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TERMINALIA- A TREASURY OF PHARMACOLOGICAL BENEFITS A REVIEW

Saharan Anjali ^{*1}, Dhiman Anju ² and Dureja Harish ²

M. M. School of Pharmacy ¹, Maharshi Markandeshwar University, Rohtak - 124021, Haryana, India.

Department of Pharmaceutical Sciences ², Maharshi Dayanand University, Rohtak - 124001, Haryana, India.

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Correspondence to Author:

Anjali Saharan

Department of Pharmaceutical Sciences, Maharshi Dayanand University, Rohtak - 124001, Haryana, India.

E-mail: anajalisaharan12@gmail.com

ABSTRACT: World major population was dependent on traditional medicines, derived from medicinal plants. Among which India plays a crucial role in health management using herbal derivatives and excipients. Majority of plants and their derivative products isolated from different parts shown to have significant therapeutic and pharmacological potentials. Various plants species have been envisaged, among which Terminalia is one of the treasuries in which all parts of this plant having therapeutic activity by isolation of different Phytochemicals in varying solvents according to polarity and nature of compounds isolated using extraction. The amount and quantity of phytochemicals present in different plants differ from one another. Among the various screened species of genus Terminalia, it was reported that around 200-250 species are widely used as traditional medicine in curing various ailments such anti-HIV reverse transcriptase, anti-diabetic, antioxidant, antifungal, anti-cancer, hepatoprotective, anti-inflammatory, anti-hepatitis and aphrodisiac effects. The aim of present study was to review its extracted phytoconstituents present in different parts along with their pharmacological benefits and usage. Which further helps emerging researchers to investigate the some unknown potential and therapeutic effects of these medicinal species.

INTRODUCTION: Plants are being considered as rich and prime source which has been long served as a prolific supply of helpful medicine, food and additives, seasonal agents, colorants, binders and lubricants. Main stream of the plants founded in surroundings have been used commercially in pharmaceutical industries due to their renowned pharmacologically active constituents having pharmacological benefits. Such types of species of plantae are known as medicinal plants. Ethnobotanical information may be an affluent resource for natural drug analysis and development ^{1,2}.

From literature, it was noted that therapeutic use of plants is as from since 4000 - 5000 B.C. Among all over world, china people were among the first and foremost where the plant has been used as remedial medicines sources. On the basis of assessed data it was found that in developed countries like U.S, 25% of the medicines has biological herbal origin whereas in developing countries like India and China, the quantity is quantified up to 18% only.

From the above study, it was concluded that plants and derivative products used as extracts, tinctures, powders *etc.* ^{5, 3} which contained bioactive constituents used in cure and medication as mentioned in Siddha and Unani ³. Examples of some dosage units used are as analgesic drug- pain pill from *Filipendula ulmaria* Linn., anti-malarial drug from cinchona species, the anti-hypertensive drug-reserpine from rauwolfia, vinblastine from *Catharanthus roseus*, artemisine from sweet

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wormwood etc.^{7,4} Form the above stated different edible parts of plants plays and effective role and proved themselves to be nutritionally, medicinally and pharmaceutically valuable to human beings. Among various herbal plants with therapeutic potential, one with various pharmacological properties is tropical almond due to its unconditional benefits used world with botanically named as *Terminalia catappa*. Taxonomical classification and species of *Terminalia* was found to be around more than 200. Further division of species on basis of their origin countries as Asian in which India carries about 6 species by origin, 14 species are from African origin, 2 species are from American origin and 3 species are from Oceania (Australia) origin^{5,6}. *Terminalia catappa* Linn. species explored among various pharmaceutical studies as it comprises a range of chemical constituents which reveals various biological activities such as anti-inflammatory (triterpenic acids, especially ursolic acid and its derivatives)⁷, antioxidant (punicalin, chebulic acid, benzoic acid, cumaric, punicalagin, , terfluvina A and B, and its derivatives)^{8,9,10} anti-diabetic (β -carotene)¹¹, anti-cancer (punicalagin)¹², anti-viral (ellagic acid)¹³, anti-microbial (flavones and flavanols)^{14,15,16} and hepato-protective activities (punicalagin, punicalin)¹⁸ etc. due to variety of such biologically active constituents, they ensure that drug is pharmacologically beneficial for future research and investigations.

Descriptive Information of the Plant: Family Combretaceae along with largest family of flowering plants includes variety of flowering plants with well-versed includes trees, shrubs, and lianas of about 200 species. Among which *Terminalia* genus is one among the category of large trees distributed in tropical regions of the world. This genus name coined from Latin word *Terminus*, depicted the fact that the leaves appear at the very tips of the shoots. Plants and trees from *terminalia* are known for their potential sources of secondary metabolites such as flavonoids, tannins, aromatics and derivative metabolites such as cyclic triterpenes and their derivatives^{17,18}.

Terminalia catappa Linn. (combretaceae) is found primarily in the warmer regions throughout the India and coined by title named as, Tropical Almond, Malabar Almond, Indian Almond¹⁹.

Bengal almonds, Country almond, Falsekamani, Sea almond. Synonyms for *catappa* L. are *Terminalia moluccana* Lamk, *Terminalia procera* Roxb and *Terminalia mauritiana* Blanco. Regional and local nomenclature of these species are termed as Ketapag (Malayalam), Janglibadam (Marathi), Janglibadam (Hindi), Badamalili (Gujarati), Desabadama (Sanskrit), Tapasataruvu (Telugu), Kadubadami (Kannada), Desiyobadamo (Oriya), Nattuvadumai (Tamil), Kshudrabija and²⁰. *Terminalia catappa* belongs to the largest trees family that grows mainly in tropical countries with a maximum height of 35 m, being upright, with horizontal branches and symmetrical crown, tropical, deciduous and erect tree, reaching about 15-25 m, trunk 1-1.5 m in diameter, often buttressed at the base. Its trunk is 1-1.5 m in diameter, frequently buttressed at the base, the leaves were obviate and alternate between one another, petioles are short, spirally gathered at the branch tips, the leaves are dark green above, paler underneath, glossy and or leathery.

The fruit appeared rounded and flattened and resembles to egg like shaped, with a green or reddish shade and yellow after ripening^{20,19}. Seeds containing oil are enclosed in cylindrical vessel along with seed enclosed in fleshy mericarp in tough, fibrous shell^{19,21}. This tree is grown for its ornamental purposes and its edible nuts and its kernel can be eaten raw. The juice of its fresh leaves also used in various formulations such as lotions for leprosy and scabies and taken orally for stomach-ache and headache. Recently, the significance and effectiveness of herbal drugs associated engaged in it among which is one *Terminalia catappa* with more fruit full and eegvtuve results^{23,20,22}.

Phytochemistry: Phytochemical studies performed on different *Terminalia* species revealed that different phytoconstituent such as pentacyclic triterpenes, flavonoids, tannins, glycoside derivatives, and other phenolic compounds^{23,24}. Concentration of different phytoconstituents present in different parts of plants such as barks, fruits and seeds of the *T. Catappa* varied accordingly. The fruit contain about 1.95 g of protein, 12.03 g of carbohydrate, and 1.21 g of ash. B-carotene (2.090 μ g) and vitamin C (138.6 mg) are present in high amounts. The mesocarp of fruits

dehydrated by the sun having ash, protein, glucose, moisture, tannin, carbohydrate, and oil with 3,434.5 kcal/kg calorific value is very essential for its nutritive value. The seed is composed of fixed oil (51.2%), olein (54%) and stearin (46%). The seeds yield 4.13% moisture, 4.94% crude fiber, 23.78% crude protein, 4.27% ash, 51.80% fat, and 16.02% carbohydrate; the total calorific value is 548.78 kcal. The bark contains glycoside, cardiac tannins, volatile oils, saponin, steroid, glycosides, and phenols. Classified in the oleic-linoleic acid group, the oils contain huge levels of unsaturated fatty acids, exclusively oleic (up to 31.48%) and linoleic (up to 28.93%)^{25, 26}.

Apart from all concentration individual components present in different parts of the plant are as leaves of *T. catappa* contain 1- degal-loyl-eugeniin, 2,3-(4,4',5,5',6, 6'- hexahydroxy-diphenoyl) -glucose, chebulagic acid, gentisic acid, corilagin, geraniin, tercatin, tergallagin, terflavin, A and terflavin B, granatin B, kaempferol, quercetin, punicalagin and punicalin²⁷. Reddish brown leaves contain flavonoid apigenin 6- c-(2-galloyl)- L-Dglycoside, apigenin 8-c-(2- galloyl)- L-D-glycoside, isovitexin, vitexin, isoorientin, rutin and tannins such as ellagic acid, puricalagin, punicalin, gallic acid are isolated from the leaves and barks of *T. catappa* different hydrolysable tannins and their derivative compounds along with flavone glycosides are isolated. Their structures were established as chebulagic-acid, apigenin 6-C-(2-O-galloyl)-â-Dglucopyranoside and apigenin 8-C-(2-O-galloyl)- â - D-glucopyranoside, together with four known flavone glycosides, sovitexin, vitexin, isoorientin, and rutin on the basis of spectroscopic method.

The Leaf of *T. catappa* contains, 2, 3-(4,4',5,5',6,6'-hexahydroxy- diphenoyl) -glucose, 1-degalloyl-eugeniincorilagin, gentisic-acid, geraniin, granatin-b, kaempferol, punicalagin, punicalin, quercetin, tercatin. The bark of *T. catappa* contains arjunolic- acid- 28- o- beta- d- glucoside, beta-sitosterol, beta-sitosterol, betulinic-acid, (+)-catechin, (-)- epicatechin, 3, 3', 4- tri- omethyl-ellagic- acid, 3, 3'-di-o- methyl -ellagic- acid, daucosterol, oleanolic acid, oxalic-acid, ellagic-acid, leucocyanidin, arjunolic-acid, tannin. 2888 2, 3-(S)-HHDP-D-glucose, punicalagin, corilagin, tercatin, casuarinin, castalagin, grandinin, castalin,

3- methoxy-4- hydroxyphenol- 1- O- b- D- (6é-O-galloyl)- glucoside, 3, 5- dimethoxy- 4- hydroxyphenol -1- O- b- D- (6é-O-galloyl) - glucoside, (-)-epicatechin- 3- O- gallate, (-)- epigallocatechin- 3- O- gallate, procyanidin B- 1, 3é- O- galloyl procyanidin B-2, acutissimin A and eugenigrandin A²⁰.

The seeds contain carbohydrates, protein, fat, fiber, iron, carotene, linoleic acid, myristic acid, oleic acid, ascorbic acid, palmitic acid, arachidic acid, palmitoleic acid, stearic acid, phosphorus, potassium, niacin, riboflavin, thiamine and water. Arachidic-acid, ascorbic-acid, carbohydrates, beta-carotene, fat, fibre, iron, kilocalories, oleic-acid¹⁸. Fruit of *T. catappa* contains glucose, cyanidin-3-glucoside, pentosans, gallic acid, tannin corilagin, brevifolin carboxylic acid, β-carotene, and ellagic acid^{29, 18}. Ellagic acid has shown to have anti-diabetic effect in diabetic rats^{30, 27}. The entire green fruit with seed inside has shown to have more phenolic content and other phytochemicals¹⁸. The different phytoconstituents isolated such as flavonoids, carotenoids, and phenolic compounds depicts the traditional use of this plant^{11, 28}.

Pharmacological Activity:

1. Anti-oxidant: Diabetes mellitus (DM) is defined as metabolic disorder with a resultant of elevation of blood sugar level than the normal level because of the impairment in production of insulin results in (type 1 DM) or either the cells do not properly respond to the insulin (type 2 DM) leading to hyperglycemia. Hyperglycemia generates reactive oxygen species which causes lipid per oxidation of cells and damages membrane and various vital organs such as eye, kidney, blood vessel, and nerve damage. Antioxidants having ability to inhibit the destruction of β-cells by impeding the per oxidation chain reaction and prevent form occurrence of diabetes^{31, 32}. Plants which are having natural antioxidants such as (tannins, flavonoids, vitamins C and E) also helps to combat and preserve β-cells function and combat diabetes induced ROS formation 1-3.^{33, 34} Herbal medicines have been used since long time because of limitless benefits and safety towards humanity. And from the study it was concluded that majority of the plants having antioxidant activities and plays as vital role in treatment of unbeatable diseases and toxicity of drugs^{35, 36}.

Chukwumaet *et al.*, (2015) characterized the antioxidant properties and total phenolic content, using 1, 1-diphenyl-2-picrylhydrazyl (DPPH) reagent and reducing power assays. Observations from the study revealed that 73.42% inhibition rate of free radical was observed with a methanolic extract of 80%³⁷. Antioxidant efficiency of the various extracts derived by six different extraction methods was evaluated by different assays such as 2, 2'-Azino- bis- (3-ethyl) benzothiazoline) -6-sulfonic acid diammonium salt radical cation inhibition assays *viz.* 2, 2'-diphenyl-1-picrylhydrazyl, superoxide, and ferric reducing antioxidant power. The results showed that the extraction method significantly altered the antioxidant activity^{11, 38}. From the above study it was concluded that the tropical almond leaf and fruits as they antioxidant, phenolic content and anthocyanin and their concentration increases with increase in fruit maturity^{39, 40}. And acts as best remedial source in management of oxidative stress³⁷.

2. Anti-diabetic / Hypoglycemic Activity: Ahmed *et al.* (2005) was performed a study on antidiabetic activity of leaf extract of *T. catappa* on alloxan induced diabetic rats. Administration of alloxan (150 mg/kg, i.p) led to increase in concentration of fasting blood glucose levels, which is to be carried forward for 3 weeks. After three weeks dose administration of extract shown a decline due to dose dependent profile in blood sugar levels by 25-62%.⁴¹ After dose administration effects was shown to be maximum after 15 days and maintained throughout the rest of duration. Further research was preceded for determination of blood sugar levels and serum biochemical analysis in alloxan induced diabetic rats using aqueous and cold leaves extract of *Terminalia catappa* Linn. (Combretaceae). Both the extract shows significant difference against anti-diabetic activity at dose levels of 1/5th of their lethal doses. Contemporaneous histological studies of the pancreas shows the regeneration of these animals using aqueous and cold extracts which were earlier necrosed by alloxan¹⁹.

A.N. Nagappa *et al.*, (2003) reported that *T. Catappa* fruit extract in methanolic and aqueous extracts will exhibit substantial anti-hyperglycemic effect in diabetic rats sample rats treated with alloxan. The above stated extract along with higher

affinity revealed significant improvement and changes in different parameters such as body weight, regeneration of cells in pancreas and lipid which all cumulatively plays a vital role in diabetes treatment⁴².

3. Anti-microbial Activity: Antimicrobial activity is defined as ability to destroy and inhibit the growth of microorganisms, mainly pathogenic one. Harmful microbes are the root cause of various disease and deaths. A huge amount of medications are available in market, But not able to render their benefits optimistic results leading to discovery of herbal drugs. Among herbals various plants parts explored among them one found by study effective is *Terminalia*. The root extract in chloroform of this plant shown good antimicrobial activity against both gram positive and gram negative bacteria microbes such as *Escherichia coli* and *Staphylococcus aureus*. Various extract have been prepared such as petroleum ether and methanolic which shows minimal activity as compared to chloroform, as reported that petroleum ether have null effect against antimicrobial activity, while methanolic extract shows an minimal inhibition concentration (MIC) rate of 0.065 mg/ml against *E. coli* and the chloroform extract exhibits MIC of 0.4 mg/ml against *Staphylococcus aureus*⁴³. Further investigated found that leaves extract in some solvents exhibits antimicrobial activity.

The two extracts of aqueous and methanolic were used under investigations found that they both have different affinity for different microbes such as *Pseudomonas*, *pseudoalcaligenes*, *Bacillus megaterium*, *Alcaligenes faecalis*, *Pseudomonas aeruginosa*, *Staphylococcus subflava* *Pseudomonas testosteroni*, *Escherichia coli*, *Staphylococcus aureus*, *Staphylococcus epidermidis*, *Proteus mirabilis*, *Streptococcus faecalis*, *Proteus vulgaris*, *Proteus morganii*, *Bacillus cereus*, *Candida tropicalis*, *Bacillus subtilis*, *Citrobacter freundii*, *Micrococcus flavus*, *Enterobacter aerogenes*, *Salmonella typhimurium*, *Klebsiella pneumoniae*, *Streptococcus cremoris* and *Streptococcus agalactiae*. It was concluded from the above that methanolic extract have high affinity against microbial strains than aqueous one⁴⁴.

Chanda et al., (2011) stated that antimicrobial activity is also reported in leaf of *T. catappa* also.

It has been observed that methanolic, acetone and N, N-dimethylformamide extracts shows potent antimicrobial activity when tested using agar disc diffusion assay. For experimental evaluation 91 strains are used among which all are clinically isolated and compared with the standard drugs such as Piperacillin and gentamicin used for antibacterial assay. The ease of inhibition will help to determine about the extent of activity around each paper disc using both types of microbes and concluded that gram-positive bacteria were more vulnerable than the gram-negative bacteria. From above, all it was concluded that methanolic extracts shows greater affinity against microbes than other two extracts⁴⁵. Shikhamandloi et al., also reported that methanolic extract shows greater affinity to antimicrobial against *Penicillium chrysogenum*, *Trichophyton tonsurans*, *Cochliobolus lunatus* and *Aspergillus niger*¹¹. Taganna et al., reported that leaves having property to inhibit certain phenotypic expressions of quorum sensing (QS) in some testing strains due to the majority of tannins content present in leaves. Akharaiyi et al., also performed studies and concluded that aqueous extracts also shows inhibition effect against microorganism's⁴⁶.

Mudi et al., (2011) carried a research study on Phytochemical Screening and Antimicrobial Activities of *Terminalia catappa* extract of leaves and concluded that it contains a variety of secondary constituents among which resins is foremost in all. Among the various extracts observed it was found that antimicrobial assay of chloroform, ethyl acetate and n hexanes hewn a positive indicative response against bacterial strains. Chloroform fraction proven its activity against *Salmonella typhi* and gram-negative *Escherichia coli* at 500 µg/disc where as ethanol and aqueous methanol fractions show activity against only for *Salmonella typhi* at concentrations range of 300 - 500 µg/disc⁴⁷. Chanda et al., (2013) was carried a research on antimicrobial activity of *Terminalia catappa* L. It was concluded that the using the methanolic extract it shows greater affinity and proven to be virtuous antimicrobial activity individually or in synergistic effect along with standard antibiotics⁴⁸.

4. Anthelmintic Activity: Anthelmintic are a group of anti-parasitic drugs which helps to remove parasitic worms from your body either stunning or

killing them and without causing significant damage to the host. Nuruliani et al., (2011) concluded in a study using leaves of plant for the determination of anthelmintic potential in selected *in-vitro* bioassay which was modified using established assay. Larvae was added in 96 multiwell plates at a concentration of 50 L3 (n= ± 50) which were incubated with diluted crude extract of *T. catappa* at a ratio of 1:1 and the plates were stored at 20 °C for 3 h and 5 h. Positive control consists of phosphate buffer saline and distilled water was taken as negative control. After the completion of incubation period, the motility of the larvae was evaluated using inverted microscope. All the non motile L3 larvae were identified. After 3 h, it was concluded that the reduction percentage for motility was 70%, 63% and 73% for *T. colubriformis*, *C. curticei* and *H. contortus* respectively while after 5 h, the reduction percentage was 77%, 67% and 80% for each species respectively. Percentage of reduction in motility was calculated by comparing the number of L3 before and after incubation. Control did not show any reduction in motility. From the study, it was concluded that *T. catappa* leaves can be considered as potential alternative as anthelmintic⁴⁹.

5. Anti-tumor Activity or Anti-cancer Activity: Tumours are defined as hysterical replication of DNA along with irregular division of cells results in the growth of metastasis of neoplastic cells, which invade and destroy adjacent tissues blood as well as the lymphatic system. Aqueous extract of *T. catappa* leaves plays a vital role in protection of cancer cells as it contains in major part tannins such a punicalagin which helps in protection of cancer cells⁸. Saroja M et al., (2011) concluded that potent anticancer activity was found in higher concentration in Ehrlich ascites induced carcinoma mice in the methanolic extract of *Terminalia catappa* leaves⁵⁰. This was concluded that activity is due to flavonoids present and assessed on Ehrlich Ascites Carcinoma (EAC) in mice and observed that extract shows this effect in higher dosage only⁵¹.

Chiou Y et al., (2003) concluded that supercritical CO₂ extracts of *Terminalia catappa* leaves are cytotoxic to human hepatoma cells. Ames test was utilized to assess the anti-mutagenic potential of the

same at lower dose of 0.5 mg/plate and no toxicity and anti-mutagenicity was observed. The activity was temperature dependent as it increases with decrease in temperature and pressure used for extraction. The SC-CO₂ extracts possess more cytotoxic potential to Huh 7 cells as compared to Chang liver cells. The observation on the anti-mutagenic and cytotoxic potential of with *T. catappa* warrants further investigation⁵².

Ko et al. reported that leaf extracts of supercritical CO₂ of *T. catappa* helps in exhibiting anti-mutagenicity effect and have not any cytotoxic effects to human hepatoma cells in comparison to liver disease⁵². Oral administration has a great in reduction of number of aberrant β -catenin accumulated crypts/cm/rat and crypt foci/colon/rats in comparison to control group⁵³. *T. catappa* and punicalagin treatment also affects anchorage independent growth that may have been due to a cell cycle arrest at G0/G1 phase. Punicalagin treatment decreased the levels of intracellular superoxide and also the levels of phosphorylated c-Jun N-terminal kinase 1 (JNK1) as well as protein kinase³⁸ (p38). This will support the chemo preventive effect of punicalagin¹¹.

6. Anti-bacterial Activity: Pawar et al., stated that the antibacterial effects were shown by the dried roots of the chloroform, methanol and petroleum ether using the cup plate agar diffusion method. From the above mentioned extracts, it was rectified that petroleum ether extract shown annulled results and contains no antimicrobial activity. Potent antimicrobial efficiency using extracts of chloroform and methanol was found to be against gram negative and positive microbes. It was concluded that chloroform extract showed prominent antimicrobial activity against *E. coli* and *S. aureus*. Only the methanolic extract exhibited potent activity against *E. coli*⁴³. Shahina et al., stated the antibacterial activity of *T. catappa* leaves and fruits against species of Corynebacteria, Staphylococci, Enterococci, Escherichia, Salmonella⁵⁴ and Shigella.

Sangavi et al., stated that antibacterial activity of *T. catappa* bark using extracts of aqueous ethyl acetate and hexane extracts carried against some pathogenic bacteria. Among the three extracts, aqueous extract show the prominent activity against

pyrogens even in small concentration. This activity was compared using ciprofloxacin as standard antibiotic. The extracts exhibited growth inhibitory activity in a dose-dependent manner. It was finally concluded from the study that aqueous extract is significantly prominent also against standard. And found to be much pharmacologically active^{55,56}.

Opara F. N. et al. (2012) carried a study on antibacterial activities and phytochemical screening of leaf extracts of *Terminalia Catappa*. Antibacterial screening using isolated cultures of various species such as *Pseudomonas aeruginosa*, *Staphylococcus aureus* and *Escherichia coli* using agar cup diffusion method found that *P. aeruginosa* was the most sensitive while *S. typhithe* least, ethanolic extract have more activity than aqueous extract. Methanolic extracts shows bactericidal effect at 62.5 mg/ml on *S. aureus*, but nullified effect was observed using aqueous extract inhibited bactericidal activity at 125 mg/ml on *S. aureus* and *P. aeruginosa*. From all, it was concluded that *P. aeruginosa* and *S. aureus* were more reactive to ethanolic extract than aqueous one⁴⁴.

Neelavathi et al. (2013) was reported that aqueous and ethanolic extract of *Terminalia catappa* leaves and bark shows the Antibacterial activities against some pathogenic bacteria. Bacterial strains used were of *Bacillus subtilis*, *Escherichia coli*, *Staphylococcus aureus* and *Enterobacter aerogenes*. Activity was determined using agar disc diffusion method. The zone of inhibition was determined by comparing to standard antibiotic using Ciprofloxacin by using variable dosage such as 100, 200, 300 μ g/ml, out of which dose of 300 μ g/ml results in higher output¹⁹.

Manzur et al., (2011) evaluated the antibacterial activity of leaf extracts of *T. catappa* using various solvents such as acetone, methanol, and N, N-dimethyl formamide. By using standard drugs as Gentamicin and piperacillin, antibacterial assay was performed⁹¹. Stains are used which are both clinically isolated and identified strains. Using agar diffusion method antibacterial activity was determined.

From the above results, it was observed that gram positive bacteria are more susceptible than the gram negative bacteria and antibiotics⁵⁷.

7. Hematological Activity / Erythropoiesis Enhancer:

Erythropoiesis is the phenomenon of formation of red blood cells known as erythrocytes from erythropoietin stem cell. Aimola *et al.*, (2011) concluded from this study that Erythropoiesis in Adult BalbC Mice shows enhanced activity using methanolic extract of the leaves of *T. Catappa*. This extract leads in production of haemoglobin higher than the controlled groups. Further investigation and quantification was done using determination of packed cell volume test of treated and untreated mice and concluded that treated mouse with extract shows higher activity as compared to the group treated with folic acid^{58, 59, 7}.

8. Anti-ulcer Properties: Peptic ulcer disease (PUD) also called as open sores in stomach where tissues are destroyed by gastric juices and stomach acid, which results in destruction of lining of the stomach. Bharath *et al.*, (2014) evaluated using pyrolic ligated induced ulcer model in rats between two groups one with standard omeprazole and other with the ethanolic extract of *T. catappa* and resultant was determined using ulcer index and histopathological examination. The extract shows a significant decline observed in dose dependent specific profiles such as pH, gastric volume, ulcer index and total acidity other than control one. From above study it was concluded that due to flavonoid present in the extract proven its activity⁶⁰.

9. Aphrodisiac Properties: Aphrodisiac Properties have ability to induce libido and sexual activity. Ratnasooriya and Dharmasiri (2000) explored aphrodisiac activity using kernels of tropical almond in a suspension using 1% methylcellulose in rats. Sexual behaviour was monitored for male rats were observed after a given oral dose of 1500 mg/kg Or 3000 mg/kg in vehicle and their sexual activity was observed along with same procedure for next 7 days. The sexual activity and fertility rate was observed on a regular interval on 1st and 3rd and 7th day was observed with post-treatment by pairing them with pro-oestrous female overnight. It was concluded that dose of 1500 mg/kg dose have aphrodisiac action which leads to prolongation of ejaculation potential. It was concluded from the above study that the extract with kernel and seeds of tropical almond shows significant aphrodisiac properties and acts as helpful in treatment of

various sexual disorders such as premature ejaculation⁶¹.

10. Wound Healing Activity: A wound is defined as a stage which will leads to disruption of normal structures along with disruption of functioning of skin or underline soft tissues. Abundant use of allopathic medicines leads to blizzard of them against their pharmacological activity. To overcome the resistance herbal medicines are explored to counter beat the problem. Khan *et al.*, preformed a study and found that wound healing activity was evaluated on excision wound model in rats. On the dorsal thoracic regions of the rat a cut of around 2 cm was made using ether anaesthesia in aseptic environment. The ointment formulations was prepared and evaluated by parameters such as Epithelization, granuloma weight and scar formation. Sample animals were observed at successive intervals of duration and compared using control group and standard group (betadine) with respect to effect on wound healing ability. As a result of which effectiveness was proved to be about 97% which is much more than control group animals (81%). It was concluded form the above study that bark of *T. catappa* have found to be have much more efficiency of Epithelisation as compared to control⁶² in wound healing ability¹¹.

11. Anti-inflammatory, Analgesic and Modulatory Activity: Anti-inflammatory (or anti-inflammatory) is defined as ability of a substance used in treatment and reduction of inflammation or swelling. To overcome, this medicinal plants plays a vital role in inflammation. Various constituents such as triterpenoids and phenolic compounds found in the leaves are responsible for anti-inflammatory activities. Ratnasooriya *et al.*, reported that tender leaves of extract shown potent activity as anti-inflammatory and analgesic. 63 YM Fan *et al.*, stated that leaf extract of ethanol of *T. catappa* shown anti-inflammatory effect on 12-O - tetradecanoylphorbol -13-acetate (TPA) -induced ear edema in both acute and chronic animal models. Bioassay-based fractionation using fractions of chloroform, contains ursolic acid and 2 alpha, 3 beta, 23-trihydroxyurs-12-en-28- oic acid reveals anti-inflammatory action⁷.

12. Anti-aging Activity: Skin-aging, wrinkles, hyper pigmentation and spots are primarily caused

due to the free radicals present in the body and results in premature cell damage. The factors which are responsible primarily are such as aging, pollution, exposure to UV light (UVB), exposure to the sun (photoaging) and loss of subcutaneous tissues results to skin ageing.

Ching *et al.* stated that erythrocytic hemaolysis can be prevented using DPPH-free radical scavenging activity in hydrophilic extract of *T. catappa* persuaded by 2, 2'-Azobis (2-amidinopropane) dihydrochloride (AAPH). *T. catappa* also hinders collagenase activity on basis of dose dependence such as (10-500 µg/mL). 11,33. Gelse *et al.*, (2003) reported Type 1 collagen is the prime most connective tissue found in abundances synthesized primarily by fibrin oblasts that are foremost for maintaining the strength and flexibility of skin which helps in depreciation of aging. Wen *et al.*, (2011) investigated that skin exposed to UVB radiation leads to Photo aging can be diminished or prevented using hydrophilic extract of tropical almond in human dermal fibroblasts. The free radical scavenging diphenylpicrylhydrazyl (DPPH) was exhibited on exposure and used to protect the erythrocytes from hemaolysis using a precursor as (peroxyl radical initiator). From the all, it was rectified that the production of type I procollagen which have ability to inhibit skin ageing and photodamage was significantly enhanced using tropical almonds³³.

13. Anti-fungal Activity: An anti-fungal medication well known by different synonyms as anti-mycotic medication fungi static which plays a vital role in treatment and prevention of various severe disorders such as athlete's foot, ringworm, candidiasis (thrush) and various systemic infections such as cryptococcal meningitis and others. Gandhi *et al.*, (2015) stated that using aqueous, hexane and ethyl acetate extract of tropical almond and bark was used for identification of antifungal activity. Antifungal property was estimated using agar disc diffusion method. From the above all extracts, it was conclude that hexane extract shown to be more potent and effectiveness was compared using standard antibiotic Clotrimazole and results in inhibition of growth in a dose dependent manner⁶⁴. Cunningham *et al.*, the methanolic extract in different states such as in form of methylene chloride and methanol extracts of *T. catappa*

showed significant and prominent anti-fungal activity against *Pythium ultimum*, *Rhizoctonia solani*, *Sclerotium rolfsii*, *Aspergillus fumigates* and *Phytophthora parasitica*⁶⁵. Parimalagandhi *et al.*, had reported that antifungal activity of the aqueous, ethyl acetate and hexane extracts of *T. catappa* wood and bark against some fungal species. The extracts exhibited growth inhibitory activity in a dose-dependent manner⁶⁶.

14. Anthelmintic Activity: Anthelmintics or anti-helminthics are defined as agents who are primarily used to treat, expel parasitic worms (helminths) from the body by either stunning or killing them and without causing any prior damage to host. From the study, it was concluded that crude extract of *T. catappa* leaves was evaluated for anthelmintic activity against *Trichostrongylus colubriformis*, *Cooperia curticei* and *Haemonchus contortus* and it was suggested that *T. catappa* leaves could serve as a potential anthelmintic agent⁴⁹.

15. Anti-HIV: HIV is defined as a chronic life threatening condition caused by immunodeficiency virus in humans and leads to damage of cells of immune system on large extent. The isolated compounds from tropical almonds such as penicillin and punicalagin inhibited HIV replication in infected lymphocytes with little cytotoxicity and shown HIV reverse transcriptase. The fruit of *T. catappa* contains ellagic-acid which has anti-HIV activity⁴².

16. Hypocholesterolemic Activity: Hypocholesterolemic is defined as the abnormal rise in levels of cholesterol in the blood due to inadequate production. *T. catappa* dry leaf decoction and fruit extract have been evident reversed the altered lipid levels to normal range in tumour bearing mice reported to have hypocholesterolemic effects on rats^{67, 68, 7}.

17. Immunomodulatory Activity: Immunomodulatory is defined as that those agents which are used to promote or modifies the immune response along with its functioning by stimulating the antibody formation and suppressing the activity of white blood cells. From the literature review, it was revealed that firstly by using flavonoid fractions of *T. catappa* leaves in Swiss albino mice depicted the Immunomodulatory activity prominent.

The flavonoid fraction was administered by intra-peritoneal at a dose of ED₅₀ to healthy albino mice. Intra-peritoneal administered Tcfff showed a significant increase in neutrophil adhesion and phagocytic index⁸.

18. Anti-nociceptive: Anti-nociceptive is the process in which harmful and painful stimulus are detected and get blocked by using sensory neurons. Arjariya et al., (2013) proven the anti-nociceptive activity in aqueous extract of leaves of *T. Catappa* using tail flick method and hot plate test in glacial acetic acid induced writhing rats. A significant decrease in inhibition of abdominal writhing rats was observed within dose dependent manner. From the above study it was observed that aqueous extract of leaves have analgesic properties, which are facilitated through the central and peripheral mechanism.

19. Hepatitis Treatment: Hepatitis is defined as chronic inflammation of the liver, on long run leads to fibrosis, cirrhosis and liver cancer. Lin et al., (1997) studied on the aqueous extract of *T. Catappa* has found to be potent against induced toxicity in the rat liver under testing. Using aqueous extract significant effect was observed as free radical scavenging and anti-hepatotoxic activity using superoxide radical scavenger activity.

CONCLUSION: There is no other substitute for various pharmacological benefits of herbal drugs. Despite of various allopathic medicines, herbal products and their derivatives are prevalent and beneficial. Among various isolated drugs genus Terminalia is one with various unconditional benefits. From the above mentioned literature review revealed that's *T. catappa*, is an important ethnomedicinal plant with ability with diverse spectrum of pharmacological spectrum of ailments such as antioxidant, anti diabetic, antimicrobial, antifungal, anti-cocipetive, hepatitis treatment, Hypocholesterolemic, immunomodulatory, anti-helmentic, anti-viral, anti-aging, anti inflammatory, anti-cancer, anti-tumour, hermatological, anti-thelmintic aphrodisiac, wound healing, hermatological. Numerous phytoconstituents present in the plants are such as gallic acid, ellagic acid, corrilagin, alkaloid, flavonoid, protein, phytosteroid with fruit flesh, nut and flavonoids etc. have potent pharmacological benefits. Therapeutic potential of

medicinal plants is mainly due to their phenolic compounds present in fruit, vegetables, nuts, seeds, stems and flowers.

From the present study, it is concluded, that *T. catappa* nuts contain phenolics and flavonoid, which induces various antioxidant activities. Thus, *T. catappa* nuts might act as a good antioxidant. Due to the number of significant pharmacological response the plant can choose for preparation of medication and can be use instead of synthetic drugs to avoid the undesirable adverse action. In the upcoming era on basis of pharmaco-therapeutic benefits, further investigation research should be made to determine its authenticity in dosage forms for various health impairing conditions.

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