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A Review on Utilization and Bioactive Applications of Tamarind Waste

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Abstract

Tamarind is a nutritive and bioactive rich fruit with various health benefits. The seeds from tamarind are the major waste of tamarind fruit. The presence of tannins and other pigment constituents present in seed test can make seed unfit to consume, however it is edible after processing like soaking and boiling in water. Tamarind by-products can also be used as raw material to form of adhesive, dietary fibre, polysaccharide, and tannin preparation. Seeds are of greater importance and can be used as an alternative source of protein, and are besides better source of fatty acids and high in various essential minerals, like P, Ca, Mg and K. Anti-inflammatory, anti-oxidant, anti-microbial and anti-fungal activities have been recognized from various parts of the tamarind plant. Further, tamarind is broadly used in conventional medicine in numerous cultures and for various applications. In this chapter nutritive composition, methods of processing and utilization of tamarind by-products has been descried.

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1. Introduction

Since decades, medicinal plants have been the backbone of traditional and natural medicine (Bhadoriya et al., 2012). Because of the ethnomedicinally relevant chemical components that may contribute to medication discovery, plant preparation has traditionally been passed down from generation to generation. Drugs obtained from nature are pharmacologically impact and possess little or no adverse effects, therefore, research on medicinal plants has recently risen all around the globe (Sofowora, 1993). Medicinal plant research is becoming more popular as a result of their ability to cure a wide range of diseases, as well as their lower costs and reduced incidence of adverse effects when compared to manufactured medications (Amir et al., 2016). India and Thailand are the largest producers of tamarind in Asia, followed by Indonesia, Bangladesh, Thailand and Sri Lanka. Additionally, tamarind is mostly produced in Mexico and Costa Rica in America. Although tamarind is broadly used by local people in Africa, no commercial production has been observed thus far. Kenya, Zambia, Senegal, Gambia and Tanzania, among Africa's minor producers (El-Siddig 2006). India is the only country throughout the world that produces tamarind as a commercial crop fruit. India produces the most tamarind pulp (300,000 tonnes) and exports the most of it (140,000 tonnes), followed by Thailand. 45% of tamarind trees are only grown for their edible and medicinal fruit pulp (Narina, et al., 2018). Other Asian nations produce and export tamarind on a far small scale than Thailand and India. The tamarind sour variety is the most common, accounting for 95 percent of total world production. Thailand is the largest producer of sweet tamarind in the world. India has long exported processed tamarind pulp to Western countries, primarily Europe and the Arab world, as well as the USA (Bagula et al., 2015). *Tamarindus indica* comes in a variety of flavours and can be classified as acidic or sweet. The fruit's sweetness and sourness at the same time is distinctive, and it's often utilized in cooking. Its many parts, such as roots, wood, bark, and leaves, have nutritional and medicinal benefits in addition to the fruit (Sudharsan et al., 2016; Reis et al., 2016). The branched stem can reach a height of 12-25m, with dense foliage that prevents sunlight from passing through, preventing other plants from growing at its base. The flowers are yellow-orange, often striped or speckled with purple-red. The leaves are alternate, formed of 7 to 12 pairs of leaflets, and are light green in colour (Silva et al., 2000). The mature fruit has brown bark, while the immature ones have a greenish bark. The tamarind plant has pendulous pods with a woody coat, slightly curved, 5 to 15 cm long, and each pod contains 4 to 7 seeds. When the fruits are fully ripe, they are filled with a fibrous brown or yellowish pulp that is edible and has an acid but pleasant flavour; the seeds grow firm and lustrous; the pod's bark becomes flimsy, the pulp narrows, and the bark can be readily broken by hand (Okello et al., 2018).

Tamarind seeds are shiny, flattened, and have orbicular to rhomboid shape. It is a dicotyledonous plant. The seeds are firm and range in colour from red to purple brown. A parchment-like membrane lines the seed chambers. The tamarind fruits consist of seed as by product made up of endosperm or kernel (70-75%) and testa or seed coat (20-30%) (Shankaracharya, 1998). Tamarind seeds account for around 40% of the total weight used as commercial or non-commercial uses in pharmaceutical and food applications (Bagula et al., 2015). The tamarind fruits consist of fruit pulp as product for direct consumption is prepared through purification process followed by boiling water, then filtering and concentrating the obtained liquid in a heated bath. The tamarind pulp concentrate is used both for the preparation of beverages with refreshing properties and for therapeutic uses (Feungchan et al., 1996). The composition of tamarind seeds is remarkably same as cereal seeds, making them a great food source (Okello et al., 2017).

Tamarind kernel powder is used in paper, textile, and jute industries. Tamarind seeds are rich in crude fibre, protein, carbohydrate and minerals such as potassium and magnesium shown in table 1 (Ajayi et al., 2006). Protein content is high in the seed and kernels (13-20%), whereas the seed coat is strong in tannins (20%) and fibre (20%) (El-Siddig et al., 2006). Protein present tamarind seeds can help individuals meet their daily protein requirements of 23.6 g/100 g as non-conventional protein sources. Furthermore, the relatively high crude fibre content is nutritionally significant, as fibre aids in the maintenance of gastro-intestinal tract's health (Ajayi et al., 2006). The tamarind is also associated with gelling forming components ranged from 46 to 48 percent (Kumar and Bhattacharya, 2008). Tamarind seed also contains protein, lipids, mineral salts, and tannins which is more concentrated in outer shell of seed (Ferrara et al., 2019). The albumins and globulins proteins in tamarind seeds with high biological value with balanced amino acid compositions such as leucine, valine, and isoleucine, as well as sulphurous amino acids, such as methionine and cysteine (Bhattacharya et al., 1994). The tamarind seeds consist of sugars such as mannose and glucose, with a small amount of inositol. Pentose sugars also present in seed which comprises up to 20% of soluble sugars (Marangoni et al., 1988). The young seeds contain a sweet-tasting amber oil that is mostly composed of palmitic, oleic, linoleic, and eicosanoic fatty acids, as well as stigmasterol, sitosterol, and carotenoids (Ferrara et al., 2006). The presence of hydroxybenzoates, catechins, proanthocyanidins, and flavonoids such as taxifolin, apigenin, eriodictyol, luteolin, and naringin in tamarind seeds increased the antioxidant activity The tamarind epicarp is also rich source of polyphenols with protective effects against oxidative damage caused by lipid peroxidation, mutagenesis, carcinogenesis, and arteriosclerosis (Sudjaroen et al., 2005).

Nutritional composition	Percentage	Reference
Protein	13-20%	(El-Siddig et al., 2006)
Fiber	20%	(El-Siddig et al., 2006)
Tannins	20%	(El-Siddig et al., 2006)
Pentose	20%	(Marangoni et al., 1988)
Gelling component	46-48%	(Kumar and Bhattacharya, 2008)
Linolenic acid	46.5% of total fatty acid	(Toungos, 2019)
Oleic acid	27.2% of total fatty acid	(Toungos, 2019)

Table 1: Nutritional composition of Tamarind.

2. Processing of tamarind by-products

To completely separate the outer testa from the kernel in order to avoid it from having negative consequences including constipation, depression, and gastrointestinal inflammation, the seed is roasted or soaked in water (Chandini et al., 2008). The microstructure of a tamarind seed cross section reveals the dicotyledons that are fused together and encased by the seed coat or testa. The latter is made up of an inner integument and an exterior integument, which are lengthy cells that are parallel to the outer surface. The seed coat varies in thickness from 100 to 250 microns. Storage parenchymacells, which are generally ovaloid in shape, are found in the cotyledons. Cotyledons are made up of granules of complicated carbohydrate encased in a protein matrix. After roasting, the cotyledon and seed coat separate, making it easier to remove the seed coat. The thermal characteristics and behaviour of cotyledons and seed coat are expected to differ because the mineral content of the seed coat is higher than cotyledon. This will lead to varying degrees of expansion and contraction, which aid in the detachment of the seed coat from the seed. Separation of individual cotyledons is likely to occur if the roasting severity is increased further (Chandini et al., 2008). Seeds are extensively cleaned to remove the adhering pulp and to float away diseased seeds that are partially hollow. Seeds are parched at 150°C for 10 to 15 minutes to remove the testa or seed coat. To avoid colour development, a drop in molecular weight, and a corresponding loss in viscosity of the isolated gum, the temperature and time of heating should be kept to a minimum (Anon, 1976). To remove testa and dirt, the parched seed is put into a grain cleaner with beaters and an exhaust fan (Whistler and Barkalow, 1993).

2.1. Tamarind seed powder

Seeds are hammer milled to break more brittle seed shell, which is then removed by screening or air separation to produce high-quality tamarind kernel powder. The decorticated seed is then processed to the necessary fineness by crushing it in an impact grinder and then pulverizing it (Kumar and Bhattacharya, 2008). Lo ng-term storage of tamarind kernel powder, especially in a damp environment, might cause it to deteriorate. After proper fumigation, a dry environment in moisture-proof containers is suggested for tamarind kernel powder (TKP) storage. To prevent enzymic degradation, combine the powder with 0.5 percent sodium bisulphite before packing (Kumar and Bhattacharya, 2008; Anon, 1976). In textile and paper sizing, weaving and manufacturing jute goods, as well as textile printing, tamarind kernel powder is utilised as a carbohydrate source and as an adhesive or binding agent (Khoja & Halbe, 2001). The major component of the tamarind kernel is gum, which has viscous properties and can form gel, making it suitable for usage as a rheology modifier in culinary preparations. It can also be used as an adhesive in the paper industry (Prabhu et al., 2011). To a large extent, tamarind kernel powder is used in the vegetable and food processing sectors. Tamarind xyloglucan, often called as "tamarind gum," is used in food to thicken, stabilise, and gel (Gupta and Devendra 1988). To provide a soluble polysaccharide called as tamarind gum or Jellose, the ground tamarind seed contains a reddish-brown powder. The skeleton of D-glucan is bound in (1, 4) with residues of xylose, arabinose, and galactose in this polysaccharide known as xiloglucan; it is totally soluble in water; it is stable in the acid pH range; and it reacts positively with an iodine solution (Gidley et al., 1991). In humans, xiloglucan is a fibre that increases viscosity in the small intestine and is fermented in the colon by symbiotic bacteria; the similarity to cellulose indicates that xiloglucan is easily degraded by cellulase enzymes (Ferrara, 2019). Processed tamarind seed powder is soaked in water to make tamarind gum. The water soluble dye can be extracted from the tamarind seed by simply boiling it in water and then used to colour cotton and silk garments. Tamarind seed dye is used in craft business to highlight the originality of products. When compared to the solution dye, making the tamarind seed dye into a powder can make it highly convenient (Tepparin et al., 2012).

2.2. Tamarind seed oil

Tamarind seed is dehusked and decorticated into a roller beater machine to obtain tamarind seed oil using solvent extraction method. In this method, tamarind seeds placed in a thimble-holder before placing it into soxhlet apparatus followed by the mixing of solvent hexane into round-bottomed flask as the solvent for extraction and the flask is attached to the heating mantle (set at 100 ºC temperature). To start this process, continuous flow of water is opened. During the process, the sample is filled with condensed solvent from a flask with a circular bottom. A syphon aspirates the whole contents of the thimble-holder and empties it back into the flask, transporting the extracted analytes in the bulk liquid when the liquid reaches an overflow level. Up till complete extraction is accomplished, this procedure is repeated. Tamarind kernel oil is abundant source various fatty acids like oleic acid, palmitic acid, and linoleic acid. The fatty acid content of tamarind kernel oil is 46.5 percent linoleic, 27.2 percent oleic, and 26.4 percent saturated fatty acids (Toungos, 2019). The pectin in tamarind seed polysaccharide has a high methoxyl concentration (6.8%–7.37%), which enhances gel strength and heat stability (Chawananorasest et al., 2016). Tamarind seeds are golden yellow in colour and contain 7% to 9% oil. An illuminant and varnishing agents are an amber oil derived from tamarind seeds (El-Siddig et al., 2006). Tamarind seed oil is used to keep gums and teeth healthy. It aids digestion by healing intake and increasing bile production. It contains a high amount of dietary fibre, which helps to decrease cholesterol levels. It raises healthy cholesterol while lowering bad cholesterol. Because it contains antibodies, it protects against infections of the skin, intestines, and urinary tract. Aids in the management of diabetes. It prevents the pancreas from enlarging insulin-producing cells, resulting in improved insulin sensitivity. It also aids in the natural management of blood sugar levels (Yadav et al. 2016). It also helps to lower blood pressure and slow down the progression of vascular atherosclerosis. It also aids in cell counting and signalling and is beneficial to cell membranes. It includes polyphenols, such as flavonoids, which can help lower cholesterol levels in some cases. The tamarind fruit released total cholesterol, LDL "bad" cholesterol, and triglycerides in a trial with high-cholesterol hamsters (Yadav et al. 2016). The antioxidants in this fruit can help protect LDL cholesterol from oxidative damage, which is a major cause of heart disease. The high saponification value of tamarind oil (221 mg KOH/g oil) suggests the presence of many smaller molecular weight fatty acids, allowing the oil to be used in the production of shaving creams and soaps (Ajayi et al., 2006).

2.3. Tamarind pigments

Tamarind plant waste and by-products are used to convert it into powder shown in figure 1(Gutta Tamarind). Gutta tamarind, which serves as a barrier in place of wax or wax, is nothing more than powdered (extracted) tamarind seeds. In other words, gutta tamarind is a wax or wax substitute that is frequently applied during the batik process. The wax coating will prevent the dye from penetrating the fabric, as is mentioned in the passage that follows. The wax layer that creates the lines imprinted on the fabric will instantly freeze in the air. The waxy coating will stop the colour from soaking into the fabric (Salma, 2013). The gutta tamarind technique is an evolution of the conventional batik method known as "cold batik" because it avoids the use of a heater, which is a common practise when using clay or batik gutta tamarind. The investigation of Gutta Tamarind as a painting technique intends to create technical advances, and this tamarind gutta can be employed as an aesthetic element in a painting (Lestari et al., 2019). The study method involved creating painting techniques using the gutta tamarind media as a colour barrier and showcasing different artistic innovations made possible by extensive investigation and exploration of its constituent ingredients as a replacement medium for brush strokes in paintings (Yuningsih et al., 2021). Various pigments such as anthocyanin can be extracted from tamarind using methanol. To prevent the hydrolysis and destruction of acyl groups in the anthocyanin structure, the unripe fruits of red tamarind are completely macerated, extracted with acidified methanol (Methanol: HCL, 99:1, v/v), and then incubated overnight in a shaker at low temperature (4°C). The mixture is centrifuged at 5000 rpm for 10 minutes at 4°C after 12 hours of incubation, and the clear supernatants are then collected. The supernatant is then concentrated under reduced pressure on a rotary evaporator below 40°C. Finally, the extract is sent for purification to eliminate impurities (Rampriya and Kumar, 2019).

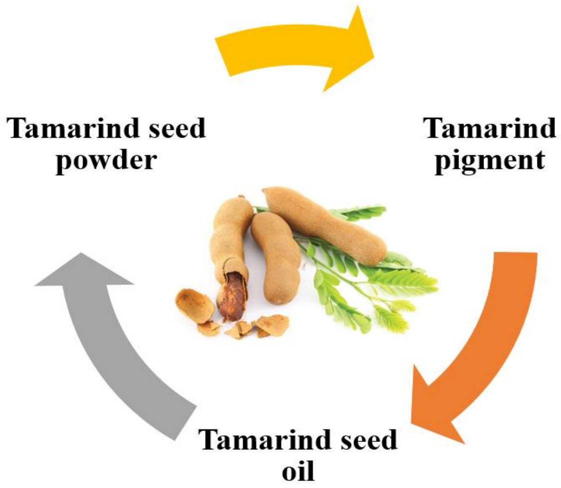

Figure 1: Graphical representation of processed tamarind byproducts.

3. Utilization of tamarind waste and by products

3.1. Utilization tamarind waste and byproducts in bakery products

Tamarind kernel powder has higher lysine than soya bean powder (Gunasena and Hughes, 2000) and can be used to replace wheat in bakery products (Kumar, and Bhattacharya, 2008). Tamarind kernel powder can be potentially used in bakery products to enhance their antioxidant properties, nutritive value, sensory attributes and the shelf life (Chakraborty et al., 2016). The effect of tamarind seed powder on the phytonutrient content, physico-chemical properties, antioxidant qualities, and sensory properties of various foods such bread, biscuits, and fruit juices were studied. It was found that the biscuits contain fats with ideal sensory characteristics to mask the astringent taste and flavour of tamarind seeds, which is not very appealing to most consumers; the fruit contains pectin in addition to a very tasty taste, which can mask astringency without affecting the antioxidant effect of tamari; and the fruit contains pectin in addition to a very tasty taste, which can mask astringency without affecting the antioxidant effect of tamarind seeds. The hardness, freshness, and thickness of the biscuits are all affected by the addition of seed crushed to cereal flour, but the flavour and taste are unaffected. Seed flour can be used up to 15% of the time in bread and biscuits (Jesionkowska et al., 2009). Nowadays, there is an increasing demand for development of nutraceutical products from waste products generated by the agricultural and food processing industries, such as stems, seeds, peels, stems, and plant leaves, because they have significant amount of phenols, anthocyanins, flavonoids, carotenoids and vitamin C, and could be used as cost-effective natural antioxidant sources for cosmetic, food, and pharmaceuticals industries (Natukunda et al., 2016).

3.2. Utilization tamarind waste and byproducts in dairy products

The incorporation of tamarind kernel products in dairy products (figure 2) have resulted in increase in sensory attributes and consumer acceptability. Tamarind kernel products, when combined with yoghurt, may give a variety of health benefits as well as prevent people from a variety of ailments (Abiraami et al., 2021). Another study determined the effectiveness of tamarind kernel powder, a low-cost agro-based product, as an adsorbent to remove COD, turbidity, and total solids from a dairy industry wastewater, finding that maximum removal of COD, total solids, and turbidity was achieved at an optimum dosage of 6g/l, and maximum removal of COD, total solids, and turbidity was obtained at an optimum rapid mixing contact time of 15 minutes and an optimum slow mixing contact time of 40 minutes, depicting that the use of tamarind kernel powder, as a coagulant to remove total solids, COD, and turbidity in dairy industry wastewater seems to be an economic alternative over traditional methods (Patel, and Veena, 2019). Tamarind seed husk is used as a source of tannin to beneficially manipulate rumen fermentation. Tamarind seed husk tannin can improve the efficiency of in vitro microbial protein synthesis. (Bhatta et al., 2001).

3.3. Utilization tamarind waste and byproducts in meat and meat products

Some animal species, such as ruminants and pigs, can digest the starch complex in tamarind flour, and it is commonly used as feed (Khairunnuur et al., 2009). In chicken feeding tests, the results were not satisfactory: the chicks fed tamarind diets gained more weight and retained more water than the control; additionally, the weight of some organs, pancreas, and intestines increased, indicating a state of suffering for the liver and kidneys, attributed to the indigestible nature of the polysaccharide, rather than the indigestible nature of the polysaccharide (Mohamedain et al., 1996). Tamarind seed extracts have a high antioxidant capacity, lowering lipid peroxidation in vitro, and antibacterial activity; thus, the seed is used as a fortifying food because of its nutritional value and low-cost nutraceutical content (Silva et al., 2014; Trill et al., 2014). The polysaccharides extracted from the dough obtained from the tamarind kernel were found to be an excellent medium for the production of lipids and penicillin via the bacterial route, and tamarind gum, which is used as a thickener and stabiliser in many foods, can be used successfully to increase the conservation time of fish due to its ability to form gels even in cold water, in the form of film (Singh et al., 2011). According to the studies, tamarind seed flour can be utilised as a rice bran substitute in broilers with no significant influence on percentage of liver weight of broilers (Sjofjan et al.,2020). It can be noted that using tamarind seed flour as a substitute for rice bran in the feed has no influence on the proportion of Broiler Heart. The candies acid seed flour has no effect on growth and percentage of heart weight rise in broilers. This is due to the fact that the nutritious content of tamarind flour still meets the requirements of broilers (Nurma et al., 2014). It was also discovered that replacing bran in broiler feed with tamarind seed flour had no influence on the proportion of broiler gizzard. The gizzard is one of the digestive organs that belongs to a variety of species, including chickens, reptiles, and many types of fish. The size of gizzard varies depending on the size of the food consumed; the larger the food consumed, the greater the constriction in the gizzard, resulting in a large size gizzard (Suryanah, 2016). Tamarind seed, a common agro-industrial waste with high calorific and nutritional properties, has a significant amount of tannin, an anti-nutrient. It has been discovered that detannification of tamarind seed by microbial technique is more appropriate than conventional physico-chemical approaches. Supplementation of fermented tamarind seed can improve the health of broiler chicken. Thus, fermented tamarind seed can be used as alternative nutrient source in broiler chicken diets without any detrimental effect consequences (Jana et al., 2015).

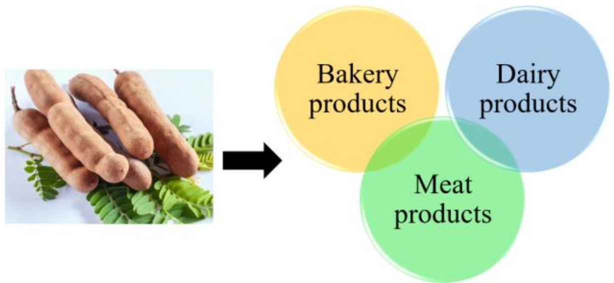

Figure 2: Utilization of tamarind waste and by-products in food.

4. Conclusion

Tamarinds are high in fibre, protein, and tannins (anti-nutritional factors). Tamarind proteins have a good amino acid profile and can be used to supplement legumes and cereals that are lacking in cystine and methionine. As a result, they can be utilized as a less expensive protein source to help alleviate protein deficiency, which is common in many underdeveloped countries. To diversify the livelihood and food security all produced products are to be used fruitfully. Tamarind by-products can be potentially used in various food industries due to their nutritive value, but utilization of protein, fatty acid and minerals of tamarind by-products is still limited. The identification and characterization of tamarind by-products still needs to be studied.

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