traditional medicine. The fruits are used as febrifuge or laxative throughout the Soudan and Sahel ecological zones. Tamarind leaves and bark are often used in the treatment of wounds, especially in the areas of central West Africa. The bark of tamarind is used to treat diarrhoea in West Africa, while in East Africa the leaves are used for this purpose.

**6.1 General Uses**

Tamarind has many uses generally ranging from culinary to religious applications. There are a number of curious beliefs associated with the historical use of tamarind as few African tribes consider the *Tamarindus indica* as sacred tree [31]. Beyond the ritualistic uses, tamarind has been used in cooking for many years. It is a versatile herb that is used in a wide range of dishes, sauces and juices. It is used in making jams, prickles and candies. The dry fruit is broken, the fibers and pulp are separated by removing the seeds. At about 20°C, pods are stored for many weeks. Pulps can be stored at 10°C for 4 to 6 months by packing in polythene of high density. For extending the storage period upto one year, it can be mixed with salt. By boiling the pulp of tamarind in water, tamarind juice is prepared and filtering the juice for pulp removal before pouring into bottles and sealing. Tamarind concentrate is easily dispersible in water and can be used for plenty of purposes, which include

preparation of sauces, ketchups, soft drinks and as a souring agent in number of dairy products.

**6.2 Pharmacologic Uses**

Tamarind is known to have strong anti-microbial and anti-oxidant properties. Researches have shown that the oil contains potent anti-cancer and anti-viral properties. Anti-oxidants are an important part of maintaining health and fitness. Tamarind may be a very important source of these essential components. Acetonic and methanolic extracts of *Tamarindus indica* exhibit important anti-microbial activities against *Klebsiella pneumonia*. The anti-bacterial activity was checked via agar disk diffusion method. The activity was compared with standard anti-microbial Piperacillin and Amikacin [32]. Strong anti-oxidant activity is also shown by ethyl acetate extracts prepared from the seed coat. The methanolic extract of leaves of *Tamarindus indica*, shows effective adaptogenic and anti-histaminic activity in animals.

**6.2.1 Anti-Microbial Activity**

A wide range of anti-bacterial activities are shown by *Tamarindus indica*. Methanolic extract of leaves of *Tamarindus indica* was studied for anti-bacterial activities against *Burkholderia pseudomallei*. Its name in in-vitro inhibitory potential recommended more animal studies to conclude the role of *Tamarindus indica* in curing melioidosis [33]. The anti-microbial activity of concentrated extracts (ethanolic, acetone, aqueous extract) was analyzed by finding the diameter of zone of inhibition against both gram-positive and gram-negative bacteria and fungi by using the paper disk diffusion method. They have potent anti-microbial activity against *Salmonella typhi*, *Salmonella paratyphi*, *Staphylococcus aureus* and *Bacillus subtilis* [34]. Other studies recommended that *Tamarindus indica* has strong anti-microbial activity and the water, petroleum ether and ethanol extract of *Tamarindus indica* ripe fruit were checked for anti-bacterial activity against gram-negative and gram-positive species [35]. Aqueous and methanolic extract of *Tamarindus indica* flower and 30 other medicinal plants possess anti-microbial activity [36]. During preliminary screening, methanolic extracts showed anti-bacterial activities. The results concluded that *Tamarindus indica* extract have strong in-vitro anti-bacterial activity tested against bacteria [37].

**6.2.2 Anti-Oxidant Activities**

Seeds and pericarp of *Tamarindus indica* are known to contain various phenolic contents that possess strong anti-oxidant potentials. Methanolic extract of this plant was tested and found active against cancer as potential chemo-protective agent. Different extracts of this plant were found active against linoleic acid emulsion system and showed good anti-oxidant strength even upto 64.5 to 71.7% that was even higher than synthetically manufactured anti-oxidants like butylated hydroxyl anisole and ascorbic acid. Ethanolic extract of seed of *Tamarindus indica* showed strong potentials in terms of higher peroxide values while ethanolic extract of fruit pulp exhibited anti-oxidant and hypolipidemic activities in hyper cholestrolemic hamsters. Even the ethanolic extract of seed coat of *Tamarindus indica* was found effective in DPPH scavenging activities using ascorbic acid as standard. Furthermore, ethanolic extract exhibited anti-oxidant effects through thiocyanate and thiobarbituric method [38].

**6.2.3 Laxative Properties**

Fruit of *Tamarindus indica* has extensively been used as potential laxatives in traditional system of medicines as it contains appreciable concentration of potassium acid, malic acid and tartaric acid. Its fruit is generally given to young children in breakfast in order to control severe constipation and long term stomach disorders. This laxative medicine is used as sweetmeat in various regions of the world that is also termed as "Bengal". It is more preferably used by people of Senegal Wolof. Bengal is formed by unripened fruit of tamarind that is mixed with lime juice and honey [39]. In few countries such as Mali and Bamako, different types of drinks are prepared from the pulp of tamarind. In Burkina Faso, fruits of tamarind are dipped and squeezed with little salt and water before using as a drink [40]. Tamarind is also used as laxative agent when ingested along with mashed leaves with potash in northern Nigeria [41].

**6.2.4 Abdominal Pain**

Abdominal pain is a complaint, not a specific disorder it means a painful abdomen. It is may be due to various causes, including diarrhea or constipation. In Nigeria, to treat constipation, soaked fruits are also eaten by rural Fulani. When tamarind leaves are used, it is difficult to judge the cause of abdominal pain. In East Africa, it is considered that it may be due to diarrhea. In West Africa, leaves are known as a laxative agent and macerated fresh bark of the young twigs was used both to relieve abdominal pain and as a purgative agent. Prepared extract of roots are used for curing painful abdomen or stomach ache. In East Africa and in Burkina Faso mainly, it is used for the treatment of abdominal pain and related disorders. In Benin, fresh bark of young stems is macerated for 24 hours and given orally for abdominal pain or as a purgative agent.

**6.2.5 Wound Healing**

*Tamarindus indica* is often used for curing the wounds, cuts and abscesses. Leaves and bark of *Tamarindus indica* are mostly used on the wounds when applied in the form of a powder or decoction or as a poultice, separately or with other species. In Dakar market of medicinal plant, bark of tamarind is mainly sold for the purposes of wound healing. While other plant parts of tamarind are used in healing medicine, like pod husks, fruit or gum. A decoction of leaves of *Tamarindus indica* is also an important agent to clean wounds which are due to the infections of Guinea worm [42].

**6.2.6 Fever and Malaria**

In Madagascar; tamarind fruits are known as a febrifuge. Malaria is cured with leaves of tamarind in Ghana. The tamarind fruit pulp is used as a laxative and febrifuge [43].

**6.2.7 Effect on Blood and Cardiovascular System**

In Bangladesh, fruits of *Tamarindus indica* were analyzed for their actions on diastolic and systolic blood pressure, lipid profile and humans body weight. In hyper cholestrolemic hamsters, the pulp crude extract effects were studied on levels of atherosclerotic lesions and lipid serum. Extracts of tamarind has much potential in reducing atherosclerosis risk in human beings. In another report on hamsters, it was found that hydro alcoholic extract of the pulp of tamarind affect the inflammation mediator system [44].

**6.2.8 Antivenom Activities**

In traditional medicines of India, different plants are used as treatment against snakes bite. The effect of *Tamarindus indica* seeds extract was studied in a report for its enzymatic and pharmacological activities. Extract of tamarind seeds inhibited protease, phospholipase A, l-amino acid oxidase, hyaluronidase and 5′-nucleotidase enzyme activities of venom in dosage dependent mode. The *Tamarindus indica* extract stabilized the β-chain degradation of human's fibrinogen and indirect hemolysis affected by venom. The extract extended the time of clotting and myotoxic effects like hemorrhage and edema induced by venom whilst different doses of extracts were given, hence for serum therapy, tamarind extract is potential alternative [45].

**6.2.9 Anti-Diabetic Activity**

*Tamarindus indica* seeds aqueous extract had a strong anti-diabetogenic activity in diabetic male rats that are induced with Streptozotocin. *Tamarindus indica* seeds aqueous extract was given to both severe and mild diabetic rats and hyperglycemia was lessened notably and measured by checking levels of blood glucose in a fasting condition. In the same way, by measuring the different contents of cholesterol, it was found that hyperlipidemia level was significantly reduced. This rat model also explains basis of ancient Indian herbal therapy [46].

**6.2.10 Anti-Asthmatic and Hepato-Protective Activity**

Some innovative analysis has reported that *Tamarindus indica* exhibits hepato-protective and anti-asthmatic effects. *Tamarindus indica* leaves methanolic extract showed outstanding adaptogenic, anti-histaminic and mast cell stabilizing activity in laboratory animals. *Tamarindus indica* (Caesalpiniaceae) protective effect was checked by injecting paracetamol in rats. Aqueous extracts of different parts of *Tamarindus indica*, such as 350 mg per kg of leaves, fruits and 700 mg per kg of unroasted seeds were directed and they showed remarkable hepato-regenerative effects that were observed at some parameters [47].

**6.2.11 Analgesic and Anti-Inflammatory Activity**

Traditionally, the bark of *Tamarindus indica* is used for treating the pain. This work was proved scientifically by using satisfactory models of animal screening, such as induced acetic acid (AA) writing test at 50 mg per kg dose and hot plate test. As compared with other extracts, petroleum ether extract exhibit notable increase in time of reaction. Phytochemicals preliminary test exhibited presence of triterpenes and sterols in the extract. So it is considered that these compounds are responsible for analgesic activity of tamarind. Ginger leaf juice of tamarinds is used for treating the bronchitis. The bark is dried, pounded and added to water for treating eye inflammation [48].

**6.2.12 Proteinase Inhibitions**

In the seeds of tamarind tree, proteinase inhibitors were abundantly found. They have high inhibitory activities against human neutrophil elastase. By using ammonium sulfate and acetone precipitation activity, a serine proteinase inhibitor denoted PG50 was purified. They showed that PG50 favored affected release of elastase by a stimuli factor which activates the platelet and this may form inhibition selective on platelet activating factor (PAF) receptors. The bio-insecticidal investigation involved both in vitro and in vivo studies. In vitro study of *Tamarindus indica* seeds (TTI), a proteinaceous inhibitor showed a significant activity about enzymes of insect digestive systems from different orders of Diptera and Coleoptera. In a in-vivo bio-insecticidal study, larvae were given artificial diets that are TTI-incorporated. The TTI concentration added to cause the 50% death rate (LD50) was 3.2%. The addition of more than 4% TTI caused 34% death rate roughly. From jakari strain (*Clostridium chauvoei*) neuramidase activity was decreased in a dosage established manner by partly purified *Tamarindus indica* methanolic extract [49].

**6.2.13 Anti-Helminthes or Parasitic Activity**

For the extraction of Guinea worms, tamarind leaves are used. It is also used for the treatment of wounds which are due to the parasite. The macerate of seeds and fruits is used as vermifuge. In some parts of Tanzania, tamarind root and leaves extracts is used to treat hookworm (ankylostomiasis) [50].

**6.2.14 Dysentery and Diarrhea**

Tamarind is used for the treatment of dysentery and diarrhea. Dysentery is caused by an intestine infection. It is a type of diarrhea containing blood or mucus. The patient has risks of death or dehydration, if diarrhea is not treated properly. To treat diarrhea, tamarind pulp with lemon juice is mostly used. The root of tamarind is used to treat dysentery [51].

**7. Summary**

*Tamarindus indica* L. or Tamarind of the family Fabaceae, subfamily Caesalpinioideae, is an important food in the tropics. Every part of *Tamarindus indica* including root, wood, bark, leaves and fruits has either medicinal or nutritional value, with a number of commercial and

industrial applications. Tamarind is a multipurpose tree having its uses in every field, either medicinal or nutritional. This plant is indigenous to tropical Africa but it has been introduced worldwide in more than 50 countries for its food flavoring, essential oil applications and in traditional medicines. Mostly tamarind contains oleic acid, palmitic acid, eicosanoic acid and linoleic acid. It also contains many minerals like calcium, copper, iron, manganese, phosphorus and zinc. It is also a source of Vitamin B, Vitamin C and carotene. The extent of these chemical constituents varies depending on its types and cultivation conditions. Tamarind is an essential component of several industrial applications. Tamarind is also well known for its anti-oxidant, anti-microbial, anti-inflammatory and anti-fungal activity that has been reported from various plant parts. More uses and applications of tamarind by-products are continuously added. Further research on maximizing yield and optimum preservation and oil extraction methods are needed.

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