Chapter 21

Antimicrobial and Antioxidant Potential of *Tamarindus indica* Plant Extracts against Microbial Infections

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ABSTRACT

Tamarindus indica belongs to the family Leguminosae, commonly known as tamarind (imli). This plant belongs to the tropical and subtropical regions. The extracts of leaves, fruits, stem and bark of this plant contain various chemical compounds or secondary metabolites such as flavonoids, glycosides, alkaloids, tannins, terpenoids, phenol, steroids, and proteins. The presence of these secondary metabolites confers the antimicrobial, anti-oxidative and laxative properties of this plant. It is used to treat the abdominal pain, infectious wound, diarrhea, constipation, severe malaria, pyrexia and the cardiovascular defects. Besides this, Tamarind plant is also used as anti-ulcerative, anti-inflammatory, anti-diabetic, anti-cancerous, hepatoprotective, anti-venom, and as an analgesic. Historically, the fruit and other extracts of this plant used as herbal drug for the treatment of wounds or for curing the abdominal pain. Today, as many microbes are getting resistant to a wide range of medicinal drugs, so we cannot overlook the importance of natural plants and their extracts. The purpose of writing a comprehensive chapter on Tamarindus indica plant is to explore the medicinal and pharmacological properties of this plant.

KEYWORDS
Drugs, Antimicrobial resistance (AMR), Alternative, *Tamarindus indica*, Treatment

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INTRODUCTION

The use of plants and their preparations for medical purposes dates back to ancient times, virtually spoken word (Holt et al., 2023). Plants possess a number of medicinal and pharmacological properties because these plants have been used as an anti-venom (Ekele, 2023), anti-ulcerative (Malli et al., 2019), anti-cancerous (Singh et al., 2020), antidiabetic (Hung et al., 2012), antibacterial (Swamy et al., 2016), antiviral (Denaro et al., 2020), antifungal (Uma et al., 2017), insecticidal (Boulogne et al., 2012), antiparasitic (Wink, 2012), and as anthelmintics (Zaman et al., 2017). These properties of medicinal plants are due to the presence of numbers of secondary metabolites and chemical components. These are very beneficial for mankind in a variety of ways, including treatment of diseases (Souza-Fagundes et al., 2002; Sen and Samanta 2015). Recently, failure to treat and control infectious diseases along with resistant bacteria are well-established worldwide. Researchers are focused on natural plant products as an alternative for disease control. Plants have provided a variety of drug components used for medicinal purpose. Exploiting plants for medicinal purpose exclusively found in countries like China and Japan. Some African countries have also breakthrough in area of using plants as a potential source of new drugs. These countries include Egypt, Ghana, Faso, Burkina, Zimbabwe, Zambia, Nigeria, and South Africa (Abdullahi, 2011).

Tamarindus Indica commonly known as Tamarind, belongs to the dicotyledon family Leguminosae and the subfamily Caesalpiniaceae (Khanzada et al., 2008). The tamarind tree, used for medicinal purposes, is a long-lived evergreen tree found in different countries i.e., Egypt, Africa (tropical region), and Asia (Bhadoriya et al., 2011; Aly et al., 2023; Ghaly et al., 2023). Its extract obtained from pulp, seeds, and leaves of the tamarind tree, and its fruits are the most valuable parts and

have been reported in several pharmacopoeias. The leaves have proven incredible to protective activity linked with the presence of polyhydroxylated compounds, many of them of flavonoid nature (Joyeux and Escalona et al, 1995). Leaves also contain rich sources of protein, fiber, fat, and vitamins i.e., thiamine, riboflavin, ascorbic acid, niacin, and B-carotene (El Siddig et al., 2006). Tartaric, citric, and maleic acids, Potassium bitartrate, pectin, water, gum, and parenchymatous fiber are rich in the pulp of the Tamarind tree (Nyadoi and Abdullahi, 2004). WHO (World Health Organization) report indicates that the fruit of Tamarind have most of the essential amino acids (Glew et al., 2005; Kuru, 2014). Reportedly, different parts of the Tamarind tree have shown anti-microbial, anti-viral, anti-fungal, anti-oxidant, anti-diabetic, anti-asthmatic, anti-venom, anti-malarial and anti-inflammatory activity (Bhadoriya et al., 2011; Kuru, 2014; Ghaly et al., 2023; Usman et al., 2023). However, not much information is available on peel and seed extract of Tamarind fruits.

Table 1: Antibiotic drugs, their mechanism of action and resistance developed against these antibiotics

Class	Example (and producing organism)	Molecule target	Resistance mechanism		Reference
			Endogenous resistance	Positive-function resistance	
Penicillin	Amoxicillin Semi-synthetic derivative of penicillin (*Penicillium crysogenum*)	Cell wall synthesis: penicillin binding proteins	Multiple changes in penicillin binding proteins, PBPs (*Streptococcus pneumoniae*)	Penicillinases, B-lactamase inhibitor	Truman, 2019 Silver et al., 1993
Cephalosporins	Cefacetrile Semi-synthetic derivative of cephalosporin C (Acremonium crysogenum)	Cell wall synthesis: penicillin binding proteins	Multiple changes in penicillin binding proteins, PBPs.	Cephalosporinase, B-lactamase inhibitor	Truman, 2019 Silver et al., 1993
Glycopeptides	Vancomycin (*Amycolatopsis orientalis*)	Cell wall synthesis: D-Ala-D-Ala termini of lipid II		Membrane protein: ligase with altered specificity	Truman, 2019 Silver et al., 1993
Macrolides	Erythromycin (*Saccharopolyspora erythraea*)	Protein synthesis: 50S ribosomal subunit		Methylation of 23S rRNA; inactivating enzymes; active efflux	Truman, 2019 Silver et al., 1993
Chloramphenicol	Chloramphenicol (*Streptomyces venezuelae*)	Protein synthesis: 50S ribosomal subunit		Antibiotic-inactivating enzymes; efflux system	Truman, 2019 Silver et al., 1993
Lincosamide	Clindamycin Semi-synthetic derivatives of lincomycin (*Streptomyces lincolnensis*)	Protein synthesis: 50S ribosomal subunit		Efflux and inactivating enzyme	Truman, 2019
Tetracyclines	Tetracycline (*Streptomyces aureofacians*)	Protein synthesis: 30S ribosomal subunit		Active efflux; ribosome "protection"	Truman, 2019 Silver et al., 1993
Aminoglycosides	Kanamycin (*Streptomyces kanamyceticus*)	Protein synthesis: 30S ribosomal subunit	Mutation linked to *nek* or *rpsQ* clinical relevance unknown	Antibiotic-inactivating and modifying enzymes	Truman, 2019 Silver et al., 1993
Quinolones	Norfloxacin	DNA synthesis: DNA gyrase, DNA complex	Single mutation in *gyrA* or *gyrB*; permeability changes		Truman, 2019 Silver et al., 1993
Fluroquinolones	Ciprofloxacin	DNA synthesis: inhibition of DNA gyrase and Topoisomerase IV	Target site gene mutations	Efflux pump, modifying enzymes	Truman, 2019 Mancuso et al., 2021
Diaminopyrimidines	Trimethoprim	Folate synthesis: inhibition of dihydrofolate reductase	Single mutation lowers affinity relative to substrate; derepression	Resistant dihydrofolate reductase; metabolic bypass	Truman, 2019 Silver et al., 1993
Sulfonamides	Mafenide	Folate synthesis: inhibition of dihydrofolate reductase		Resistant dihydrofolate reductase;	Truman, 2019 Mancuso et al., 2021

Flavonoids, Polyphenol, and other organic acid metabolites are found in the extract of Tamarind leaves, which contribute to its anti-microbial activity. These compounds have antimicrobial activity in many other plants (Chitra, 1999). Tamarind paste has an anti-microbial activity which is the reason why Tamarind paste is frequently used to treat wounds (Gupta et al., 2014). Due to its antimicrobial, anti-fungal, and anti-septic effects, it has extensive ethnobotanical uses in many areas of Latin America such as Puerto Rico, Mexico, and Trinidad and Tobago, and in other countries like Asia and Africa (Khare et al., 2004; Muthu et al., 2005; Melendez et al., 2006; Lans et al., 2007).

Keeping in view the significance and its role as an anti-bacterial, anti-viral, and anti-fungal along with other anti-inflammatory and anti-oxidative properties, the researcher begins to think about its use in medicinal drugs as in the modern era many bacteria develop anti-microbial resistance (AMR) against a wide range of antibiotics.

Chemical Drugs used against Bacteria and Resistance Develop against it

Bacteria, a natural foe of the humans and other animals since from the past, is the root cause of a number of diseases in animal as well as in humans. As knowledge expands and new discoveries are being made, humans become capable of dodging bacterial infections through the discovery of many chemical components that are being used to produce a number of chemical drugs called antibiotics. An antibiotic is defined as a substance used to kill or inhibit the growth of microorganisms. However, the development of new synthetic methods and techniques resulted in the modification of definition and now antibiotic is defined as a substance produced by microorganisms or similar substances that in low concentration inhibit the growth of microorganisms (Giguere et al., 2006; Szczepanowski et al., 2009). Among other classes of antimicrobials, antibiotics are comparatively less harmless to the host. They are small molecule having molecular weight less than 2000 (Kaiser, 2009). Antibiotic have both the bactericidal and bacteriostatic effect as well (Grenni et al., 2018). It can restrict the growth of bacteria by interacting with the cellular components of bacteria thus limiting the growth of bacteria. In general, antibiotics restrict the growth of bacteria in a variety of ways. Some of the antibiotics and their mechanism of action is discussed in the Table 1.

Discovery of antibiotics proves blessing for the mankind. It was used in the treatment of many diseases and infectious wound. As the knowledge about the antibiotics spread, people start using it blindly. Due to excessive misuse of antibiotics without understanding its mode of action, bacteria develop resistant against antibiotics (Muteeb et al., 2023). This phenomenon of bacterial resistance is also referred as antimicrobial resistance. Antimicrobial resistance (AMR) develops when microorganisms evolve to such extent that they become resistant to several antimicrobial medications, such as antibiotics, which are used for treatment (Tang et al., 2023). AMR is widely referred as "Silent Pandemic" and is a problem where immediate action should be taken and managed more effectively and should not be considered as future situation (Founou et al., 2021). If no preventive measure taken, it is estimated that by 2050, AMR could potentially become the world's major cause of death (O'Neill, 2016). AMR is one of the leading causes of potential failure of several antibiotics. Some of the antibiotics against which bacteria develops resistance are discussed in the table 1.

Why there is a Need of *Tamarindus indica* Plant Extracts and its Antimicrobial Activity

As in the modern era of advancement in medicine field that leads to the development of many new antibiotics, the bacteria are also becoming quite resistant to certain antibiotics due to excessive misuse of antibiotics. AMR is becoming a major issue as many bacteria have developed a resistant mechanism to overcome the effect of certain antibiotics. They have developed certain degradation enzymes like β-lactamase that causes the lysis or breakdown of β-lactam ring, by active efflux of antibiotics, receptor modification, conjugation, transduction, transformation and mutation in the genetic makeup. AMR is a growing trend and it is uncertain to overlook the antimicrobial use in near future. Now the use of natural plants as an alternative source to treat certain bacterial infection is increasing. According to World Health Organization (WHO), the medicinal plant could be the best alternative to obtain a wider variety of drugs (Suntar, 2020). Since then, many plants are being discovered to treat bacterial infection.

Antimicrobial Activity

Antibacterial Activity

Tamarindus indicus phytochemical analysis indicates the presence of various chemical compounds like flavonoids, alkaloids, glycosides, terpenoids, tannins, steroids, phenol, proteins and various other compounds. It possesses antibacterial activity due to the presence of these chemical compounds that have shown broad spectrum antibiotic effect against wide range of harmful bacteria. Methanolic extracts of *Tamarindus indicus* leaves have potent antibacterial activity against *Burkholderia pseudomallei*. Its extracts (methanolic and acetonic extracts) have potential antibacterial effect against *Klebsiella pneumonia* (Parekh et al., 2006; Dhama et al., 2014). Its inhibitory activity is compared with standard antibiotic amikacin and piperacillin (Vaghasiya et al., 2009; Naeem et al., 2017). The antimicrobial activity of ethanolic, aqueous and acetonic extracts against gram positive and gram negative is analyzed by the inhibitory activity and measuring the zone of inhibition of extracts. They have latent antibacterial activity in opposition to *Staphylococcus aureus*, *Salmonella typhi*, *Salmonella paratyphi* and *Bacillus subtilis* (Doughari, 2006; Mehar and Dash, 2013). Some other studies reveals that the ether, water and ethanolic extracts of *Tamarindus indica* has strong antibacterial activity against gram positive and gram negative species (Mansingh et al., 2021). *Tamarindus indica* flowers extract (aqueous and methanol) possess antimicrobial activity (Fatimi et al., 2007; Ahmad et al., 2018). Pure essential oil and extracts (ethanol) from the fresh leaves of

Tamarindus indica has showed the strong antibacterial activity against the tested bacterial strains i.e., *Pseudomonas aeruginosa* and *Salmonella typhimurium* (Escalona-Arranz et al., 2010). The ethanolic extracts of *Tamarindus indica* leave and fruit was proven potent antibacterial agent against *shigella* spp. (Abdallah and Muhammad, 2018). The bark of *Tamarindus indica* also have the antimicrobial properties, its ethanolic extract was tested against gram positive (*B. cereus, S. aureus*) and gram negative bacteria (*K. pneumoniae, E. coli*) by well diffusion method. The large zone of inhibition is seen in case of *S. aureus* and *B. cereus* bacteria (Kapur and John, 2014). Furthermore, the ethanolic extract of fruit pulp is proven effective against *Escherichia coli* and *Pseudomonas aeruginosa* comparative to Gentamycin (Faisal, 2020).

General Mechanism of Action of *Tamarindus indica* against Bacteria

Tamarindus indica plant extracts possesses a strong anti-bacterial property that acts in one way or other, hence restricting the growth of bacterial cells by interfering with the host cell wall synthesis, interfere with DNA replication, inhibit the transcription and translational process results into the protein synthesis inhibition, and by the inhibition of synthesis of essential metabolites. The possible antibacterial mechanism of action is described in a picture below:

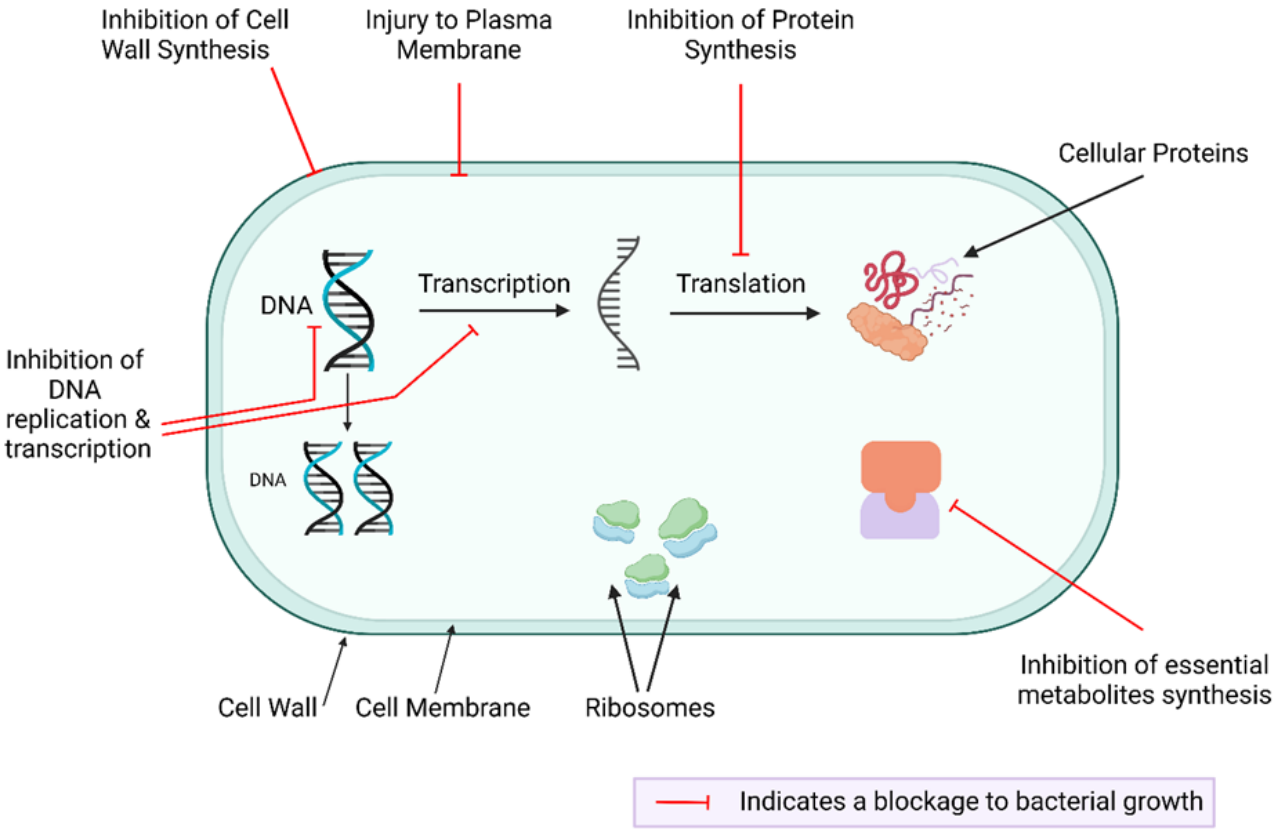

Fig. 1: The general antibacterial mechanism is illustrated in the diagram. Created with BioRender.com

Antiviral Activity

Tamarindus indica exhibit the anti-viral activity. The fruit extracts of *Tamarindus indica* have a potent antiviral activity against cow pea mosaic virus, watermelon mosaic virus and tobacco mosaic virus (Kuru, 2014). The crude ethanolic extracts of *Tamarindus indica* have inhibitory role against virus replication and results prove its inhibitory action against Newcastle disease virus (Perera et al., 2021).

Antifungal Activity

Tamarindus indica shows the antifungal activity. *Tamarindus indica* fruit extracts exhibit the antifungal activity against *Candida albicans* and *Aspergillus niger* (Kuru, 2014). Earlier studies of ethanolic extracts of leaves and mash proves the antifungal activity of *Tamarindus indica* against *Aspergillus flavus*, *Aspergillus niger* and *Fusarium oxysporum*. Bark of this plant can inhibit the growth of *A. flavus* and *F. oxysporum* up to some extent and growth of *A. niger* was not affected (Abubakar et al., 2010).

Some other Properties of *Tamarindus indica*

Anthelminthic Activity

The leaves of *Tamarindus indica* is used for Guinea worm (*Dracunculus medinensis*) extraction in Nigeria and its leave extract also used for wound treatment caused by parasites (Bhadoriya et al., 2011; Chimsah et al., 2020). The squash of

seeds of *Tamarindus indica* is used as vermifuge in Ethiopia (Malathi et al., 2022) and fruit squash is used in Niger for this purpose (Havinga et al., 2010). In certain region of Tanzania, the leaf and root extract of *Tamarindus indica* is used as a treatment for Hook worm (ankylostomiasis) infestation (Chimsah et al., 2020). *Tamarindus indica* leaves and bark extracts (aqueous and ethanol) when tested against *Tubifex tubifex* and *Pheretima posthuma*, it paralyzes the worm and causes its death in much shorter time as compared to standard piperazine citrate (Soni and Singh, 2017; Khamesipour et al., 2021). Similar results were obtained in another study where the juicy extracts of *Tamarindus indica* leaves causes paralysis and quick death of *Pheretima posthuma* as compared to piperazine citrate, a standard drug (Mute et al., 2009; Manke et al., 2015). The anthelminthic activity of *Tamarindus indica* leaves extract (ethanol and aqueous) was also studied against earthworm infestation (Bondada et al., 2013). *Tamarindus indica* also have anti-nematodal against pine wood nematode, *Bursaphelencus xylphilus* (Meher et al., 2014).

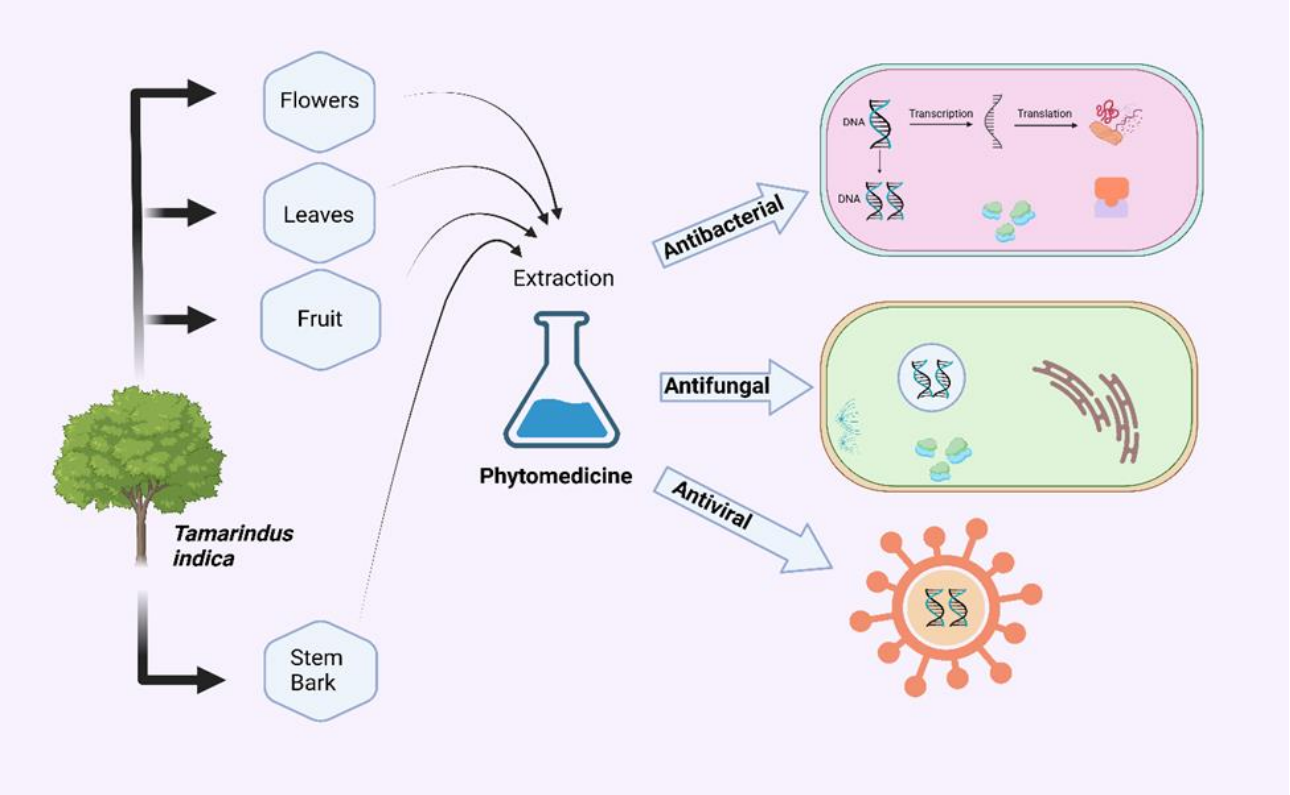

Fig. 2: The general antimicrobial effects of *Tamarindus indica* extracts. Created with BioRender.com

Anti-oxidant Activity

The good anti-oxidant activity of *Tamarindus indica* is due to the presence of phenolic compounds in its extracts primarily of seed and pericarp extracts (Sudjaroen et al., 2005). *Tamarindus indica* fruit pulp ethanolic extracts when exposed to the hamster, it shown noticeable anti-oxidant activity both in-vivo and in-vitro (Martinello et al., 2006; Atawodi et al., 2014). Furthermore, the ethanolic extracts of *Tamarindus indica* stem and roots have shown the strong anti-oxidant activity in DPPH radical, hydrogen peroxide scavenging assay and phospho-molybdenum assay (Borquaye et al., 2020). The seed coat ethyl acetate extracts also possess strong anti-oxidant activity (Luengthanaphol et al., 2004; Kahimbi et al., 2023). Aqueous acetonic extracts of *Tamarindus indica* exhibit highest anti-oxidant activity (Siddhuraja, 2007).

Anti-inflammatory and Analgesic Activity

The methanolic extracts of *Tamarindus indica* seeds causes the inhibition of human serine proteinase and neutrophils elastase thus exhibit a remarkable anti-inflammatory action in-vitro (Caluwe et al., 2010; Malathi et al., 2022). Furthermore, the seeds extract causes a significant decrease in IL-1β, IL-6 and TNF-α levels in arthritic rats (Sundaram et al., 2015; El-Gazzar, 2024). In another study a model of rat suffering from pleurisy caused by carrageenan is used to examine the anti-inflammatory activity of methanolic extracts of *Tamarindus indica* plant (Suralkar et al., 2012; Mans et al., 2019). Moreover, in male Wistar albino rat paw edema caused by carrageenan is reduced significantly by the ethanolic extracts of *Tamarindus indica* leaves (Bhadoriya et al., 2012). However, in another experimental investigation conducted on mice and rat models suffering from arachidonic acid and carrageenan induced ear edema, the results strongly convince the greater anti-inflammatory of both the ethanolic and chloroform extracts (Rimbau et al., 1999). *Tamarindus indica* also causes the inhibition of leukotriene production and activation of NF-B pathways, thus exhibiting a strong anti-inflammatory property (Komakech et al., 2019). Bronchitis is treated by the ginger juice extracts

of *Tamarindus indica* leaves (Smruti, 2021). The dried bark is added to water and the resulting extracts used as a treatment for eye inflammation (Ajaiyeoba et al., 2001). Sterols and triterpenes present in the *Tamarindus indica* extracts have an analgesic effect (Dighe et al., 2009).

Anti-venom Activity

The extracts of seeds of *Tamarindus indica* plant is used to antagonize the effect of snake bite. Traditionally, it is used as folk medicine (More et al., 2021). *Tamarindus indica* seed extracts inhibit the protease, phospholipase A, 5′ nucleotidase enzymes, hyaluronidase and 1-amino acid oxidase activities of the venom in a dose dependent mode (Ushanandini et al., 2006; Fatimi et al., 2007). It inhibits the breakdown of β-chain of fibrinogen in human and thus preventing the hemolysis caused by venom hence prolonged the blood clotting process. The venom induced myotoxic effect like hemorrhage or edema is reduce markedly when extracts injected in a dose dependent mode. The results prove that the seed extracts of *Tamarindus indica* plant can be used as a serum therapy for the treatment of venom (Ushanandini et al., 2006; Bhadoriya et al., 2011).

Anti-cancerous Activity

Tamarindus indica has potential to treat the cancer thus having the anticancer effect. The strong antioxidant activity of *Tamarindus indica* seed extracts aid in the treatment of cancer. (Afzaal et al., 2023). The methanolic extracts of *Tamarindus indica* seed and inspect its cytotoxic potential on human lymphoma cell lines and rhabdomyosarcoma cancer. Results prove that the extracts of seed possess the strong anticancer effect on the cancer cell lines (Soni and Singh, 2019; Arshad et al., 2019). Anticancer effects of *Tamarindus indica* bark in the ethanol extract was observed on the human colorectal adenocarcinoma cell line (HT29). The evidence shows that the ethanolic extracts of the bark possess the anticancer activity against the human cancer cell line (Rini and Saini, 2022).

Anti-diabetic Effect

The anti-diabetic activity of aqueous extracts of seeds of *Tamarindus indica* plant is proven experimentally by the streptozotocin induced diabetes in an experimental model rat, the results showed the strong anti-diabetic activity of extract (Maiti et al., 2005). Furthermore, the ethanolic extract display the strong anti-diabetic activity in the alloxan induced diabetes in the rat (Bhadoriya et al., 2018).

Anti-ulcer Activity

Tamarindus indica plant possess ulcer healing character. A study proposes that the anti-ulcerative property is due to strong anti-oxidant activity (Raja et al., 2008; Singh et al., 2023). The methanolic extract of *Tamarindus indica* seed coat remarkably reduce the total acidity and volume of gastric juice in experimental pylorus ligated subject in comparison with ranitidine, a standard drug. It proves the anti-ulcerative effect of Tamarind (Kalra et al., 2011).

Hepatoprotective Activity

The aqueous extracts of *Tamarindus indica* unroasted seeds, fruits and leaves had a noticeable hepatoprotective effects in rats exposed to paracetamol induced hepatotoxicity (Pimple et al., 2007). However, the ethanolic extracts of bark showed strong protective functions in Sprague Dawley rats which are exposed to chemotherapy thus preventing the hepatic damage (Meena et al., 2019). Another study confirms the hepatoprotective activity of *Tamarindus indica* flower, the results confirmed that the Rifampicin and Isoniazid induced hepatotoxicity in Wistar albino rats is prevented by the ethanolic extracts of the *Tamarindus indica* flower (Ramirez-Maroquin et al., 2019). *Tamarindus indica* show hepatoprotective effect in case of alcohol induced liver toxicity, thus preventing the apoptosis of liver cells. *Tamarindus indica* causes stabilization of membranes and decreases the consumption of Glutathione. Additionally, it causes the fragmentation of DNA and activation of CASP-3 and causes histopathologic amelioration (Caluw et al., 2010; Kuru, 2014).

Effect on Cardiovascular System

In Bangladesh, the effect of *Tamarindus indica* fruit was evaluated on the Systolic and diastolic blood pressure, lipid profile and the human body weight (Xie et al., 2021). In a study on the hypercholesterolemic hamster, the *Tamarindus indica* extracts was examine on the atherosclerosis lesion and the lipid serum level. *Tamarindus indica* extracts have a greater potential of decreasing the risk of atherosclerosis in human (Arshad et al., 2019).

Abdominal Pain, Diarrhea and Constipation

Abdominal pain is a non-specific disorder of abdomen resulting in a pain in the abdomen which may be caused by the Diarrhea or Constipation. In Nigeria, the rural Fulani eats soaked fruits to relieve pain resulting from constipation (Lockett et al., 2000; Havinga et al., 2010). Although treatment with *Tamarindus indica* relieve pain but it makes it difficult to determine the cause of disease. In East Africa abdominal pain maybe due to Diarrhea. *Tamarindus indica* squash of young fresh bark is used as laxative to relieve abdominal pain (Fandohan et al., 2007). Similarly in Benin the young stem squash for 24 h and taken orally to treat abdominal pain. In East Africa, root extract is used to treat

abdominal pain or stomach ache (Geissler et al., 2002; Chimsah et al., 2020). It is also used in Burkina Faso for the treatment of abdominal pain and other related complains (Kristensen et al., 2003). *Tamarindus indica* leaves are used for diarrheal treatment, for constipation fruit of *Tamarindus indica* is used and for abdominal pain roots and soft parts of bark can be used (Havinga et al., 2010).

Wound Healing

Tamarindus indica has great efficiency of wound healing, its leaves and bark when applied on the wound either in the form of concentrated extract, powder form or as a plaster (Malabadi et al., 2021). Its fruit is also used as medicine for wound healing (Vuyyala et al., 2020). The wound healing potential of seed and cork ash of *Tamarindus indica* was studied against Wistar albino rat, the results showed that it has a greater wound healing potential caused by tissue injury (Naik et al., 2017). The *Tamarindus indica* leaves extract are used to treat wound caused by Guinea worm (*Dracunculus medinensi*) in Nigeria and also for treatment of other parasitic wounds (Chimsah et al., 2020). In Dakar, the bark of *Tamarindus indica* plant is sold for wound treatment, other parts of the *Tamarindus indica* is used in medicine like pod husks, fruits or gum (Bhadoriya et al., 2011).

Malaria and Fever or Anti-pyretic

In Madagascar, the *Tamarindus indica* fruit is known as febrifuge (Baiyeri et al., 2019). In Ghana, *Tamarindus indica* leaves are used as a treatment for malaria (Asase et al., 2005). The pulp of tamarind fruit is used as laxative and febrifuge (Naeem et al., 2017). In a study conducted on rat, the experimentally induced pyrexia in rat due to yeast and lipopolysaccharides, the strong anti-pyretic activity of *Tamarindus indica* fruit pulp is proven (Izquierdo et al., 2007).

Laxative Properties

The *Tamarindus indica* fruit used conventionally as a laxative because of the presence of higher amount of tartaric acid, maleic acid and potassium acid (Chimsah et al., 2020). In Madagascar, the fruit of *Tamarindus indica* is given to the children to treat constipation. In Bamako, the *Tamarindus indica* pulps are used to prepare drinks and in Burkina Faso, the *Tamarindus indica* fruit is chopped and soaked in water with salt for half times a day before consumption. In Northern Nigeria, the *Tamarindus indica* leaves mash along with potash is used and also the fruit is used as laxative (Naeem et al., 2017).

Conclusion

Tamarindus indica, a Leguminosae family plant, found in the Africa, Egypt, Asia and other tropical and subtropical regions. The importance of this plant is due to its medicinal as well as the pharmacological properties. In ancient time, it is used for wound treatment and for abdominal pain. The extracts of different parts of this plant such as seed, leaves, fruit, and bark are used for the treatment of diabetes, ulcer, wounds, abdominal disorders, diarrhea, constipation, and even as a laxative, antipyretic, anti-inflammatory and as an analgesic. Its antimicrobial such as antibacterial, antiviral and antifungal properties are truly explained due to the presence of phytochemical compounds such as alkaloids, flavonoids, glycosides, terpenoids, tannins, steroids, phenol and proteins. It also possesses the anti-oxidative, laxative, hepatoprotective and anti-cancerous properties. A detailed information about the medicinal usage of *Tamarindus indica* plant and its extracts is discussed in this chapter. However, more experimental work should be done to explore the beneficial uses of natural extracts of this plant.

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