



## REVIEW ON *INVIVO* AND *INVITRO* STUDIES ON THE PHARMACOLOGICAL ACTIVITIES OF *MUSA* SPECIES

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### ABSTRACT

*Musa* species, commonly known as banana, is one of the valuable plant species having a number of pharmacological activities. All parts of the plant including fruits, stem, leaves and flowers are used for its nutritional as well as therapeutic effect. Studies show that *Musa* species having various activities like ulcer protective activity, immunomodulatory potential, anthelmintic activity, Anti-diabetic activity, antibacterial, antioxidant, anti cancer and anti HIV activity. The aim of this article is to review *invivo* and *invitro* pharmacological studies of *Musa* species. This review helps to explore the medicinal value of *Musa* species for the initiation of further extensive research on other possible biological activities as well as for the development of new generic drugs for the better treatment of uncontrolled diseases.

**Keywords:** *Musa* species, pharmacological activity, *in vivo* and *in vitro* studies.

### INTRODUCTION

It is widely accepted that there is an increasing use of herbal remedies or phytomedicines by the general public to replace or complement conventional medicines. Recently, the World Health Organization (WHO) estimated that 80% of the people worldwide rely on herbal medicines for some part of their primary healthcare<sup>1</sup>. Of the 250,000 to 300,000 plant species, only 5000 have been studied exhaustively for possible medical application. Hence our medicinal future is bright if the integrity of these plants and their growing conditions can be

maintained. Also the WHO has emphasized the need to ensure the quality of medicinal plant products using modern controlled techniques and applying suitable standards. The goal of modern phytochemical research is to develop preparations derived from herbal drugs of traditional medicine to meet present day international standards of quality, safety and efficacy<sup>2</sup>.

*Musa* species is one of the valuable plant species having nutritional as well as therapeutic value. It is commonly known as banana which is an antique fruit crop of the world and known as “Apple of the Paradise”. It is a cheapest and plentiful fruit and extensively consumed by the people all over the world. Botanically, it belongs to the family Musaceae in the order Zingiberales (formerly Scitaminae). The banana is an herbaceous (does not have woody components) plant with height varies from 2-8 meters. Banana plant is perennial (can live for more than 2 years) and monocarpic which means, the shoot can flower only once and will die after the fruit is produced. They can be divided into different groups according to chromosome numbers and ploidy as well as characteristics by two ancestors, *Musa acuminata* (genome type A) and *Musa balbisiana* (genome type B)<sup>3</sup>.

Banana and plantains are continuously exhibiting a spectacular growth worldwide. Its year round availability, affordability, varietal range, taste, medicinal and nutritive value makes it a favorable fruit among all classes of people with good export potential. At the world level 105.32 million tonnes of banana is produced from an area of 5.14 million ha with the average productivity of 20.7 tonnes/ha during 2012 ((FAO, 2012). India is the largest producer of banana in the world, producing 28.45 million tonnes from an area of 8.16 lakh hectares with a productivity of 35.7MT/ha. Although India accounts for only 11.9% in area, it accounts for 37.2% of world's production. Thus banana has emerged as one of the important fruit crops, which is in the easy reach of common man. There is also a considerable scope for the export of banana and its products, which further enhances the demand<sup>2</sup>.

### **Taxonomical classification**

Kingdom : Plantae  
Division : Magnoliophyta  
Class : Liliopsida  
Order : Zingiberales  
Family : Musaceae  
Genus : Musa  
Species : *Musa paradisiaca*, *Musa sapientum*, *Musa acuminata* etc.

## NUTRITIONAL IMPORTANCE

Banana is rich of starch and it is a rich source of potassium. Musa family contains starch, fructosans, phenolic acid, anthocyanins, terpenoids and sterols. In unripe plantains, starch is present over 80% of dry weight of the pulp. Fat content of plantains and bananas are very less about 0.5% and so fats do not contribute much to the energy content. The total protein value of plantain is relation to dry weight is more than 3.5% in ripe pulp and it is slightly less in fresh fruit. About 1.3% of sugars are present in total dry matter in unripe plantains, but this rise to around 17% in the ripe fruit<sup>4</sup>.

It is an excellent source of some vitamins like vitamin A (carotene), B (thiamine, niacin, riboflavin, B6) and C (ascorbic acid). The minerals usually present in bananas are calcium, iron, iodine, potassium. The sodium content is comparatively less.

## IN VIVO PHARMACOLOGICAL STUDIES

### Effect on Immune system

**Singhal et. al., 2013** studied the immunomodulatory potential of methanolic and hexane extract of *Musa acuminata* Peel (Plantain) extracts in Wistar albino rats. Immunomodulatory activity was studied at dose (100, 300, 500mg/kg b.wt.p.o.) by carbon clearance method, neutrophil adhesion and footpad swelling method<sup>5</sup>.

**Phagocytic index:** Phagocytosis provides the first line of defence of the host against infectious microorganisms. Phagocytic index was determined by carbon clearance method. The results showed that phagocytic index of standard drug septicin(500mg/kg. p.o.) was 0.671, methanolic extract of *Musa acuminata* peel(100mg/kg.p.o.) was 0.792 and hexane extract was 0.783. The study demonstrated that 7 days treatment with methanolic and hexane extract of *Musa acuminata* peel potentiated more elimination of foreign particles from its surroundings by enhancing the phagocytic activity of macrophages when compared to standard drug treated animals. The methanolic extract exhibited more immunogenic activity compared to hexane extract.

**Neutrophil adhesion test:** It is an indicative of marginalization of phagocytic cells in the blood vessels, i.e. an indication of immunostimulation. Percentage neutrophil adhesion in control group animals was 18.9 and standard drug was 45%. Methanolic and hexane peel extracts showed higher activity in a dose dependent manner. 55.57% neutrophil adhesion was shown by methanolic extract treated animals and 44.57% for hexane extract treated animals

with a dose of 500mg/kg.p.o. It was evident from the results significant increase in neutrophil adhesion was observed after administration of methanolic peel extracts as compared to hexane extracts.

**Delayed type hyper sensitivity (DTH):** Increase of DTH reaction in response to T-cell dependent antigen revealed the stimulatory effect of both methanolic and hexane extracts. It is determined by foot pad swelling method. Result shows that methanolic extract having more protective activity compared to hexane extract.

### **Effect on gastric ulceration**

**Kumar et.al., 2006** studied the antiulcer and mucosal defensive factors of methanolic extract of *Musa sapientum. var. paradisiacal* (MSE 100mg/kg) in normal and Non Insulin Dependent Diabetes Mellitus (NIDDM) rats. NIDDM was induced by administering streptozotocin (STZ 70mg/kg) to 5days old rat pups. The study carried out on two ulcer models- cold restraint stress induced gastric ulcer (CRS) and Ethanol model. Standard drug used was ulcer protective drug sucralfate (SFT 500 mg/kg) and antidiabetic drug glibenclamide (GLC 0.6mg/kg). MSE showed better ulcer protective effect in NIDDM rats compared with SFT and GLC in cold restraint stress induced gastric ulcer (CRS). Percentage ulcer protection against CRS was 55.4% in normal and 54.3% in NIDDM rats, while in Ethanol model it was 13.8% in normal and 21.4% in NIDDM rats. For oral hypoglycemic drug GLC, percent ulcer protection CRS: normal 17.9%, NIDDM 34.4%. For Ethanol model normal 5.1%, NIDDM-21.1%. Ulcer protective drug, SFT showed significant ulcer protection in both the ulcer models studied CRS: normal 67.2%, NIDDM 40.9%, Ethanol: Normal 64.6%, NIDDM 41.9%. The data of the present study indicated antiulcerogenic effect of plantain banana against cold restraint stress and ethanol induced gastric ulcer in rats<sup>6</sup>.

**Praba et.al., 2011** studied the antiulcer activity of *Musa sapientum* on peptic ulcer. Albino rats were used for this study. Dried and powdered fruits of *Musa sapientum* (100 mg/kg b.wt) were used as an anti-ulcerogenic drug. Indomethacin (used as reference NSAID) was administered (20 mg/kg b.wt) by oral gavages to induce gastric lesions in rats. Esomeprazole was used as standard drug and was administered subcutaneously (20 mg/kg b.wt) to experimental animals. There was a significant decrease in the body weight (100%) in the ulcer induced group when compared to normal. Treatment with herbal drug of *Musa sapientum* (200%) and standard antiulcer drug esomeprazole (57%) showed a significant weight gain. There was increase in the gastric volume (160.33%), and decrease in pH

(51.61%), in the indomethacin administered group. On administration of *Musa sapientum* and esomeprazole, the level of gastric volume was significantly reduced (46.03%, 34.92%) and the pH was increased (93.33%, 76.66%) when compared to indomethacin-induced rats<sup>7</sup>.

### Effect on gastro intestinal transit time

**Adewoye et. al., 2011** studied the effect of methanolic extract of *Musa sapientum* leaves (MEMSL) on Gastro Intestinal Transit Time (GITT) in male albino rats with and without hyperglycemia. The concentrations of extracts used were 250mg/kg and 500mg/kg. Plant extracts used for treatments were dissolved in normal saline and administered orally using orogastric tube. Charcoal meal was used as marker in the estimation of GITT. The study showed significant decrease in GITT in the normal rats treated with 250mg/kg and 500mg/kg of extract. In the diabetic rats treated with 500mg/kg MEMSL, there was significant increase in GITT and this was comparable with the gut response to glibenclamide (5mg/kg). *Musa sapientum* extract produced significant decrease in transit time in the calcium chloride pre-treated normal rats and this is comparable to the effect observed in Nifedipine treated group. The study concluded that significant reduction in GITT produced by MEMSL in the normal rats reflects a strong possibility of MEMSL acting as calcium channel antagonist through the voltage gated calcium channel which may be due to the presence of alkaloids, saponins and cardenolides. There is the possibility of the extract acting as an inhibitor of potassium channel at higher concentration as observed in glibenclamide treated groups<sup>8</sup>.

### Antidiabetic activity

**Suneetha et.al., 2010** studied the antidiabetic activity of stem juice of *Musa paradisiaca* on alloxan induced diabetic rats. Two different doses of stem juice of *Musa paradisiaca* were used (1 and 2 g/kg b.wt.p.o.). Antidiabetic activity was evaluated using alloxan induced diabetic rat model in which the rats received stem juice of *Musa* showed significant decrease in blood glucose level. The study shows serum glucose level on 21<sup>st</sup> day of experiment was 65.66 mg/dL for glibenclamide and for animals treated with 4mL of stem juice shows glucose level as 63.96mg/dL<sup>9</sup>.

**Dikshit et.al., 2012** studied the antidiabetic and antihyperlipidemic effect of the stem of *Musa sapientum* in streptozocin –induced diabetic rats. Diabetes was induced in rats by streptozocin injection (45mg/kg, i.p.). Diabetic rats were treated for 2 weeks with different doses of lyophilized stem juice of *Musa sapientum* ( 25, 50, and 100 mg/kg ) to select the most effective dose. The results showed that the most effective dose was 50mg/kg, four

weeks treatment with this dose resulted in significant decrease in fasting and post prandial plasma glucose<sup>10</sup>.

**Dhanabal et.al., 2005** studied the hypoglycemic effect of ethanolic extract of flowers of *Musa sapientum* on alloxan induced diabetic mellitus in rats. Oral administration of the ethanolic extract showed significant blood glucose lowering effect at 200mg/kg in alloxan-induced diabetic rats (120mg/kg, i.p). This study concluded that the antidiabetic activity observed in this plant may be attributed to the presence of flavonoids, alkaloids, steroids and glycoside principles<sup>11</sup>.

#### **Effect on Haematological Parameters**

**Paul et.al., 2013** studied the effect of *Musa paradisiaca* stem extrude on rat haematological parameters. Albino wistar rats were used for this study and the duration of study was 28 days. Rats were sacrificed and blood samples were collected by cardiac puncture then used for the haematological studies. The results shows that there wassignificant increase in rat RBC, PCV, Hb and WBC counts at concentrations of 75 and 100% stem aqueous extracts when compared with the control and a significant decrease in MCH (Mean Corpuscular Haemoglobin) and MCHC(Maen Corpuscular Haemoglobin Concentration). The levels of MCV (Mean Corpuscular Volume) were not significantly altered at all extract concentrations. It can therefore be concluded that *Musa paradisiacal* stem extrude has a haematopietic and immunomodulatory effect consistent with its ethnomedicinal use<sup>12</sup>.

### **IN VITRO PHARMACOLOGICAL STUDIES**

#### **Anti-HIV Activity**

**Swanson et.al., 2010** studied about the inhibition of HIV replication by a lectin isolated from bananas. BanLec is a jacalin-related lectin isolated from the fruit of bananas, *Musa acuminata*. In this study they demonstrated that BanLec inhibits primary and laboratory-adapted HIV-1 isolates of different tropisms and subtypes. BanLec possessed potent anti-HIV activity and might inhibited HIV-1 through binding of the glycosylated HIV-1 envelope protein activity, with IC<sub>50</sub> values in the low nanomolar to picomolar range. An enzyme-linked immunosorbent assay confirmed direct binding of BanLec to gp120 and indicated that BanLec can recognize the high mannose structures that are recognized by the monoclonal antibody 2G12. BanLec was also able to block HIV-1 cellular entry as indicated by temperature-sensitive viral entry studies and by the decreased levels of the strong-stop product of early reverse transcription seen in the presence of BanLec. Thus, the data indicated

that BanLec inhibits HIV-1 infection by binding to the glycosylated viral envelope and blocking cellular entry. Based on these results, BanLec is a potential component for an anti-viral microbicide that could be used to prevent the sexual transmission of HIV-1<sup>13</sup>.

### Anti-tumor activity

**Kazi et.al., 2003** studied the antitumor activity of a natural *Musaceae* plant extract. The study demonstrated the inhibition of proteasome activity and induction of apoptosis selectively in human tumor and transformed, but not in normal and non-transformed cells. In this study they reported that CellQuest, a patented formula which contains high level of tannic acid obtained from a *Musaceae* (plantain) plant extract, will inhibit the tumor cell proteasome activity. They also showed that a partially purified CellQuest fraction, S3 potently inhibits the proteasomal chymotrypsin like activity of Jurkat T cell extracts in a concentration dependent manner. In contrast, non-transformed, immortalized human natural killer cells and normal human fibroblasts are resistant to S3-mediated proteasome inhibition and apoptosis induction. This study suggested that CellQuest targets and inhibits the proteasome selectively in tumor cells, which may contribute to the claimed anticancer activity<sup>14</sup>.

**Roobha et.al., 2011** studied the anticancer property of anthocyanin extracts from *Musa acuminata* bract. Anthocyanins have potent anticarcinogenic property against several cancers. In this study they investigated the chemo preventive effects of anthocyanin extracted from *Musa acuminata* bract against human breast cancer cell line (MCF-7). Anthocyanin extracts suppressed the proliferation of MCF-7 cell lines. Cell viability decreased in a dose dependent manner. The result indicated that increasing concentration of anthocyanin from 3.9 µg/mL to 1000 µg/mL, the percentage of growth dilution of MCF cells increased progressively from 90.87% to 12.24%. This study suggested that anthocyanins from *Musa acuminata* bract extracts have strong anti-proliferative activity against MCF-7 cell lines at varying concentrations<sup>15</sup>.

**Misalang et.al., 2010** studied the cancer chemopreventive activity of the characterized bioactive alkaloid extract from *Musa sapientum* flowers. The chemopreventive activity of the alkaloid extract was determined through clastogenicity bioassay and micronucleus test. It was found out that 1% and 2% alkaloid extract has no significant difference as shown by a low mean difference but was significantly different with the colchicine (positive control with a proven mitotic poison). Cancer chemopreventive activity of the 2% alkaloid extract and colchicine was comparable, so they reported that the 2% alkaloid extract is as effective as

colchicine in inhibiting mitosis. The ability of the 2% *Musa sapientum* alkaloid extract to induce micronucleus formation in the bone marrow of albino rats was relatively effective as that of the positive control cyclophosphamide. They found that *Musa sapientum* flower alkaloid extract was able to exert effects on cell-energy production required for the mitosis and interference with nucleic acid synthesis thereby inhibiting transcription of various genes such as DNA and RNA. This study concluded that alkaloids present in *Musa sapientum* flowers are effective in chemoprevention<sup>16</sup>.

### **Anthelmintic activity**

**Prasanta et.al., 2013** studied the anthelmintic activity of leaf extract of *Musa acuminata* colla. The study was conducted on Indian earthworm (*Pheretima posthuma*). Various concentrations (10mg/mL, 20 mg/mL, 30 mg/mL) of plant extract were tested and results were expressed in time of paralysis and time of death of worms. Albendazole at the same concentrations of plant extracts was used as reference standard and normal saline solution as control. The results showed that methanolic extract of *Musa acuminata* colla at 30 mg/ml concentration showed paralysis at 45.43 min and death at 129.83 min. The reference drug albendazole exhibit the same at 2.33 min and 10.83 min respectively.<sup>17</sup>

**Hussain et.al., 2010** studied the anthelmintic activity of the leaves of *Musa paradisiacal*. This study evaluated ovicidal efficacy of *Musa paradisiacal* leaves, used locally for worm control in sheep. For this purpose, Egg Hatch Test (EHT) was conducted on nematodes ova to investigate the *in vitro* ovicidal effects of crude aqueous (CAE) and crude aqueous-methanol extracts (CAME) of the leaves of the plant. Lethal concentration- LC<sub>50</sub> values of CAE and CAME of *Musa paradisiaca* leaves were 0.0207 and 0.4813 respectively. This study showed that *Musa paradisiaca* leaves possess *in vitro* anthelmintic activity<sup>18</sup>.

### **CONCLUSION**

In this review, we have given special emphasis to draw attention to the *in vivo* and *in vitro* studies carried on different pharmacological activities of *Musa* species. This study reveals that all the parts of the plant including the byproducts of cultivation like flowers, bract etc. has got potential therapeutic activity. Different *Musa* species are used for different purpose for their particular individual features and that makes them special and different from other plant in respect of all. The current review will be an insight for the pharmaceutical researcher for the development of less toxic and more potent therapeutic agent for the better treatment and ailment of several diseases. In addition, it might be used as an educational tool to the



academicians and students who would like to explore the details about the pharmacognostic, pharmacological and nutritional properties of *Musa* species.

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