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BIOLOGICAL ACTIVITIES of *Musa* SPECIES

Musa TÜRLERİNİN BİYOLOJİK AKTİVİTELERİ

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ABSTRACT

Musa species (Musaceae), a tropical plant, have been consumed since many years by mankind for its nutricious and delicious fruits. In addition to this, Musa species have been reported to have various biological activities such as antiulcerogenie, antidiabetic, antiatherogenic, antidiarrheic, antitumoral, antimutagenic and have been also found to be effective in treatment of migraine, hypertension, cholesterol and hiperoxalury.

In this review, general information about biological activities of Musa sp. is given.

Key Words: *Musa, Musaceae, biological activity, tropical plant*

ÖZET

Tropikal bir bitki olan Musa türü, besleyici ve lezzetli meyvelerinden dolayı insanoğlu tarafından yıllardan beri tüketilmektedir. Buna ilaveten, Musa türlerinin antiülserojenik, antidiyabetik, antiaterojenik, antidiyareik, antitümoral, antimutajenik gibi çeşitli biyolojik aktivitelere sahip olduğu bildirilmiş ve ayrıca migren, hipertansiyon, kolesterol ve hiperoksalüri tedavisinde de etkili olduğu bulunmuştur.

Bu derlemede, Musa türlerinin biyolojik aktiviteleri hakkında genel bilgi verilmektedir.

Anahtar Kelimeler: *Musa, Musaceae, biyolojik aktivite, tropikal bitki*

INTRODUCTION

Musa sp. (Musaceae), called banana in English, are one of the interesting tropical plants which have been consumed since centuries by humans and animals as a nutricious food. Yet, ethnobotanists do not know exactly where the plant has been originated. The most generally

accepted theory is that Indo-Malesian area is the main center of the plant. The banana is such a pan-tropical that it grows everywhere man has planted it.

There are hundreds of edible banana varieties; in Indonesia alone, there are over 230 recorded. Two species of banana that are considered to be the parents of most edible seedless bananas eaten by man are Musa acuminata and M. balbisiana. In addition to being eaten fresh, bananas may be cooked, chipped, made into alcoholic drinks or processed into starch in far eastern countries. The leaves are used to wrap foods or to line utensils in which food is prepared particularly in Philippines. The flowers of inflorescence and the center of the stem is also edible in some countries in Asia. Another banana with the striking red flowers, Musa coccinea, is ornamental as its fruits are small and hard (1). In Turkey, M. acuminata, known as "cüce Cavendish", is cultured in Alanya and Anamur located in Mediterranean region.

In this review, a general information about Musa sp. has been given from the bioactivity point of view:

Effect on gastrointestinal system

In a study by Best et al., various preparations of dried unripe plantain banana were used in aspirin- induced ulcerations in rats. Although ripe fruit bananas were inactive, dried unripe bananas showed antiulcerogenic activity and were effective both as a prophylactic treatment and in healing ulcers already induced by aspirin. They found that the active fraction was water-soluble and the antiulcerogenic action of banana appeared to be due to its stability to stimulate the growth of gastric mucosa (2) .The effects of different biological variables on the antiulcerogenic effect of banana were also reported and this study indicated that this effect was present in primarily in the unripe, green plantain banana and the antiulcerogenic principle appeared to be present in mature unripe fruits (3). Sanyal and his co-workers also showed that orally administered pulp powder of M. sapientum var. paradisiaca had a significant antiulcerogenic activity in rats subjected to aspirin, indomethacin, phenylbutasone, prednisolone, cysteamine and in guinea pigs subjected to histamine. According to them, banana powder not only increased mucosal thickness but also significantly increased [3H] thymidine incorporation into mucosal DNA. Their histological studies showed that banana treatment increased staining by alcian blue in the apical cells. Besides, banana-treated and control sections

were also stained for DNA by the Feulgen reaction. The banana-treated sections showed a greater aggregation and intensity of pink spots when compared to controls. This study suggested that banana powder treatment not only strengthened mucosal resistance against ulcerogens but also promoted healing by inducing proliferations (4). Mukhopadhyaya et al worked on the same variety for its effects on gastric mucosal resistance and supported the results found by Sanyal et al in the previous work (5).

Physical studies on banana suspensions have shown that bananas are highly surface active at both liquid-air and solid-liquid interfaces .Electron microscopy of the fruit demonstrated lamellar bodies, the same form in which phospholipid is so surface-active in the lung. When administered to intact rats and scored by two methods (ulcer length and area), banana imparted appreciable (75 %) protection against acid insult in a dose-dependent manner. These studies supported the concept of a gastric mucosal barrier (6). Extracts of plantain banana were studied on the accumulation of eicosanoids in incubates of human gastric and colonic mucosa. The ethanolic extract caused a concentration-dependent increase in the eicosanoid accumulation but the water fraction was inactive. Since all the eicosanoids studied tended to increase, banana may act by increasing the availability of arachidonate (7).

The protective capacities of fresh green sweet bananas along with phosphatidylcholine and pectin as banana ingredients against acute (ethanol- or indomethacin-induced) and chronic (indomethacin-induced) gastric mucosal lesions were evaluated in rats. The banana suspension reduced acute lesions as did pectin and phosphatidylcholine in higher concentrations. In the model of chronic ulcers, the banana suspension provided an incomplete and temporary protective effect (8).

In a study by Lewis et al, the active antiulcerogenic ingredient was extracted from unripe plantain banana by solvent fractionation and it was identified as the flavonoid leucocyanidin (9).

Effects on blood glucose and cholesterol

Banana is a tasty fruit which is often restricted in the diet for diabetics owing to the high content of free sugar. In under-ripe bananas, starch contitutes 80-90 % of the carbohydrate content as the banana ripens changes into free sugars. The increase in blood glucose in insulin-dependent diabetics after different fruit meals including apple, banana and orange by comparing

with an equal amount of glucose was investigated by Vaaler and et al in 1982. The postprandial blood glucose responses to glucose, apple and banana were almost identical. Therefore, it was concluded that these fruits contain considerable amounts of fructose (10). According to a similar study to determine the glycaemic response to meals with banana, apple, orange, grapes, honeydew, and strawberry in 10 insulin-dependent diabetics, the authors stated that the small amount of starch in apple and banana may have contributed to their lower blood-glucose response compared to the other fruits tested (11). In another study, the plasma glucose and insulin responses were determined in 10 non-insulin-dependent diabetes mellitus female patients following the ingestion of some tropical fruits including pineapple, mango, banana, durian and rambutan. The results showed that the glucose-response curves to mango and banana were significantly less than those to rambutan, durian and pineapple (12). To study the effect of ripening on the postprandial blood glucose and insulin responses to banana, 10 type-2 non-insulin dependent diabetic patients consumed three meals consisting of under-ripe banana and over-ripe banana on separate days. Glycaemic indices of the under-ripe and over-ripe bananas differed (43 +/-10 and 74 +/- 9, $p<0.01$, respectively). The researchers stated that the low glycaemic response of under-ripe compared with over-ripe bananas may be ascribed to the high starch content (13).

In another study on banana *(Musa sapientum),* mainly used in Indian folk medicine for the treatment of diabetes mellitus, oral administration of chloroform extract of the banana flowers in alloxan-induced diabetic rats for 30 days resulted in a significant reduction in blood glucose, glycosylated heamoglobin and an increase in total haemoglobin. Oral glucose tolerance test was also performed in diabetic rats in which there was a significant improvement in glucose tolerance in animals treated with the banana flowers and the effect was compared with glibenclamide (14). Considering there is a decrease in starch and an increase in free sugar content of banana due to progressive ripeness, plasma glucose, serum insulin, C-peptide, and plasma glucagon responses to bananas with increasing degrees of ripeness were examined on 7 male subjects with untreated non-insulin dependent diabetes mellitus. According to the results obtained, the glucose, insulin, C-peptide, and glucagon area responses varied little with ripeness of the bananas (15).

Effect of feeding isolated dietary fiber of banana *(M. paradisiaca)* on the metabolism of carbohydrates in the liver was investigated. Fiber fed rats showed significantly lower levels of fasting blood glucose and higher concentration of liver glycogen (16). The pulp of banana fruit *(M. sapientum* var. *covendishii)* was examined for its cholesterol-lowering effect with male rats fed on a diet containing lard and cholesterol. Freeze-dried banana pulp showed a remarkable cholesterol-lowering effect when incorparated into a diet. Starch and tannin prepared from banana pulp were not responsible for this effect. Banana lipids did not affect the concentration of serum cholesterol. Both soluble and insoluble fibres fractionated from banana pulp had a cholesterol-lowering effect. The results obtained supported the conclusion that soluble and insoluble components of dietary fibre participate in the hypocholesterolaemic effect of banana pulp (17,18).

Dietary fiber isolated from unripe banana altered the concentration of aortic glycosaminoglycans in rats fed cholesterol-free and cholesterol diet. Concentraiton of hyaluronic acid, heparan sulphate, chondroitin-4-sulphate, chondroitin-6-sulfate, dermatan sulphate and heparin increased in aorta of the rats fed cholesterol-free diet. In rats fed cholesterol diet, concentration of heparan sulphate, chondritin sulphate and heparin increased while hyaluronic acid showed a decrease (19).

Effect on diarrhea

Diarrhea is among the foremost disorders responsible for high mortality and morbidity in children of third world countries. In a clinical experiment carried out at Pennsylvania Hospital in U.S.A., banana flakes were examined against diarrhea in 31 enterally fed patients. These patients with diarrhea and receiving enteral feedings were randomized to receive either banana flakes and medical treatment for diarrhea. Both banana flakes and medical treatments reduced the severity of diarrhea in critically ill tube-fed patients. Although both groups achieved similar levels of nutrition support, the banana flake group had less diarrhea clinically. The researchers concluded that banana flakes can be used as a safe, cost-effective treatment for diarrhea (20,21).

Effect on urinary system

Influence of stem extact of banana was studied on glycolic acid oxidase (GAO) and lactate dehydrogenase (LDH) enzymes in liver tissues of sodium glycolate-induced hiperoxaluric rats.

Activity of GAO was significantly lowered in the extract-treated rats compared to that of the glycolate-fed rats. LHD increased significantly in glycolate administered rats when compared with the extract-treated rats (22). A similar study with the banana stem extract on urinary risk factors in an animal model of hyperoxaluria was performed on 30 male rats. In the rats treated with aqueous banana stem extract, urinary oxalate excretion was remarkably reduced when compared with the controls. The extract reduced urinary oxalate, glycolic and glyoxylic acid and phosphorus excretion in the hyperoxaluric rats. The extract appeared to have no effect on urinary calcium secretion. According to the results obtained, it was stated that the banana stem extract may be a useful agent in the treatment of patients with hyperoxaluric urolithiasis (23).

Effect on muscular system

An experiment with banana trunk juice as a neuromuscular blocker was carried out by Lee et al. They found that the juice of banana trunk produces a non-depolarising neuromuscular block and oxygenation of the extract enhances its potency (24,25). Besides, the extract of banana stem juice was reported to induce twitch augmentation in skeletal muscles. The mechanism of this action was investigated in the mouse hemi-diaphragm preparation. Directly evoked twitches and potassium-induced contractures were both augmented by the extract. Nifedipine enhanced the augmenting effect of the extract on twitches but shortened the time-course of this action. The results were consistent with an action of banana tree juice on the molecule responsible for excitation-contraction coupling in skeletal muscle (26). The extract of the banana trunk juice was assayed in the isolated phrenic nerve-diaphragm muscle preparation of the rat. Monopotassium oxalate was found to be the active compound and the effect of this compound on the muscle preparation was investigated. The findings in this work suggested that monopotassium oxalate could be responsible for the muscular paralysis caused by the juice of banana trunk (27). The stem juice of banana, used as an arrow poison in Africa, was tested in the same kind of experiment. Lyophilized, partially purified extracts of the juice augmented and then blocked both directly and indirectly evoked contractions of the mouse diaphragm. The active components were identified as potassium nitrate and magnesium nitrate. They had the same activity profile as authentic samples. Therefore, it was concluded that two active major principles in the banana stem juice were potassium nitrate and magnesium nitrate (28).

Effect against cancer and mutagenity

A case-control study was conducted in Thailand with 279 incident cases against cancer. Each subject was interviewed with regard to bowel pattern information, family history, past history of illness and dietary information. The major findings indicated that there was a protective effect provided by banana and papaya for colorectal cancer (29). In a similar case-control study conducted at an oncology hospital in Uruguay, dietary patterns were assessed in detail by use of a food frequency questionnaire on 61 food items. Nutrient residuals were calculated through regression analysis. The strongest protection was observed for banana intake (30).

135 methanol extracts prepared from 48 plant families which were comprised of edible Indonesian plants were screened for their in vitro antitumor-promoting activities using the tumor promoter 12-0-hexadecanoylphorbol-13-acetate (HPA)-induced Epstein-Barr virus (EBV) activation test in Raji cells. A high potential of edible Southeast Asian plants including banana for cancer chemoprevention was indicated (31).

Considering differences in cancer incidence between Polinesians and Europeans living in New Zealand depending on their diet, 25 food plants that are typically eaten in different amounts by these two population groups were selected. Antimutagenic properties of three extracts from each of the selected plants were investigated using a preincubation mutagenity assay with *Salmonella typhimurium* strain TA1538 against the mutagenity of the heterocyclic amine 2-amino-3-methylimidazol [4,5-f]quinoline (IQ). The data revealed strong antimutagenic activites in several food plants such as rice, watercress, pawpaw, taro leaves, green banana and mango. Possible active compounds in these extracts were reported to include chlorophylls, carotenoids, flavonoids, and coumarins, many of which are also known to be anticarcinogens, by using the New Zealand food database (32).

Effect on migraine

In a clinical trial in Italy, 43 patients aged from 7 to 18 who were suffering from migraine without aura according to the classification of International Headache Society were selected to establish the possible correlation between migraine and food intolerance. Each patient was

challanged weekly in an open trial, introducing in the diet the different foods. They were controlled in a simple double blind study. Skin tests (Prick method), plasma levels of total and spesific IgE (Prist and Rast method) and histamine plasma levels at the beginning and at the end of the diet. After the dietetic treatment, the food responsible of the migraine attacks recognised as cacao, banana, egg, and hazelnuts (33).

Effect on hypertension

The effect of banana on cold stress induced hypertension, peak expiratory flow rate and plasma ACE activity in healthy human volunteers was tested. Systolic blood pressure, diastolic blood pressure and mean arterial blood pressure were significantly decreased during cold stress after banana treatment compared to controls subjected to cold stress. There was no significant changes in heart rate and peak expiratory flow rate but only significant decrease in plasma ACE activity after banana treatment (34).

Effect against bacterial growth

Extracts prepared from the peel and pulp of bananas in increasing stages of ripening were evaluated for their ability to modulate the growth of non-pathogenic and pathogenic bacteria by Lyte in USA. Extracts increased the growth of gram-negative bacterial strains *Escherichia coli, Shigella flexneri, Enterobacter cloacae and Salmonella typhimurium,* as well as two non-pathogenic E. coli strains. The growth of gram-positive bacteria was not altered by any of the extracts (35).

In an antibacterial assay performed by Ono et al in Japan, banana showed antibacterial activity against *E. coli* and *Staphylococcus aureus* (36).

Effect on enzymes

The proteolysis of casein by trypsin, chymotrypsin and papain was inhibited by ripened and unripened banana cultivars named as bontha, poovan, nendran, cavendish and rasthali bananas in India. The inhibition of trypsin, chymotrypsin and papain by different ripened banana cultivars was much more than that of unripened banana cultivars. In this study, the probable role

of unripened banana papain inhibitors in curing stomach ulcers and antinutritional role of ripened banana trypsin inhibitors were indicated (37).

In a study by Pari et al, the extract prepared from banana flowers (M. sapientum) caused a decrease in free radical formation in the rat tissues. The decrease in thiobarbituric acid reactive substances and the increase in reduced glutathione, glutathione peroxidase, superoxide dismutase and catalase showed the antioxidant properties of the banana flower extract (38).

CONCLUSION

Musa species (Musaceae), commonly known as "banana", are used as a folk medicine in India, Pakistan and some other southeast countries (38). It is also one of the medicinal plants used in the United States (39). Tasty and edible fruits of Musa sp. have been a food source for humans since centuries. Therefore, banana is cultivated particularly for its fruits in the world. In addition to its nutritional value, a number of biological activity studies have been carried out on banana and these studies showed that this food plant has possessed bioactivities including antidiabetic, antiulcerogenic, antitumoral, etc. The results have supported the hypothesis of its use in folk medicine against some disorders. However, further research is needed to identify the active components in banana extracts and to evaluate their biological activity potential.

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