Chapter 19
Tamarindus indica: Phytochemical Constituents, Bioactive Compounds and Traditional and Medicinal Uses

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19.1 Introduction

19.1.1 Tamarind Plant Origin

The tamarind tree (*Tamarindus indica* L.) is occupant to the dry savannas of tropical Africa (Fig. 19.1). The tree was acquainted with Asia by Arab dealers with its pleasant, acidic tasting natural product. Later on the tamarind achieved the new world from West Africa. In Caribbean and Latin America the plant is abundantly valued, as in Africa and Asia, for the succulent, sweet-acrid mash that fills its units. In any case, India remains the main nation misused the tamarind broadly, more than 250,000 tons are reaped there every year, 3000 tons of which are sent out to Europe and North America for use in meat sauces and refreshments (Gunasena and Hughes 2000). The tamarind tree is chiefly developed as a decorative and for shade however has been utilized both as a starvation sustenance and for restorative purposes.

The tamarind tree is a wonderful, fine finished tree and it makes a fantastic shade tree in extensive scenes. Usually planted out in the open parks and as a road tree in tropical. For all intents and purposes all aspects of the tree (wood, root, leaves, bark and organic products) has some an incentive in trade and especially in the subsistence of rural individuals. The name tamarind gets from the Arabic name tamarhind which implies date of India (Morton 1987).

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Fig. 19.1 Tamarind tree. (Source: https://commons.wikimedia.org)

19.1.2 Tamarind Plant Description

Tamarindus indica is an evergreen tree, up to 24 m in stature. It is an extensive evergreen tree with an incredibly lovely spreading crown. Leaves alternate, compound, with 10–18 sets of inverse leaflets; petiole and rachis finely haired, midrib and net veining pretty much clear on both surface. Blossoms appealing light yellow or pinkish, in little, lax spikes about 2.5 cm in width. Flour buds totally encased by two bracteoles, which fall early. Natural fruit is a pod, indehiscent, subcylindrical, 10–18 × 4 cm, straight or bended, smooth, corroded darker; the shell of the pod is brittle and the seeds are inserted in a sticky palatable pulp. Seeds are 3–10, around 1.6 cm long, sporadically molded, and testa hard, gleaming and smooth (Bhadoriya et al. 2011; El-Siddig et al. 2006).

19.1.3 Distribution of Tamarind Plant

Tamarind plant exists broadly all through tropical Africa, where it is as often as possible planted as a shade tree. The tamarind tree is presently generally spread all through semi-arid South and Southeast Asia. It is as of now developed in home nurseries, farmlands, on roadsides, on basic grounds and on a constrained plantation scale in India and Thailand. While tamarind tree is acquainted with the American mainland from Asia over the pacific with the Spanish. It is now produced commercially in different states of Mexico. Also tamarind grows throughout the Caribbean islands such as Jamaica and Cuba. Likewise there are business plantation in Brazil and some Latin American nations (El-Siddig et al. 2006).

19.1.4 Adaptation

The tamarind trees are well adapted to semiarid tropical conditions, although they do well in many humid tropical areas of the world with seasonally high rainfall. Young trees are very susceptible to frost, but mature trees will withstand brief periods of 28 °F without serious injury. Dry weather is important during period of fruits development (Gunasena and Hughes 2000).

19.1.5 Pests Infestation

Tamarind trees are at risk to assault by an expansive number of creepy crawly insect. The significant pest which assault tamarind incorporate shot gap borers, toy beetles, leaf nourishing caterpillars, bag worms, mealy bugs and scale insects. A portion of these bugs assault the flower buds and the growing fruits and seeds, while others harm the fruits amid storage (Coronel 1991).

19.2 Chemical Compositions of Tamarind Fruits

The most extraordinary attributes of tamarind fruit is its acidity which is because of for the most part tartaric acid (2,3-dihydroxybutanedioic acid, $C4H6O6$) extending from 12.3% to 23.8% which is unprecedented in other plant tissues (Ulrich 1970). Albeit tartaric acid happens in other sour fruits, for example, grapes, grapefruit, and raspberries, yet it is absent in such high sums as in tamarind.

Sweet tamarind cultivars are grown in Thailand, where tartaric acid content varied from 2.0% to 3.2% and the sugar content was as high as 39.1–47.7% (Feungchan et al. 1996). Total sugars and tartaric acid content were reported to be 41.2% and 8–18% respectively in sour tamarind cultivars (Duke 1981; Ishola et al. 1990; Shankaracharya 1998).The brown edible pulp is high in sugar (about 20–30%), where the reducing sugars are the main sugars (glucose and fructose) and the sucrose level is low in comparison to the level of reducing sugars, it is pleasant acid taste due to the presence of tartaric acid (Siliha and Askar 2000). The reducing sugars content are in the range of 25–45% (Ishola et al. 1990; Duke 1981). The moisture content of the tamarind fruit is in the range of 17–35% (Shankaracharya 1998;

Feungchan et al. 1996; Coronel 1991). Protein content is in the range of 2–8.79% (Shankaracharya 1998; Feungchan et al. 1996; Coronel 1991; Ishola et al. 1990).

Fiber content is in the range of 2.2–18.3% (Shankaracharya 1998, Feungchan et al. 1996, Coronel 1991; Ishola et al. 1990). Small amount of ascorbic acid as reported that varies from 2–20 mg/100 and no any detectable amounts of phytic acid (Ishola et al. 1990). Tamarind pulp is rich in potassium, phosphorus, calcium and less iron (Saka and Msonthi 1994; Ishola et al. 1990; Marangoni et al. 1987; Bhattacharyya et al. 1983). The total ash content is in the range of 2–3.9% (Shankaracharya 1998, Feungchan et al. 1996, Coronel 1991; Ishola et al. 1990).

19.3 Industrial Uses of Tamarind

19.3.1 Fruit Pulp

Tamarind is grown basically for its pulp (Fig. 19.2) which is utilized to set up a refreshment and in flavor sweets, curries and sauces, and is made into jelly and syrups. Jugo or Fresco de Tamarindo is a most loved drink in numerous Latin Americans nations and is produced industrially in some of them (James 1981).

Tamarind extract is used as one of the ingredients in preparing a traditional Sudanese fermented drink (Hulu Mur) to provide acidity and enhance the perception of flavors (Agab 1985). Tamarind powder is one of the convenience foods developed from tamarind by modern food processing methods. It is conveniently used as a souring agent in the culinary preparation of rasam, sambar, puliogare mix, sauces and chutney (Manjunath et al. 1991; Ahmed 2009).

Fig. 19.2 Tamarind fruits

Tamarind extract from the fruit is utilized as alternative for phosphoric acid, citrus extract and different acids that are added to soft drinks. Drinks containing the concentrate have an enhanced shelf life, of realistic usability, because of low pH, likewise flavor profile comparable to or superior to refreshments improved with aspartame (Linda 1995; Zoblocki and Pecore 1996; Mustafa 2007). Rich aroma tamarind extract has been used widely as beverage drink in Egypt and India (Askar et al. 1987).

Tamarind juice concentrate (TJC) is a convenience product easy to disperse and reconstitute well in hot water. The concentrate is hygienic and can be stored well for long periods. It was made by extracting the tamarind pulp in boiling water, filtered and concentrated under vacuum, to a jam-like consistency and then filled in bottles or cans. Also pickles and pastes can be made from tamarind fruit (Shankaracharya 1998).

The extraction and processing techniques for the preparation of canned tamarind pulp and the manufacture of tamarind soft drinks have been reported. Wine and vinegar production from tamarind fruit was also reported by. A process for making drinks, syrup, juice, liquor and solid extracts based on tamarind were developed. Good quality ready-to-serve (RTS) beverage, syrup, and concentrate were prepared from tamarind fruits. All these products have been satisfactory preserved and stored at 33 °C for over 180 days without affecting their quality (Kotecha and Kadam 2003).

19.3.2 Tamarind Seeds

The major modern use for tamarind seeds (Fig. 19.3) is the maker of tamarind bit powder which is an essential material for the jute and textile. The seeds additionally are picking up significance as a rich wellspring of protein and amino acids

Fig. 19.3 Tamarind seeds

(Anon 1984). Likewise seed bits have been utilized as foods in scarcity periods either alone or blended with grain flours. Also seed kernels have been used as foods in times of scarcity either alone or mixed with cereal flours. Polysaccharides obtained by extraction from the kernel of tamarind seeds form mucilaginous dispersions with water and possess the characteristics property of forming gels with sugar concentrates, as do fruit pectin's. However, the tamarind polysaccharides fruit pectin are capable of forming gels over a wide pH range, including neutral and basic pH conditions (Bhattacharyya et al. 1983). Several products made from tamarind fruits pulp and seeds e.g. tamarind juice concentrate, pulp powder, kernel powder, tartaric acid, and pectin.

19.4 Phytochemical and Bioactive Constituents of Tamarind

Many Foods are rich in phytochemical compounds which play an important role in the prevention of diseases. The antibacterial activities from plant origin have been linked to the presence of phytochemicals, these compounds contain secondary metabolites such as alkaloids, saponin, tannin, terpenoids and phenolic compounds which have been associated with antimicrobial, antioxidants and anti-inflammatory properties (Daniel 2006). Researchers have investigated for possible alternative of synthetic antibiotics by natural ones, many plants could be usefully for this purpose for example black pepper, curly leaf, coriander, onion, ginger, bay leaf and tumaric (Bag and Chattopadhyay 2015).

Tamarind plant contains many bioactive compounds in the leaves, seeds, bark, pulp and flowers with the useful effects to the human health and the opportunity of application in the pharmaceutical industry. Several studies have been carried out about tamarind compounds in its different parts, which have a significant role as antimicrobial, antidiabetic, anti-inflammatory, control of satiety, prevention of obesity and other chronic diseases (Menezes et al. 2016).

Bark of tamarind is a good source of tannin compounds e.g. proanthocyanidin. So the bark has the properties of antiallgeric, antimicrobial, antibiotic, antityrosiase, antioxidant and analgesic (Menezes et al. 2016).

Tamarind seed could be considering as a good source of protein and starch, sulfur amino acids and phenolic antioxidants. It has antiflammmatory activity, also it has impact on the control of satiety. It has a great potential for treatment or prevention of obesity and gastro protective effects (Menezes et al. 2016). Extracts from seeds were found to be enriched in xyloglycans which is an active agent in a cosmetic and/or pharmaceutical product for tropical usage for the skin and/or other exposed parts of the body (Pauly 1999).

Leaves of tamarind plant being consider as source of protein, lipid, fiber and vitamins like thiamine, riboflavin, niacin, and ascorbic acid and B- carotene. Also composed 13 essential oils like benzoate, benzyle, pentadecaol and hexadecaol. Leaves have an antiemetic activity and also have the property of protection the liver (Leng et al. 2017; Menezes et al. 2016). Recent research findings showed that, the tamarind leaves warm water extracts have higher zone inhibition against *Pseudomonas putida.*

Stem bark of tamarind plant contains flavonoids, cardiac glycosides, alkaloids, saponins and tannins. Tea made from stem bark used for sore throat. The stem bark has many bioactive activities such as spasmogenic, analgestic, antimicrobial and hypoglycemic.

Tamarind fruit pulp contains vitamins, minerals, many acids, amino acids, invert sugar (25–30%), pectin, protein, fat, some pyranzines, and some thiazoles. Also it has alkaloids, flavonoids, saponins and tannins. Tamarind pulp has many bioactivities such as hypolipidemic activity, antioxidant, antifluorose, analgesic, hepatoregenerativa and antispasmodic (Menezes et al. 2016).

Early research studied the bacteriostatic effect of tamarind. Ethanol extraction from tamarind fruit was the most effective inhibitor against all tested organisms in soft drinks (Alian et al. 1983). A recent research was carried out on antimicrobial activity of ethanol and water extracts of tamarind fruit pulp against some pathogenic bacteria. The research findings revealed that, the ethanol extracts produce strong antibacterial activity against *E.coli, Klebsiella pneum* A and *Pseudomona aeruginosa* (Daniyany and Muhammad 2008). While tamarind pulp hot water extracts have good antimicrobial activity against some bacteria such as *Aeromonas hydrophila* and *Hafnia alvei* (Adeniyi et al. 2017). The antibacterial activity of tamarind fruit pulp against some bacteria propose that, there is a scientific basis for their utilization in traditional medicines for the treatment of some bacterial infections.

Tamarind wastes such as tamarind fruits shells and tamarind seed coat extracts also have antioxidant like (−)-epicatechine (Ganesapilla et al. 2017).

19.5 Traditional Medicinal Uses of Tamarind Fruits Pulp

Numerous therapeutic employments of the tamarind were accounted for, where the pulp has been utilized by numerous individuals in Africa, Asia and America (Kuru 2014). Tamarind uses are all around perceived as refrigerants in fevers and as diuretic and carminatives. Alone or in a blend with lime juice, nectar, milk, dates flavors or camphor, the pulp is viewed as powerful as a digestive even for elephants and as a solution for biliousness and bile issue.

For quite a long time in numerous nations, the pulp of the fruit has been used as an antiscorbutic, in Brazil as diaphoretic, emollient, urgative and for hemorrhoids. In Eritrea, the pulp is sold for looseness of the bowels and jungle fever; in Indonesia for hair nourishment; in Madagascar for worms and stomach issue; in Mauritius as a liniment for stiffness; in Tanganyika for snakebite; in Sri Lanka for jaundice, eye illnesses and ulcer and in Cambodia for conjunctivitis (Duke 1981). The pulp is said to enhance loss of hunger, it is accessible economically in tablet shape in Thailand for the decrease of overabundance weight. In Southeast Asia, the pulp is recommended to neutralize the impacts of overdoses of chaulmoogra (Hydnocarpus anthelmintica Pierre), which treat leprosy (Gunasena and Hughes 2000). In Colombia, the tamarind pulp is powerful in destruction of vermin in residential animals, through the use of pulp with butter and different compounds (Morton 1987).

19.6 Future Prospects for the Utilization of *Tamarindus indica*

19.6.1 Medical Field

The aphrodisiac potential and reproductive safety of profile of aqueous extract of *Tamarindus indica* pulp in male Wistar rates was evaluated. The results showed that, the aqueous extract of *Tamarindus indica* possessed aphrodisiac together with spermatogenic potential (Rai et al. 2018). Research results showed that, the benefits of tamarind fruit extract in colon carcinanogensis might be related to it is hepatic protection against lipid peroxidation (Martinello et al. 2017).

19.6.2 Food Industry Field

The fermentation process of tamarind seeds substantially decreased phytic acid content, tannin content and trypsin inhibitor activity. While the phosphorus content which is the major mineral in the seed was increased (Olagunju et al. 2018). Mucilage has been isolated from tamarind seed (Reyes et al. 2017). The mucilage has great functional properties such as solubility, water holding capacity and oil holding capacity which increased with the temperature. Additionally, the swelling index. Emulsifying capacity of tamarind mucilage expanded and emulsifying soundness diminished when the heaviness of powder of tamarind seed mucilage/oil volume expanded. In this manner mucilage of tamarind possibly can be utilized in food processing as practical, cheep and ecological benevolent hydrocolloids rather than business hydrocolloids. Now globally there is a great interest for natural antioxidant sources like seeds, leaves and fruits to be utilized as food preservatives instead of using synthetic preservatives. The phenolic content of tamarind seed is a promising source of natural antioxidant in the food industry (Reis et al. 2016). Pectin from tamarind pulp was found to have significantly higher antioxidant activity as compare to apple pomace pectin, citrus peel pectin and commercial pectin. So tamarind pectin could be utilize as an excipient for food and pharmaceutical industry (Sharma et al. 2015).

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