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MUSA PARADISIACA – A REVIEW ON PHYTOCHEMISTRY AND PHARMACOLOGY

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ABSTRACT

Musa paradisiaca is a monoherbacious plant belonging to the family Musaceae, distributed throughout the tropical and subtropical countries. The plant parts are widely used to treat different diseases in humans in traditional medicines, such as diabetes, diarrhea, dysentery, hypertension, hysteria, epilepsy, leprosy, hemorrhages, renal calculi and ulcers. The main pharmacological activities of this plant are antilithiatic, antioxidant, antibacterial, antidiabetic, antiulcer, antidiarrhoeal, hypocholesterolaemic, hepatoprotective, antisnakevenom, wound healing, hair growth promoting, antifungal and antimenorrhagic activity. This review presents information on morphology, traditional uses, phytochemistry and pharmacological activities of *Musa paradisiaca*.

KEYWORDS: *Musa paradisiaca*, antilithiatic, antioxidant, pharmacological activities.

INTRODUCTION

Medicinal plants are frequently used in traditional medicine to treat different diseases. The World Health Organization (WHO) estimated that 80 % of the earth's inhabitants depend on traditional medicine for their primary health care needs, and most of this therapy involves the use of plant extracts or their active components. This helped in exploration of different medicinal plants to find the scientific basis of their traditional uses [1]. Ayurveda and other Indian literature mention the use of plants in treatment of various human diseases. Use of herbal remedies for prevention and cure of ailments is of increasing interest due to the superiority and efficiency of activity provided by phytoconstituents in herbs and undesirable effects of modern medicine. Medicinal plants contain number of medicinal properties. One of such plant is *Musa paradisiaca*. It has been reported to have pharmacological activities such as antilithiatic, antioxidant, antibacterial, antidiabetic, antiulcer, antidiarrhoeal, hypocholesterolaemic, hepatoprotective, antisnakevenom, wound healing, hair growth promoting, antifungal and antimenorrhagic activity.

Taxonomy

Kingdom: Plantae
Subkingdom: Tracheobionta
Super division: Spermatophyta
Division: Magnoliophyta
Class: Liliopsida
Subclass: Zingiberidae
Order: Zingiberales
Family : Musaceae
Genus : Musa
Species : paradisiaca

Monographs

English : Banana tree
Hindi : Kelaa, Kelaa kaa phuul
Tamil : Vazhei
Telugu : Artipandu
Kannada : Balayhanu
Malayalam : Pisang
Gujarati : Kel phool
French : Banane
Thailand : Kluai

Distribution

Edible Bananas originated in the Indo-Malaysian region reaching to northern Australia. They were known in the Mediterranean region in the 3rd Century B.C and are believed to have been first carried to Europe in the 10th Century A.D. Early in the 16th Century, Portuguese mariners transported the plant from the West African coast to South America. It even spread into the Islands of the Pacific and to the West Coast of Africa as early as 200-300 BC. [2] In different countries about 300 varieties of bananas are grown, of which a vast majority have been growing in Asian, Indo-Malaysian and Australian tropics and are now widely found throughout the tropical and subtropical countries. India, Philippines, China, Brazil, Indonesia, Mexico, Colombia, Thailand are the top banana producing countries. Bananas and Plantains are today grown in every humid tropical region and

constitute the fourth largest fruit crop of the world, following the grape, citrus fruits and apple.

Morphology

The Banana plant, *Musa paradisiaca* often erroneously referred to as a "tree", is a large herb, with succulent, very juicy stem, which is a cylinder of leaf-petiole sheaths, reaching a height of 20 to 25 ft (6-7.5 m) and arising from a fleshy rhizome or corm. Leaves are tender, smooth, oblong or elliptic numbering 4 or 5 to 15, arranged spirally and they unfurl, as the plant grows, at the rate of one per week. The inflorescence, a transformed growing point, is a terminal spike shooting out from the heart in the tip of the stem. At first, it is a large, long-oval, tapering, purple-clad bud. As it opens, it is seen that the slim, nectar-rich, tubular, toothed, white flowers are clustered in whorled double rows along the floral stalk, each cluster covered by a thick, waxy, hood like bract, purple outside, deep-red within. Female flowers occupy the lower 5 to 15 rows. Above them may be some rows of hermaphrodite or neuter flowers. Male flowers are borne in the upper rows. The bracts are soon shed and the fully grown fruits in each cluster become a "hand" of Bananas, and the stalk droops with the weight until the bunch is upside down. The fruit turns from deep-green to yellow or red, or, in some forms, green- and white-striped.

Morphological view of *Musa paradisiaca*

TRADITIONAL USES

All parts of the Banana plant have medicinal uses. The flowers are used in treating bronchitis, dysentery, menorrhagia and ulcers. [3] Cooked flowers are used to treat diabetes. The astringent plant sap is given in cases of hysteria, epilepsy, leprosy, fevers, hemorrhages, dysentery and diarrhea, and it is applied on hemorrhoids, insect and other stings and bites. Young leaves are placed as poultices on burns and other skin afflictions. The astringent ashes of the unripe peel and of the leaves are taken in dysentery and diarrhea and are also used for treating malignant ulcers. The roots are administered in digestive disorders, dysentery and other ailments. It also has anthelmintic property. [4] Banana seed mucilage is given in cases of catarrh and diarrhea in India. Antifungal and antibiotic properties are found in the peel and pulp of fully ripe Bananas. The plant is also used in inflammation, pain and snakebite.

PHYTOCHEMISTRY

Prasobh et al., 2016 proved that the extracts of stem of *Musa paradisiaca* showed the presence of alkaloids, steroids like β-sitosterol, saponins, flavonoids like quercetin, reducing sugar, tannins and anthraquinones by chemical tests, UV, IR, Flame photometric and HPTLC studies. [5, 6]

Indera Mahkota et al., 2011 studied the phytochemical constituents and antioxidant activities in the flower of *Musa paradisiaca* extracts. The extracts from various solvents; petroleum ether, chloroform, ethanol and water were investigated for the presence of alkaloid, saponin, glycoside, tannin, flavonoid, terpenoid and steroid. Particular reagents were used to screen phytochemicals in the samples and their presence was indicated by the changes of color, precipitation or turbidity. Phytochemicals studies on banana flower extracts showed the presence of alkaloids, glycosides, steroids, saponins, tannins, flavonoids and terpenoids. Quantitative analysis by gravimetric method showed that the flower of *Musa paradisiaca* contains 1.56 ± 0.2 g/100g alkaloid and 1.43 ± 0.14 g/100g saponin. In spectrometric method, the flower also contains 5.83 ± 0.78 g/100g total phenolic, 88.31 ± 4.53 mg/100g tannin and 3.98 ± 0.01 mg/100g flavonoids. DPPH (1, 1-diphenyl-2-picrylhydrazyl) free radical scavenging assay of ethanol extract demonstrated stronger antioxidant activity than aqueous extract in which the IC50 value were 1.01 ± 0.16 mg/ml and 1.52 ± 0.13 mg/ml respectively.[7]

Adeolu et al., 2013 studied the proximate, mineral, vitamin and phytochemical constituents of plantain (*Musa paradisiaca*) bract flour as possible sources of nutrients in formulating animal feeds. The determinations were done using standard methods of analyses of Association Official Analytical Chemists and Atomic Absorption Spectrophotometric methods. The result of the proximate composition showed the following; moisture (9.53%), ash (7.83%), crude protein (11.47%), crude fat (1.83%), crude fibre (8.47%) and carbohydrate (60.87%). The mineral contents; Ca (135 mg/100g), Mg (18 mg/100g), P (151.67 mg/100g), K (40 mg/100g), Fe (14 mg/100g), Na (280 mg/100g). It also contained vitamin A (0.97 mg/100g), vitamin B2 – Riboflavin (0.5 mg/100g), vitamin B1 – Thiamine (0.2 mg/100g), vitamin B3 – Niacin (1.13 mg/100g) and vitamin C – Ascorbic acid (8.17 mg/100g). The phytochemical composition results revealed the presence of bioactive compounds such as alkaloids (24 mg/100g), tannins (115 mg/100g), flavonoids (145 mg/100g), phenols (4.5 mg/100g), saponins (563.33 mg/100g), phytates (46.67 mg/100g) and oxalates (30 mg/100g). The plantain wastes can be sources of nutrients in animal feed preparation, as they are high in protein, fibre, essential mineral content and phytochemicals. [8]

Shukla et al., 1973 studied the Carbohydrate metabolism in *Musa paradisiaca*. Considerable variations exist in the content of glucose, fructose, sucrose, starch and protein and in the activities of enzymes involved in carbohydrate metabolism between different parts of the banana plant (*Musa paradisiaca*). Sucrose synthetase is present in the highest concentration in rootstock and fruit pulp, and sucrose phosphate synthetase in the pseudo stem. The highest ratio of the activity of sucrose phosphate synthetase to sucrose synthetase is found in leaves. Acid invertase is present in leaves, leaf-sheath and fruit pulp and is not demonstrable in rootstock and pseudo stem. Neutral invertase activity is high in pseudo stem and leaf-sheath. Starch phosphorylase is largely concentrated in fruit pulp and rootstock. The maximum activity of ATP: D-phosphoglucose (ADPG) pyrophosphorylase is found in rootstock. β-Amylase is not demonstrable in rootstock and is largely concentrated in leaf-sheath. Hexokinase is most active in rootstock and the lowest in leaves. Acid phosphatase and alkaline phosphatase activity is highest in fruit pulp and pseudo stem. Glucose phosphate isomerase is most active in the rootstock and lowest in the leaves. [9]

Miabiye et al., 1996 studied the Chemical analyses for the elementary compositions of the ashes of the fruit peels and trunks of the tropical plantain *Musa paradisiaca* . The elements, categorized as trace elements, generally are found to have higher mean concentrations in the fruit peels than in the trunks (except in the case of Zn). Their peel-trunk uptake ratios have been calculated and range between 1 and 4, showing normal levels of accumulations in the fruit peels over the trunks. [10]

Surjeet Singh et al., 1975 identified three forms of α-glucan phosphorylase from mature banana fruit pulp separated by ammonium sulfate fractionation and DEAE-cellulose chromatography, were anodic at pH 8·6 on starch gel electrophoresis. The three forms differed in sensitivity to the phenolics extracted from immature and mature banana fruit pulp. Only two forms of the enzyme were detected in immature banana fruit pulp. [11]

Alexandra Pazmino Duran et al., 2001 identified Anthocyanins from banana bracts (*Musa paradisiaca).* Anthocyanins were extracted with acidified methanol, purified FOO using C-18 resin, and characterized by UV-visible spectroscopy, physicochemical reactions, HPLC, and electrospray mass spectrometry. Monomeric anthocyanin content was 32.3 mg/100 g bracts on a cyanidin-3-rutinoside basis. Color characteristics (Hunter CIE *L*hc*) of a solution (absorbance of 0.3, 520 nm, pH 3.5), were *L**=86.8, *h*=44.2 and *c*=12.7. Cyanidin-3-rutinoside represented ~80% of the total pigment. Other anthocyanins were 3-rutinoside derivatives of delphinidin, pelargonidin, peonidin and malvidin. One acylated anthocyanin (~2% of the pigment) was found but not identified. Acid hydrolysis of anthocyanins revealed the concomitant presence of six more common anthocyanidins (delphinidin, cyanidin, petunidin, pelargonidin, peonidin and malvidin) suggesting that, besides being a good pigment source, it could also be a useful tool for anthocyanin identification.[12]

Madhulika Baijal et al., 1972 studied the activities of starch phosphorylase, β-amylase, phosphohexoisomerase, acid and alkaline invertase, sucrose synthetase, sucrose phosphate synthetase and acid and alkaline phosphatase in various parts of the banana plant, using homogenates prepared in media supplemented with polyvinylpyrrolidone or Triton X-100. The results indicated that the supplement of choice depended on the enzyme and the tissue under study. [13]

Dae Sik Jang et al., 2002 isolated a new bicyclic diarylheptanoid, *rel*-(3*S*,4a*R*,10b*R*)-8-hydroxy-3-(4-hydroxyphenyl)-9-methoxy-4a,5,6,10b-tetrahydro-3*H*-naphtho[2,1-*b*]pyran (1), as well as four known compounds, 1,2-dihydro-1,2,3-trihydroxy-9-(4-methoxyphenyl) phenalene (2), hydroxyanigorufone (3), 2-(4-hydroxyphenyl) naphthalic anhydride (4), and 1,7-bis(4-hydroxyphenyl)hepta-4(*E*),6(*E*)-dien-3-one (5), from an ethyl acetate-soluble fraction of the methanol extract of the fruits of *Musa paradisiaca* cultivar, using a bioassay based on the induction of quinone reductase (QR) in cultured Hepa1c1c7 mouse hepatoma cells to monitor chromatographic fractionation. The structure and relative stereochemistry of compound 1 were elucidated unambiguously by one- and two-dimensional NMR experiments and single-crystal X-ray diffraction analysis. Isolates 1−5 were evaluated for their potential cancer chemo preventive properties utilizing an *in vitro* assay to determine quinone reductase induction and a mouse mammary organ culture assay.[14]

PHARMACOLOGICAL ACTIONS

Antilithiatic activity

Many Indian plants have been quoted to be useful as antilithiatic agents. They are effective and inexpensive. One such plant is *Musa paradisiaca*. Kalpana Devi et al., 1993 investigated the effect of *Musa paradisiaca* stem kernel juice in experimental urolithiatic rats. The extract was administered through oral route at a dosage of 1.5 ml/ rat/day. Stone forming rats exhibited a significant elevation in the activities of two oxalate synthesizing enzymes - Glycollic acid oxidase and Lactate dehydrogenase. Deposition and excretion of stone forming constituents in kidney and urine were also increased in these rats. The enzyme activities and the level of crystalline components were lowered with the extract after treatment. The extract also reduced the activities of urinary alkaline phosphatase, lactate dehydrogenase, r-glutamyl transferase, inorganic pyrophosphatase and β-glucuronidase in calculogenic rats. No appreciable changes were noticed with leucine amino peptidase activity in treated rats. [15]

Gopakumara pillai 1995 observed the core of the pseudo stem of *Musa Paradisiaca* is used in the treatment of

urinary stones. Seventy one patients diagnosed to be suffering from urolithiasis were treated with juice of the core of the pseudostem of *Musa Paradisiaca* and *Musa sapientum*. A significant segment of them passed out after consuming the drug for two weeks. Recurrence of stone formation was also prevented by the treatment. Results suggested that the plant material is quite effective in curing urolithiasis, especially the calcium oxalate stones. [16]

Prasobh et al., 2014 studied the use of *Musa* species in the management of renal calculi. *Musa AAB* formulations were used. A significant decrease in the size of kidney stone under *invitro* condition was observed. This is due to the presence of organic constituents like β-sitosterol, quercetin, tannins, saponins and inorganic constituents like magnesium, potassium and nitrate. The result from these experiment demonstrate the potential of concentrated *Musa AAB* formulations extract was a good natural remedy against kidney stone. The recent treatment of urolithiasis involves NSAID's, Antidiuretics and Extracorporeal Shock Wave Lithotripsy. Recurrence is quite common with these therapies. The liquid of the *Musa* AAB formulations may be useful to overcome the major drawback of surgical procedures which is reoccurrence of stones**.** [17]

Joy et al., 2012 described that the stem juice of *Musa paradisiaca* is more effective in preventing the reoccurrence of renal stones. [18] Surgical treatment & Extracorporeal shock wave lithotripsy causes some problems like long term renal damage, hypertension and reoccurrence of stones. Literature proves that litholytic herbs for treatment of renal stones are used since ancient periods and are found to prevent reoccurrence of stones. Herbal drugs are reported to be effective with no side effects. [19, 20]

Tirumala et al., 2013 investigated the aqueous extract of stem core of *Musa paradisiaca* on ethylene glycol and ammonium chloride induced urolithiasis in rats. Dose selection was made on the basis of acute oral toxicity study (200 mg/kg-1,400 mg/kg-1 body weight) as per OECD guidelines. Oral administration of extract of *Musa paradisiaca* for 28 days resulted in significant reduction in urine level, results suggests that the aqueous extracts of stem core of *Musa paradisiaca* restored the metabolic changes in ethylene glycol and ammonium.[21]

Antioxidant Activity

Sidiqat Adamson Shodehinde et al., 2013 evaluated and compared the antioxidant activities of the aqueous extracts of unripe plantain (*Musa paradisiaca*) and assessed their inhibitory action on sodium nitroprusside induced lipid peroxidation in rat pancreas *in vitro* and also characterized the main phenolic constituents of the plantain products using gas chromatography analysis. Aqueous extracts of plantain products (raw, elastic pastry, roasted and boiled) flour of 0.1 g/mL (each) were used to determine their total phenol, total flavonoid, 1,1 diphenyl-2 picrylhydrazyl (DPPH) and hydroxyl (OH) radical scavenging ability. The results revealed that all the aqueous extracts showed antioxidant activity. The boiled flour had highest DPPH and OH radical scavenging ability while raw flour had the highest Fe^{2+} chelating ability, sodium nitroprusside inhibitory effect and vitamin C content. The antioxidant results showed that elastic pastry had the highest total phenol and total flavonoid content. Characterization of the unripe plantain products for polyphenol contents using gas chromatography showed varied quantity of apigenin, myricetin, luteolin, capsaicin, isorhaemnetin, caffeic acid, kampferol, quercetin, p-hydroxybenzoic acid, shogaol, glycitein and gingerol per product on the spectra. Thus the antioxidant activities and ability to inhibit lipid peroxidation of unripe plantain was proved.[22]

Nataraj Loganayaki et al., 2010 Compared the chloroform, acetone, and methanol extracts from stem and flower of banana (*Musa paradisiaca*) and leaves, stem, and flowers of mustai (*Rivea hypocrateriformis*) & were evaluated for their *in vitro* antioxidant activity using ferric reducing antioxidant power (FRAP), 2,2-diphenyl-1-picryl-hydrazyl ($DPPH^{\bullet}$), 2,2′azinobis (3-ethylbenzothiozoline-6-sulfonic acid) diammonium salt ($ABTS^{\bullet+}$), iron chelation, and antihemolytic activity. Among the solvents used, methanol gave the maximum yield in banana, whereas in night glory acetone was reported to having higher extractive value. The total phenolic content was also higher in these extracts. The antioxidant potential of the extracts was well established with their $DPPH^{\bullet}$ and $ABTS^{\bullet+}$ radical scavenging activities and ferric reducing antioxidant capacity. The potential of multiple antioxidant activity of samples can be further evidenced by inhibition of reactive oxygen mediated erythrocyte cell lysis and metal ion chelating activity. The results implied that the leaves, stem, and flowers of banana, and mustai could be considered as health supplements and nutraceuticals/functional foods.[23]

Methanol extracts of banana flowers possess antioxidant properties and thereby stabilize the free radicals formed as a result of various metabolic processes in the body. If the free radicals are not neutralized, their unstable electrons react with the DNA and proteins of human cells and alter their properties. This can lead to several chronic conditions, including cancer and heart disease. So banana flower extracts can be used to make health supplements due to its antioxidant potential. Thus Loganayaki et al., 2010 proved the antioxidant effect of *Musa paradisiaca.*[23]

Sanjeev Kumar et al., 2012 studied the antioxidant activities of green banana and yellow peel of *Musa paradisiaca*. The antioxidant behavior of the extracts was evaluated by using the thiocyanate method, ß-carotene bleaching method and 1, 1-diphenyl-2-picrylhydrazyl (DPPH) free radical elimination.

Antioxidant activity of water extracts was comparable to those of synthetic antioxidants such as butylated hydroxyanisole and butylated hydroxytoluene and it showed a significant antioxidant property. The antioxidant effects of crude extracts from green banana and yellow peel were investigated and the results indicated that the extract of green peel recorded more significant activities than that of yellow peel at other solvents extracts. [24]

Vijayakumar et al. 2008 reported the antioxidant activity of the extracted flavonoids from. *Musa paradisiaca* in rats. They found that the flavonoids from banana stimulated the activities of superoxide dismutase (SOD) and catalase which might be responsible for the reduced level of per oxidation products such as malondialdehyde, hydro peroxides and conjugated dienes. [25] Based on the results it was suggested that *Musa paradisiaca* had a strong antioxidant activity.

Bashir Ado Ahmad et al., 2015 studied the radical scavenging activity of various banana extracts in comparison to pure syringin and the total phenolic contents of the extracts. The banana parts were prepared and extracted by cold extraction technique and the extracts obtained were used to carry out some phytochemical screening by Trease and Evans method. The ability of the extract to scavenge free radicals was measured using 2, 2-diphenyl-1-pcrylhydrazyl radical using quercetin as a reference radical scavenger by the method of Gyamfi. Further analysis of total phenolic contents present in the extracts was carried out using Singleton and Rossi method. Tepal methanol extract was found to have the highest radical scavenging activity compared to others, such as tepal ethanol, tepal aqueous, skin methanol, flesh methanol and pure syringin. The IC_{50} value of the tepal methanol extract was found to be 22.5 µg/ml. The highest total phenolic contents (expressed as microgram of Gallic acid equivalent per gram of the extracts) were found in tepal methanol extract (8000 µg/g) and the least in Flesh methanol extract (2150 µg/g).The results from this study showed that tepal banana extracts possess very good radical scavenging activity and as well the largest amount of phenolic contents, which could introduce phenols as the main radical scavenger in banana extracts and offering effective protection from free radicals. [26]

Jayamurthy et al., 2013 studied the free radical scavenging capacity and antioxidant activities of methanolic extracts of inflorescence and stem core of plantain and were evaluated in terms of total phenolic content, 1, 1 diphenyl-2 picryl hydrazyl (DPPH) radical scavenging activity (RSA), superoxide RSA, metal chelation and total reducing power, and the results were compared with the standard antioxidants like gallic acid, trolox and butylated hydroxy anisole. The results from the study showed that the methanolic extracts of plantain inflorescence and stem were able to effectively scavenge the free radicals. The plantain flower and stem samples showed promising metal chelating (IC_{50}– 204.9 and 417.4 µg/mL, respectively), DPPH radical scavenging (IC_{50}– 186.5 and 1,745.3 µg/mL, respectively) and reducing power with maximum superoxide scavenging activity (IC_{50}– 195.03 and 384.05 µg/mL, respectively). The results showed that plantain inflorescence possessed greater antioxidant potential as compared with the stem.[27]

Antibacterial activity

Ponmurugan et al., 2013 investigated different *Musa* species leave extracts of hexane, ethyl acetate and methanol of *Musa acuminate Colla, Musa troglodytarum, Musa sapientum* and *Musa paradisiaca* for antibacterial activity against multi-drug resistant pathogens causing nosocomial infection by agar well diffusion method. Antibacterial susceptibility test, minimum inhibitory concentration and minimum inhibitory bacterial concentration were determined All the *Musa* sp. extracts showed moderate antibacterial activities expect *Musa paradisiaca* with the inhibition zone ranging from 8.0 to 18.6 mm. Among four species, ethyl acetate extracts of *Musa paradisiaca* showed highest activity against tested pathogens particularly *E. coli*, *P.aeruginosa* and *Citrobacter* species. The minimum inhibitory concentrations were within the value of 15.63- 250 µg/mL and minimum bactericidal concentrations were ranging from 31.25- 250 µg/mL. The study concluded that among the different *Musa* species, *Musa paradisiaca* displayed efficient antibacterial activity followed by *Musa acuminata* against multi-drug resistant nosocomial infection causing pathogens.[28]

Suraj Premal Kapadai et al., 2015 studied the antimicrobial activity of banana peel extract on *Porphyromonas gingivalis* (*P. gingivalis*) and *Aggregatibacter actinomycetemcomitans* (*A. actinomycetemcomitans*). The banana peel extract was prepared, and the antibacterial activity was assessed using well agar diffusion method and minimum inhibitory concentration was assessed using serial broth dilution method. In the study, both the tested microorganisms showed antibacterial activity. In well diffusion method, *P. gingivalis* and *A. actinomycetemcomitans* showed 15 mm and 12 mm inhibition zone against an alcoholic extract of banana peel. In serial broth dilution method *P. gingivalis* and *A. actinomycetemcomitans* were sensitive until 31.25 µg/ml dilutions. From the results, it is suggested that an alcoholic extract of banana peel has antimicrobial activity against *P. gingivalis* and *A. actinomycetemcomitans*.[29]

Karadi et al., 2011 studied the *in vitro* antimicrobial effect of crude extract of *Musa paradisiaca* and *Cocos nucifera* on bacteria *Escherichia coli, Staphylococcus aureus, Bacillus subtilis, Pseudomonas aeruginosa* and fungi Candida albicans, Candida tropicalis & Aspergillus niger. The agar disc diffusion method was used to

determine the inhibitory effect of both the test plants. Both the plants extract showed inhibitory effect on test organisms. The extract of *Musa paradisiaca* produced wider zones of inhibition against Candida albicans, than the crude extract of *Cocos nucifera*. [30]

Sunil Jawla et al., 2012 studied the antimicrobial and antihyperglycemic activities of *Musa paradisiaca* flowers. The EtOH and EtOH: water (1:1) extracts of *Musa paradisiaca* flowers were screened for antibacterial activity against standard strains of *Bacillus subtilis, Bacillus cereus, Escherichia coli, Klebsiella pneumoniae, Proteus mirabilis, Pseudomonas aeruginosa Streptococcus pneumoniae, Staphylococcus aureus, Salmonella typhimurium and Candida albicans* against amikacin and clotrimazole respectively. Both the extracts were also administered to normal and alloxan induced diabetic rats. The blood glucose levels were measured daily after oral administration of extracts at doses of 100, 250 and 500 mg/(kg.d). The EtOH and EtOH: water (1:1) extracts exhibited antimicrobial activity with minimum inhibitory concentrations ranging from 5.62-25.81 and 7.60-31.50 g/mL respectively. Both the extracts reversed the permanent hyperglycemia within a week in alloxan induced diabetic rats. The EtOH extract (250 mg/kg) was found to be 7.69% more potent hypoglycemic effect than standard oral hypoglycemic drug, glibenclamide 0.2 mg/kg b.w., respectively. The alcoholic extracts of *Musa paradisiaca* flowers showed potent antihyperglycemic and moderate antimicrobial activity.[31]

Iqbal Ahmed et al., 2001 studied the Ethanolic extracts of 45 Indian medicinal plants traditionally used in medicine for their antimicrobial activity against certain drug-resistant bacteria and a yeast *Candida albicans* of clinical origin. Of these, 40 plant extracts showed varied levels of antimicrobial activity against one or more test bacteria. Anticandidal activity was detected in 24 plant extracts. Overall, broad-spectrum antimicrobial activity was observed in 12 plants (*L. inermis, Eucalyptus* sp., *H. antidysentrica, H. indicus, C. equistifolia. T. belerica, T. chebula, E. officinalis, C. sinensis, S. aromaticum* and *P. granatum*). No correlation was observed between susceptibility of test strains with plant extracts and antibiotic resistance behaviour of the microbial strains (*Staphylococcus aureus, Salmonella paratyphi, Shigella dysenteriae, Escherichia coli, Bacillus subtilis, Candida albicans*). Qualitative phytochemical test & thin layer chromatography of certain active extracts demonstrated the presence of common phytocompounds in the plant extracts including phenols, tannins and flavonoids as major active constituents.[32]

Mumtaz Jahan 2010 described that the ethanol-based extracts of banana flowers inhibit the growth of pathogenic bacteria such as *Bacillus subtilis, Bacillus cereus*, and *Escherichia coli* in the laboratory and may help heal wounds and prevent infections. [33]

Antidiabetic activity

Sanjeev Kumar et al., 2012 studied the antidiabetic activities. Methanolic extracts of mature green fruit of *Musa paradisiaca* in normal and Streptozocin treated diabetic mice using Chlorpropamide as antidiabetic agent. MEMP (100-800 mg/kg, p.o) showed significant dose related ($p<0.05 - 0.001$) reduction in the blood glucose concentration in normal and diabetic mice. Chlorpropamide (250 mg/kg p.o) also produced significant ($p<0.01$ and $p<0.001$) reduction in the blood glucose concentration in normal and diabetic mice. [24]

Santosh Kumar Singh et al., 2007 studied the effect of *Musa paradisiaca* stem juice on blood glucose level (BGL) of normal & diabetic rats. The dose of 500 mg/kg bodyweight produces a significant rise of 28.3% in blood glucose level after 6h of oral administration in normal rats. Whereas, in sub diabetic rats the same dose produces a rise of 16.4% in blood glucose levels within 1h during glucose tolerance test (GTT) and a rise of 16% after 4 h in fasting blood glucose levels of severe diabetic cases.[34] This proves the antidiabetic activity of *Musa paradisiaca.*

Antiulcer activity

Surbhi Gupta *et al.*, 2001 described the antiulcer activity. Extracts of plantain *Musa paradisiaca* was studied on the accumulation of eicosanoids in incubates of human gastric and colonic mucosa. The ethanol extracts caused a concentration dependent increase in the eicosanoid but the water extract was ineffective. Methanolic extracts of plantain banana pulp was evaluated for its antiulcer and antioxidant activities in 2 hr cold restraint stress and anti *H. pylori* activity *in vitro*. The extract (50mg/kg twice daily for 5 days) showed significant antiulcer effect and antioxidant activity in gastric mucosa homogenates where it reversed the increase in ulcer index, lipid per oxidation and superoxide dismutase values induced by stress. [35]

Pannangpetch et al., 2001 reported that the antiulcerative effect of banana may vary depending on different varieties of banana. They showed that the ethanolic extract of both *Musa.sapientum* and *Musa paradisiaca* has significant gastro protective effect but only *Musa paradisiaca* promotes ulcer healing by a similar mechanism like prostaglandins. [36]

Antidiarrhoeal activity

Sampath Kumar et al., 2012 discussed the antidiarrhoeal activity. The banana pectin (a soluble polymer) can help normalize bowel movement and stop constipation. However, intake of banana may benefit people suffered from diarrhea. In a study, 31 patients with diarrhea and receiving enteral feedings were randomized to receive either banana flakes or medical treatment for diarrhea. The researchers found that the banana flake group had fewer diarrheas clinically; with 57% of the subject's were diarrhea free on their last study day when compared

to 24% of the medically treated subjects. [37]This study proves the antidiarrhoeal activity of *Musa paradisiaca.*

Block et al., 1941 studied the antidiarrhoeal activity of banana in rats. The effect in the intestinal diseases was attributed to the pectin content of banana. Later banana diet was reported to be effective and advantageous in bacillary dysentery in a proctoscopic study on 127 patients of age nine month to forty eight years.[38]

Antidiarrhoeal activity of Banana flakes was also studied by Emery et al., 1997. Banana flakes were tested and found effective in the treatment of diarrhea in critically ill patients receiving enteral feedings.[39]

Rabbani et al., 2001 described that the antidiarrhoeal activity of green banana diet was found very effective in children with diarrhea. [40]The easy digestibility and nutritional content make ripe banana an excellent food, particularly suitable for young children and elderly people as they contain considerable amounts of vitamin B6, vitamin C, and potassium was discussed by Debaandya M et al., 2010. These studies prove the antidiarrhoeal activity of banana flakes of *Musa paradisiaca*.[41]

Hypocholesterolaemic activity

Vijayakumar et al., 2009 carried out the hypocholesterolaemic activity of *Musa paradisiaca.* In a study of male rats on a diet containing lard (50 g/kg) and cholesterol (5 g/kg), freeze-dried banana pulp showed a marked cholesterol-lowering effect when incorporated into a diet at the level of 300 or 500 g/kg, while the hot-air dried banana pulp did not show the effect. Flavonoids isolated from unripe fruits showed hypolipidemic activity evidenced by decrease in cholesterol, triglycerides, free fatty acids and phospholipids levels in serum, liver, kidney and brain of rats. The cholesterol lowering effect was attributed to a higher degradation rate of cholesterol than synthesis. [25]

Hamendra Singh Parmar et al., 2007 studied the protective role of *Citrus sinensis*, *Punica granatum*, and *Musa paradisiaca* peel extracts in diet-induced atherosclerosis and thyroid dysfunction in rats. Wistar albino male rats were fed an atherogenic diet composed of 4% cholesterol, 1% cholic acid, and 0.5% 2-thiouracil (CCT) for 14 days to induce atherosclerosis and were then treated with one of the standardized doses of a peel extract (25 mg/kg of *C sinensis*, 200 mg/kg of *P granatum*, or 100 mg/kg of *Musa paradisiaca*) for 10 consecutive days. At the end of the experimental period, changes in the levels of different serum lipids, thyroid hormones, insulin, and tissue and serum lipid peroxidation were determined in rats. In addition, histologic evaluation of liver, heart, and kidney were compared between the CCT-fed rats and those that received both the CCT diet as well as the peel extracts. In rats fed the CCT diet alone, there was an increase in tissue lipid peroxidation, serum lipids, and glucose, with a parallel decrease in the levels of triiodothyronine and thyroxine, insulin, and high-density lipoprotein cholesterol. Abnormal histological observations such as fatty liver with vacuolated hepatocytes, fatty cyst and nucleus pushed to periphery, and increased cardiomyocyte width and mild damage in renal tissues were seen in these rats. Simultaneous treatment with *C. sinensis*, *P.granatum*, or *M.paradisiaca* extract ameliorated most of the biochemical and histopathologic alterations induced by the CCT diet, suggesting the protective role of these fruit peels against diet-induced atherosclerosis and thyroid dysfunction.[42]

Mallick et al., 2006 studied the hypocholesterolaemic activity. Methanolic root extract of *Musa paradisiaca* showed total cholesterol, triglyceride, LDL and VLDL lowering effect in diabetic rats.[43]

Hepatoprotective activity

Sanjeev Kumar et al., 2012 studied the hepatoprotective activity of *Musa paradisiaca.* To investigate the hepatoprotective activity of stem of *Musa paradisiaca* in CCl4 and paracetamol induced hepatotoxicity models in rats, the aqueous and alcoholic extracts was utilized. Administration of hepatotoxins (CCl4 and Paracetamol) showed significant biochemical and histological deteriorations in the liver of experimental animals. Pretrement with alcoholic extract (500 mg/kg) more significantly and to a lesser extent the alcoholic extract (250 mg/kg) and aqueous extract (500 mg/kg), reduced the elevated levels of the serum enzymes like serum glutamic-oxaloacetic transaminase (SGOT), Serum glutamic pyruvic transaminase (SGPT), Alkaline phosphatase (ALP) and bilirubin levels, Also alcoholic and aqueous extracts reversed the hepatic damage towards the normal, which gives the evidence of hepatoprotective activity of stem of *Musa paradisiaca.*[24]

Nirmala et al., 2012 investigated the hepatoprotective activity of stem of *Musa paradisiaca* in CCl4 and paracetamol induced hepatotoxicity models in rats. Hepatoprotective activity of alcoholic and aqueous extracts of stem of *Musa paradisiaca* was demonstrated by using two experimentally induced hepatotoxicity models. Administration of hepatotoxins (CCl4 and paracetamol) showed significant biochemical and histological deteriorations in the liver of experimental animals. Pretreatment with alcoholic extract (500 mg/kg), more significantly and to a lesser extent the alcoholic extract (250 mg/kg) and aqueous extract (500 mg/kg), reduced the elevated levels of the serum enzymes like serum glutamic-oxaloacetic transaminase (SGOT), serum glutamic pyruvic transaminase (SGPT), alkaline phosphatase (ALP) and bilirubin levels and alcoholic and aqueous extracts reversed the hepatic damage towards the normal, which further evidenced the hepatoprotective activity of stem of M.paradisiaca. Thus the alcoholic extract at doses of 250 and 500 mg/kg, p.o. and aqueous extract at a dose of 500 mg/kg, p.o. of stem

of *Musa*. *paradisiaca* have significant effect on the liver of CCl4 and paracetamol induced hepatotoxicity animal models.[44]

Iweala et al., 2011 investigated the biochemical and histological effects of consumption of *Musa paradisiaca*-supplemented diet in hepatotoxic rats. Twenty-four rats were divided into four hepatotoxic and non-hepatotoxic groups and fed a *Musa paradisiaca*-supplemented diet. The parameters measured included alanine transaminase, aspartate transaminase, total protein, glucose, total triglycerides, total cholesterol, reduced glutathione, lipid peroxidation and packed cell volume. Histological changes in tissue sections of liver and testes were also examined. The results obtained showed that alanine transaminase and aspartate transaminase did not significantly change except in the hepatotoxic control group which showed an increase in aspartate transaminase. Cholesterol and triglycerides were significantly ($p<0.05$) increased in the hepatotoxic group fed *Musa paradisiaca*-supplemented diet. Protein and reduced glutathione levels were significantly ($p<0.05$) increased in non-hepatotoxic rats fed *Musa paradisiaca*-supplemented. Lipid peroxidation, glucose and PCV levels were not significantly altered in all the groups. The consumption of a *Musa paradisiaca*-supplemented diet did not significantly change the weight of the animals. Histological observations of tissue sections of liver showed necrosis in the hepatotoxic rats and varying regeneration in the groups fed *Musa paradisiaca*-supplemented diet while there were no changes in the histology of the testes in all the groups.[45]

Oluwole Israel Oyewole et al., 2015 studied the protective role of aqueous root extract of *Musa paradisiaca* on arsenic chloride-induced oxidative damage in the liver and kidney of albino rats. Twenty four albino rats were grouped in to four (A, B, C and D). Group A served as the control and received distilled water while B, C and D were administered 10 mg/kg bw of arsenic chloride weekly. Groups C and D were treated with 200 and 500 mg/kg bw of aqueous extract of *Musa paradisiaca* roots respectively for 28 days while group B was left untreated. Phytochemical screening carried out on the root powder indicated the presence of tannins, terpenoids, steroids, sarponins, cardiac glycosides and flavonoids. Arsenic chloride induced a significant elevation in aminotransferases (ALT and AST), ALP and total bilirubin and reduction in serum protein and albumin indicating derangement of liver function. Significant elevation of serum creatinine, urea, uric acid, blood urea nitrogen and electrolytes levels were also recorded in arsenic intoxicated rats indicating disruption of kidney function. Histological examination of the kidney and liver of arsenic intoxicated rats also indicated significant alteration in tissue architecture and morphology. There was significant increase in the liver and kidney weight index in arsenic treated groups compared to the control indicating tissue inflammation. Treatment of rats with different doses of *Musa paradisiaca* root extract significantly ($P<0.05$) normalized liver and kidney functions while it also restored normal tissue histology at the end of the experiment. It was reported that *Musa paradisiaca* contain bioactive constituents capable of protecting the living system against arsenic-induced disruption of liver and kidney functions in rats.[46]

Anti-snake venom activity

Prasobh et al., 2014 studied the anti-snake venom activity. Plantain juice is used as an antidote for snake bite. The roots can arrest hemoptysis and possess strongly astringent and anthelmentic properties.[17]

Borges et al., 2005 reported the *invitro* neutralizing capacity of *Bothrops jararacussu* and *Bothrops neuwiedi* snake venoms by the stem juice of *Musa paradisiaca*.The phospholipase A2 (PLA2) and hemorrhagic activities induced by the venom was inhibited by the extract as it forms unspecific complex with the venom protein. However, the *in vivo* activity of the extract in mice was not significant to protect against the venom[47]

Wound healing activity

Mokbel et al., 2005 studied the wound healing activity of *Musa paradisiaca.* The rats were given graded dose of (50-200 Kg/day) of aqueous and methanol extract of *Musa paradisiaca* orally for a period of 10-21 days depending upon the type of study. The extract when studied for incision and dead space wounds parameters increased wound breaking strength and levels of hydroxyl proline, hexuronic acid, hexosamine, superoxide dismutase, reduced glutathione in the granulation tissue and decreased the percentage of wound area, scar area. When compared with the control group the extracts showed good results.[48]

Hair Growth promoting activity

Andrade et al., 2008 carried out the hair Growth promoting activity of *Musa Paradisiaca* .The extract of *Musa Paradisiaca* unripe fruit when tested for the hair growth activity was assayed by studying hair length and microscopic study of follicles in vehicle control, 2% minoxidil treated and extracts treated animals. The findings suggest that extract of *Musa Paradisiaca* unripe fruit has potential as a hair growth promoter. An extract of the trunk's juice can be used to massage scalp to promote healthy growth of hair and preventing hair loss.[49]

Sampath Kumar et al., 2012 described that Banana is rich in Potassium, Natural oils, Carbohydrates and Vitamins. These help in softening the hair and protect the hair's natural elasticity preventing split ends and breakage. Bananas when used for hair have a number of benefits such as it creates manageability, shine, growth and controls dandruff.[37]

Antifungal activity

Effect of plantain *Musa paradisiaca* peel and stalk extracts were investigated by Okorondu et al., 2012 for determining the antifungal action, using percentage inhibition test. Complete inhibition of growth (100%) was observed for Aspergillus niger, Aspergillus oryzae and Rhizopus stolonifer at 1.0 mg/ml concentration of stalk extract. Peel extract inhibited A. niger 100%, A. oryzae 76.67% and R. stolonifer 56.67% at the same concentration. As concentration reduces, growth inhibition reduces also up to the minimum inhibitory concentration. The results justify that the plant extracts were able to inhibit and kill the growth of spoilage fungi and this implies that the extract in appropriate doses can be used in food preservation and to treat infections caused by this spoilage fungi. The results further justify the claim that *Musa paradisiaca* stalk and peel extract demonstrated antifungal action in which methanol was seen to be a better solvent for extracting active ingredients from medicinal plants considering the high susceptibility of test organisms to methanol extract than ethanol extract.[50]

Antimenorrhagic activity

Consuming one cooked banana flower with one cup of curd or yogurt is one of the most efficient ways of treating excessive bleeding during menstruation. The cooked banana flower and curd combination increases the level of progesterone in the body and thereby reduces bleeding associated with menorrhagia. The flowers are also taken as an infusion in normal doses for painful menstruation. Thus Sampath Kumar et al., 2012 described the antimenorrhagic activity of banana flower.[37]

CONCLUSION

Medicinal plants have attracted considerable global interest in recent years. *Musa paradisiaca* is a medicinal plant with diverse pharmacological activities. The main pharmacological activities of this plant are antilithiatic, antioxidant, antibacterial, antidiabetic, antiulcer, antidiarrhoeal, hypocholesterolaemic, hepatoprotective, antisnakevenom, wound healing, hair growth promoting, antifungal and antimenorrhagic activity. Due to the medicinal properties there is enormous scope for future research on *Musa paradisiaca*. It is of great importance to carry out further research to investigate the unexploited potential of this plant for the discovery of safer drugs.

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