Innovare
Academic Sciences

International Journal of Pharmacy and Pharmaceutical Sciences

ISSN- 0975-1491 Vol 6, Issue 10, 2014

Review Article

NUTRACEUTICAL APPLICATION AND VALUE ADDITION OF BANANA (*MUSA PARADISICA* L. VARIETY "BHUSAWAL KELI") PEEL: A REVIEW

SHADMA ANJUM, SHANTHY SUNDARAM*, G. K. RAI****

***Centre for Biotechnology, University of Allahabad, Allahabad, **Centre of Food Technology, University of Allahabad, Allahabad, [3]Professor, Centre for Biotechnology, University of Allahabad, Allahabad.**
Email: shanthy_s@rediffmail.com

Received: 24 Jun 2014 Revised and Accepted: 25 Mar 2014

ABSTRACT

Musa paradisica L. (Musaseae) has been used in many cultures for prevention and treatment of a wide number of health disorders such as inflammation, diabetes, diarrhea, dental plaque etc. Banana popularity is on the rise due to its high nutraceutics and pharmaceutical value. Banana is unique because each of its parts—fruit, pulp, peel, seed, leaves, flowers and the bark—are utilizable. Banana is the second largest after citrus and it accounts around 15% of global fruit production (Food and Agriculture Organization statistical databases, 2008). India's participation in the world banana production is 27% (Mohapatra, *et al.* 2010) and it also contributes about 37% of the total fruit production in India. The main by-product of banana processing industry is peel, which represents almost 30% of fruit (Arora, *et al.* 2008). However, nobody pays attention to banana peel, which is unfortunate because they could be helpful in many medicinal applications (Kumar*, et al.* 2012). As a natural source of various polyphenols and bioactive molecules (Arora*, et al.*2008), it possesses many curative properties and able to cure many kinds of illnesses (Jahan, *et al.* 2011). This review aims at providing an updated overview of the chemical constituents, traditional uses, photochemistry, pharmacology and toxicology of *Musa paradisica* L. Moreover, the focus of this review is the possible exploitation of *Musa paradisica* peel to treat different diseases and to suggest future investigations.

Keywords: Polyphenols**,** Nutraceuticals, Phytomedicinal.

INTRODUCTION

The medicinal properties of banana have been documented in ancient Indian literature and found to be effective in cure of many diseases [1]. As a staple fruit, it is available thought out the year and provides livelihood security to thousands of people [2]. The main by-product of the banana processing industry is the peel, accounting 30% of the fruit which constitute environmental hazard [3]. High dietary fiber and phenolic content of banana peels makes them promising for variety of applications in nutraceuticals and medicinal. According to the criteria established by the National Cancer Standard Institute, banana peel extract is classified as non-toxic to normal human cells [4]; therefore, it can be safely utilized as a natural source of antioxidants for value addition. Polyphenolic and related bioactive compounds are higher in peel than pulp part of banana fruit. Their medicinal actions are varied. Several studies have been carried out on banana peels for the production of biogas [5], ethanol production by hydrolysis and fermentation [6], antibacterial and antioxidant activities [7] and biomass production [8], is mentioned but these are very few. This review will concentrate not only on the nutraceuticals property of banana peels but also, some specific enzymes like oxalate oxidase (E. C 1.2.3.4) and superoxide dismutase (E. C.1.15.1.1) for their medicinal and pharmaceutical applications. The above properties of the banana peel will be exploited for its use in commercial purpose in food industry, medicinal and pharmaceutical field.

This review provides information about certain specific enzymes isolated from banana peel for for their nutraceutical application. Raghavan, (1985) reported that oxalate oxidase is an enzyme that degrades stone from kidney and plasma present in banana peel (*Musa paradisica*) and uses as phytomedicinal compound. The occurrence of oxalate oxidase in banana peel was first suggested by Richardson by his personal communication [9]. In mammalian system, oxalate is a metabolic end product with no enzyme present in the body to act upon it. Excess accumulation of oxalate causes kidney stones. It could be overcome by different methods but the best and cheapest approach is to cure it by the enzyme oxalate oxidase, presents in different fruits and vegetables. Banana peels are also rich sources of potassium and contain much more soluble and insoluble fiber than their flesh [10]. The nutritional values of banana peel specifically *Musa paradisica* variety Bhusawal keli were determine at different stages of ripening and also its antioxidant and antimicrobial property. Peel is low in calories, sugar, fats and cholesterol. Banana has good nutritional and therapeutic value; therefore it may be possible to produce functional food from it [11]. The high value of organic content (lipids, proteins and carbohydrate) indicates that banana peels are good source of carbohydrates and fibers. High fiber content also indicates that the peels could help treat constipation and improve general health and well being. Short shelf life and increased production necessitates development of non-conventional products from banana.

This property can be used for making various non conventional products from banana peel without the incorporation of any gel additive. Standardized and developed jellies from banana peel are deemed to be nutritive, health-beneficial, and more favorable than tablets or pills. Jelly is a favorite dessert among all age group, owing primarily to its digestibility and good texture [12]. Therefore, the principal objectives of this study were to explore the property of banana peel and increase its value by incorporating it into food grade oil. Therefore, as banana peels are considered to be byproduct, the economics of such a process is both favorable and attractive.

Chemical compositions of banana peel

Chemical composition varied from species to species. Anhwange, (2008) studied the chemical composition of Banana (*Musa sapientum*) peel. He had reported that K, Na, Fe and Mn content of Musa *sapintum* were 78.10, 19.20, 24.30 and 0.61 respectively where as the % of protein, crude lipid, carbohydrate and crude fiber were 0.90, 1.70, 59.00 and 31.70 respectively where as low value of antinutritional factor designate that the peel can be amass for a long time without growing moldy, as oxalate content of the peel was found to be 0.51mg/g [13]. Oxalate consumption had been associated with kidney diseases which may result to death. It decreases the availability of essential minerals like calcium. Whereas antinutritional factor as phytate and hydrogen cyanide, compared to other was low. The overall results indicated that if the peel is properly processed it could be high quality and cheap source of carbohydrate and mineral for livestock.

Nagarajaiah and Prakash, (2011) studied the chemical composition and antioxidant potential of peels from three varieties of banana. He had revealed that varietal difference affect the nutritional composition and antioxidant property of banana peel. Among three variety *Yelakkibale* banana peel have high protein, ether and Ca content, whereas *Pachabale* was high in Fe content. Antioxidant activity was positively correlated with polyphenol, flavonoids and tannin content. He had observed a higher free radical scavenging activity (90%) in ethanol extract compared to aqueous (64%) and methanol extract (62%) of *Nendranbale* peel. Among the three varieties *Nendranbale* peel exhibited high antioxidant activity. According to Leslie, *et al. (*1976), banana fruits and its byproduct has lot of medicinal benefit. It helps to prevent anemia by stimulating the production of haemoglobin in the blood due to moderate level of iron. Its role to regulate blood pressure has been associated with the high content of potassium.

Antioxidant activity in banana peels

Nguyen, *et al*. (2003) reported the total amount of phenolic compound in banana (Musa *accuminata, colla* AAA) peel ranges from 0.90 to 3g/100 gm of DW. Someya, *et al*. (2002) identified gallocatechin in banana peel at a concentration of 160mg/100g DW. Variation in ripening and growth stages causes certain changes in polyphenolic content. She has evaluated the antioxidant activity in banana peel, measured as the effect of lipid auto-oxidation, in relation to its gallocatechin content. Mokbel and Hashinaga, (2005) reported that unripe banana peel displayed high antioxidant activity as increasing the polarity, the extracts exhibited stronger antioxidant activity. Polyphenols or flavanones and flavonoids play important roles in these activities and Glycoside and monosaccharide components in water soluble extracts displayed significant antioxidant and antimicrobial activity. Whereas Arora, *et al.* (2008) reported that antioxidant activity and bioactive compound get affected on varying the cultivar of banana. Red Banana and Karpooravalli are rich source of bioactive compounds, such as carotenoids (beta-carotene), antioxidative enzymes and carbohydrate contents. Montelongo, *et al.* (2010) evaluated that the polarity of the solvent and that of the different antioxidant compounds affects the efficiency of the extraction and the activity of the obtained extracts. Acetone: water most efficiently extracted all extractable components (54 ± 4%), phenolic compounds (3.3 ± 0.8%), and anthocyanin compounds (434 ± 97 lg cyanidin 3-glucoside equivalents/100 g freeze dried banana peel). From the above results, they had concluded that banana, a tropical plant, may protect itself from the oxidative stress caused by strong sunshine and high temperature by producing large amounts of antioxidant.

Antimicrobial activity

The use of natural antimicrobial compounds is important not only in the preservation of food borne diseases but also safe for human consumption (Conner, 1993). According to Shan, *et al*. (2007) consumers too have questioning the safety of foods containing the synthetic antibacterial agent as preservatives.

Therefore, there has been increasing interest in developing new types of highly effective and non-toxic antibacterial agents from natural sources. Many studies showed that fruit peels contain various phenolics components which are effective against pathogenic microorganism (Anagnostopoulou, 2006).

Phenolics compounds like tannins and flavonoids have been reported for antimicrobial activity. Both are toxic to fungi, bacteria and viruses and inhibit their growth (Colak, *et al.* 2010). Ahmad and Beg, (2001), reported that natural compounds in fruits and vegetables such as polyphenols, flavonoids and tannins shown very promising results in combating bacteria, fungus and viral. Arora, *et al.* 2008 reported that banana peel are rich source of various polyphenols and bioactive molecules and possesses many curative properties and able to cure many kinds of illnesses (Jahan, *et al.* 2010). Some researchers showed that banana peel enhances the immune system which helps in wound healing and cure of gastrointestinal disorders. In addition, they also prevent oxidative stress as the growth and ripening proceed. However, very few literatures have been published for antimicrobial property of banana peel (Mokbel, 2005). The literature survey contains a no. of secondary metabolites like alkaloids, flavonoid and their derivatives are presents in banana fruit and its part.

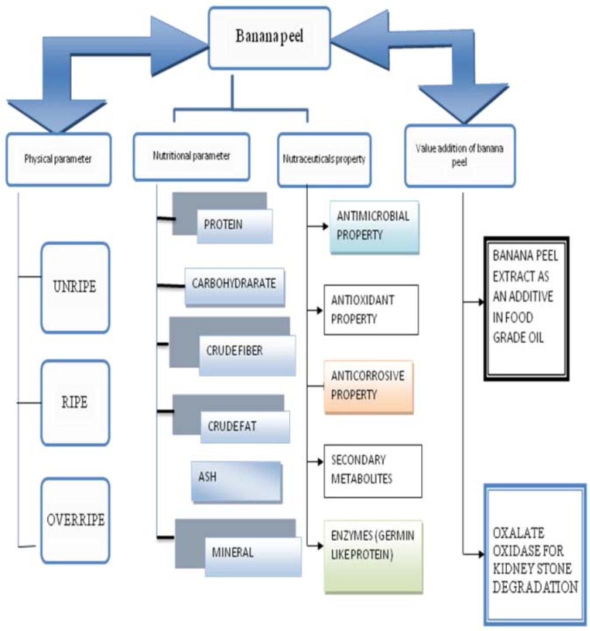


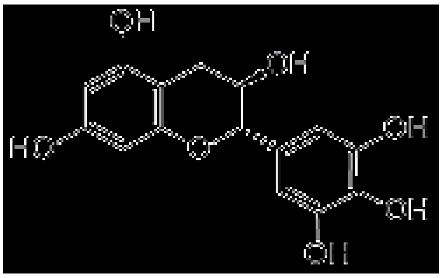
Fig. 1: Diagrammatic representations of possible uses of banana peels

Enzymes: still an urgent consumer need

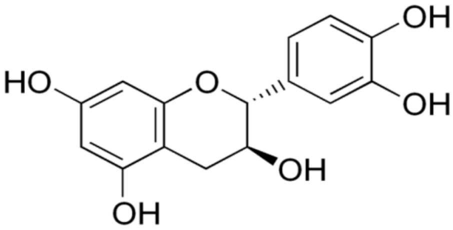
Research on the attributes of enzymes and the possible uses for enzyme supplements continues today. The biggest category for supplemental enzymes is still human digestion, an area that has become increasingly more important for maintaining optimum health. Eva Dominguez-Puigjaner (1992) reported the differential protein accumulation in banana fruit during ripening. He had extracted banana (*Musa acuminata,* var. Dwarf Cavendish) proteins from pulp tissue at different stages of ripening and analyzed it by two dimensional electrophoresis. The results provided evidence of differential protein accumulation during ripening.

The waste part of banana peel is potential source for oxalate degradation. Active oxygen species (AOS) play a significant role in many plant processes. A number of enzymes are known to generate AOS (Elstner, *et al.* 1994) including oxalate oxidase (oxalate: oxygen oxidoreductase, EC 1.2.3.4) and superoxide dismutase. Both belong to the germin family, and generate H_2O_2 Chiriboga, (1963). Proteins with oxalate oxidase activity have also been discovered in beet, spinach, banana and sorghum, however, limited evidence suggests that they are distinct proteins from the germin-type oxalate oxidase. Germin like proteins are encoded by a heterogeneous group of genes present in many land plants including monocots, dicots, gymnosperms and moss. GLP is a term referring to all germin motif-containing proteins with unknown enzyme activity or those that do not possess oxalate oxidase activity.

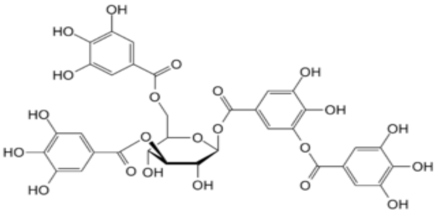
Many Germin like protein, including those from moss (*Barbulaunguiculata*; Bu), barley (*Hordeum vulgare*; Hv), wheat (*Triticumaestivum*, Ta; *Triticum monococcum*, Tm), tobacco (*Nicotiana* sp.; Naor Np), pea (*Pisum sativum*; Ps), azalea (*Rhododendron mucronatum*; Rm) and grape (*Vitis vinifera*; Vv) possess superoxide dismutase activity. Superoxide dismutase converts superoxide anions into H_2O_2. One germin like protein from barley does not possess oxalate oxidase or superoxide dismutase activity. Enzyme and gene expression data suggest that both oxalate oxidase and germin like protein genes and their encoded proteins play roles in plant defense responses (Leek, 1972). In mammalian system, accumulation of excess oxalate, results in hyperoxaluria which causes kidney stones.



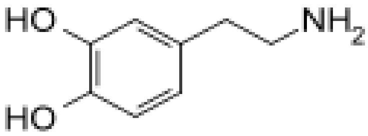
a). Chemical Structure of Gallocatechin



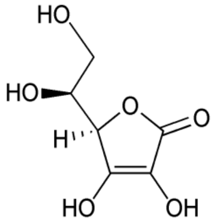
b). Chemical Structure of Catechin



c). Chemical Structure of Ascorbic acid



d). Chemical Structure of Tannin



e). Chemical Structure of Dopamine

Fig. 2: Chemical structures of gallocatechin, catechin, ascorbic acid, tannin and dopamine present in banana peel

Fig. 3: **Oxalate oxidase Source: *Hordeum vulgare.* Organism_*taxid: 4513***

Oxalate oxidase

The physiological role of oxalate oxidase has been determined in strawberry. As the fruit ripens the enzyme activity increases with the decrease in oxalate level (-0.927 correlation with oxalate oxidase) and shows that enzyme has glycoproteinatious nature and retained 76% of activity after heating it at 80^{0}C for 30 min (Dahiya, *et al.,* 2010). Kanauchi, *et al.* (2009) reported the oxalate and oxalate oxidase in Malt. Barley kernels contain a single oxalate oxidase located in the embryo and aleurone. It is already present in substantial quantities in unmalted grain and increases in activity during germination. The decrease in oxalic acid levels in late germination may be a result of oxalate oxidase action. Oxalic acid was not detected in raw barley. Production of hydrogen peroxide during the oxidation of oxalate by Oxalate oxidase destroys fungal toxins and microbes, serving as a defense mechanism in peroxidase catalyzed cross linking reactions and in strengthening the cell walls (Huang, *et al.* 2007). Determination of oxalate in different food matrices is of great interest because a high oxalate concentration level in foodstuff may cause formation of insoluble kidney stones as a result of unbalanced nutrition habits.

During the ripening of the banana peel, proteins denoted germins are expressed in the later stages of ripening because germin expression is so closely linked to the onset of germination in cereal seedling reported by Betsche, *et al*. (2005).

Superoxide dismutase

SOD is the essential antioxidant generated under stress. Beauchamp and Fridovitch showed that the superoxide radical reacted with $H_2 0_2$ in a model system to produce hydroxyl radical, which then reacted with methional to produce ethylene. Rubio, *et al*. (2004) reported that a plant Cu/Zn-SOD is partially located in the cell wall and co-locates with hydrogen peroxide production in pea nodules. Swart *et al.* 1994 reported the plant derived GLP-SOD of nodules have a role as a role as a putative rhicadhesin receptor protein and to alternative roles in plant cell development and stress biology. Superoxide dismutase (SOD) inhibited ethylene production by limiting hydroxyl radical formation. Superoxide and hydroxyl radicals are highly reactive and would be expected to react deleteriously with biological macromolecules. Since superoxide dismutase apparently protects the cell against oxygen toxicity (Fridovitch *et al.* 1972, 1973) and inhibits ethylene production from methional. Baker, (1976) found that the flavonoids from banana stimulated the activities of superoxide dismutase (SOD) and catalase which might be responsible for the reduced level of peroxidation products such as malondialdehyde, hydroperoxides and conjugated dienes.

Oxalate oxidase and superoxide dismutase activity of the proteins belonging to cupin family members are found to be responsible for their disease resistance property. In a few earlier reports, GLPs from wheat and barley have been proposed to have some structural role in relation to cross-linking of the cell wall after pathogen attack. The SOD-mediated reaction is one of the main antioxidative defense systems in plant and it converts superoxide into hydrogen peroxide (H_2O_2) and molecular oxygen. Peroxidase enzymes convert the H_2O_2 into water and there are many peroxidases which are present in the apoplastic space of the plant cells and they are ionically or covalently bound to the cell wall polymers.

Value addition of banana peels

Value added fruit product is suitable for production by small-scale farmers and processors. Complete utilization of fruit crops is a key component to the success of small farm operations. Excess fruit crops can be dried (or processed in other manners) and be used to create many value-added products. Banana peel is an underutilized source of phenolic compounds. These peels are currently either used as fertilizer or discarded in many countries (Zhang *et al.* 2005). Banana peel extract is classified as non-toxic to normal human cells criteria established by the National Cancer Standard Institute. (Someya, *et al.* 2002), therefore, it can be safely utilized as a natural source of antioxidants and enzyme to cure disease.

Banana peel is also rich in pectin 99-22%. Taking this property we can make no. of non conventional product from banana without the incorporation of any gel additive. Standardized and developed jellies from banana peel are deemed to be nutritive, health-beneficial, and more favorable than tablets or pills. Jelly is a favorite dessert among all age group, owing primarily to its digestibility and good texture (Lee, *et al.* 2010). This implies that the banana peel may also be a source of important nutrients, including minerals and amino acids. Similar results regarding the chemical compositions of banana and plantain peels were previously reported by Emaga, *et al.* (2007). Therefore, utilizing banana peels bioactive or phytochemical antioxidants extracted by suitable polar solvent in highly unsaturated food grade oil as an additive to prevent rancidity and stored it for long time period are both favorable and economically attractive. Similar work has been done by Arawande *et al.* (2010) to see the effects of citric acid and methanol extracts of banana and plantain peels on stability of refined soybean oil. The high value of soybean oil is because of its low level of cholesterol which makes it safer for human consumption. Ullah *et al.* (2003) studied that one of the major problems of storing refined soybean oil is the development of rancidity (oxidative) which leads to deterioration of the oil's quality due to the multiple unsaturated bonds in the predominant unsaturated fatty acids such as oleic acid, linoleic acid and linolenic acid. These acids are very prone to oxidation (reaction with atmospheric oxygen) during storage of the oil thereby causing unnecessary economic loss. The oxidized oils not only deteriorate the taste of food to which they are added but are considered to create many health problems such as diarrhea, poor growth rate and aggravate coronary heart diseases (Ullah, *et al.* 2003). According to Gunstone and Norris (1983), Synthetic antioxidants such as Butylated Hydroxy Toluene (BHT), Butylated Hydroxy Anisole (BHA), Tertiary Butylated Hydroxy Quinone (TBHQ) and Propyl Gallate (PG) have been proved effective antioxidants against oil rancidity. But the use of most of these synthetic antioxidants as additives in foods have been discouraged international market due to their carcinogenicity, reduced food intake and growth inhibition (Carrasquerro, *et al.* 1998).

CONCLUSION

In the present study we have providing an updated overview of the chemical constituents, photochemistry, pharmacology and toxicology of *Musa paradisica* L. Moreover, the focus of this review is the possible exploitation of *Musa paradisica* peel to treat different diseases and to suggest future investigations. However, several recently published reports on the bio-active potential of banana peel have indicated their rising pharmacological and industrial application. The nutritional values of banana peel specifically *Musa paradisica* variety Bhusawal keli were determine at different stages of ripening and also its antioxidant and antimicrobial property. Because of significant nutritional and therapeutic value; therefore it may be possible to produce functional food from it. Beside that it is good source of certain bioactive enzyme which act against aging and used for detection of oxalate crystal in food sample and for destruction of kidney stone. Therefore, it is high time to investigate the unexplored area for value addition of banana peel and to devote more efforts towards understanding the mechanism of action of the bioactive constituents which are present in them.

ACKNOWLEDGEMENT

Miss Shadma Anjum would like to thank Maulana Azad National Fellowship for the financial aid under Research University Grant Scheme (MANF-UGC) (Project No: F1-17.1/2010/MANF-MUS-UTT-5479) also thank the Centre for Biotechnology and Centre of Food Science and Technology, University of Allahabad for providing the facilities.

CONFLICT OF INTEREST

All other authors declare no conflict of interests.

REFERENCES

1. Loizzo MR, Di LG, Boselli E, Menichini F, Frega NG. Inhibitory activity of phenolic compounds from extract virgin olive oils on the enzyme involved in diabetes, obesity and hypertension. J Food Biochem 2011;35:381-99.
2. Chadha KL. Directorate of Information & Publications of Agriculture, ICAR. Banana Handbook of Horticulture: New Delhi; 2002. p. 143–53.
3. Montelongo RG, Lobo MG, González M. Antioxidant activity in banana peel extracts: testing extraction conditions and related bioactive compounds. Food Chem 2010;119:1030-9.
4. Someya S, Yoshiki Y, Okubo K. Antioxidant compounds from bananas (Musa Cavendish). Food Chem 2002;79:351–4.
5. Ilori MO, Adebusoye SA, Lawal AK, Awotiwon OA. Production of biogas from banana and plantain peels. Adv Envir Biol 2007;1:33-8.
6. Sirkar A, Das R, Chowdhury S, Sahu S J. An Experimental Study and mathematical modeling of ethanol production from banana peels by hydrolysis and fermentation. IE J 2008;88:4-10.
7. Mokbel MS, Hashinaga F. Antibacterial and antioxidant activities of banana (*musa*, aaa cv. cavendish) fruits peel. Am J Biochem Biotechnol 2005;1(3):125-31.
8. Essien JP, Akpan EJ, Essien EP. Studies on mould growth and biomass production using waste banana peel. Biores Technol 2005;96:1451-6.
9. Raghavan KG, Devasagayam TPA. Oxalate oxidase from banana peel for determination of urinary oxalate. Clin Chem 1985;31:649.
10. Anhwange BA, Ugye JI, Nyiaatagher TD. Chemical composition of Musa sapientum (banana) peels. Electr J Environ Agri Food Chem 2009;8(6):437-42.
11. Mohapatra D, Mishra S, Sutar N. Banana and its utilization: an overview. J Sci Industrial Res 2010;69:323–9.
12. Lee EH, Yeom HJ, Ha MS, Bae DH. Development of banana peel jelly and its antioxidant and textural properties. Food Sci Biotechnol 2010;19(2):449-55.
13. Kumar R. Anti nutritional factors, the potential risk of toxicity and methods to alleviate them. Proceedings of FAO expert consultation held at the Malaysia Agricultural Research & Development Marconi t Institution Kuala Lumpur, Malaysia; 1991. p. 14-8.
14. Nagarajaiah, Prakash. Chemical composition and antioxidant potential of peels from three varieties of banana. Asian J Food Ag-Ind 2011;4(01):31-46.
15. Leslie, Cobley S. An Introduction to the Botany of Tropical Crops (2nd Edition), Longman Group Limited London; 1976. p. 153–15.
16. Nguyen TBT, Saichol K, Doorn WGV. Relationship between browning and the activities of polyphenol oxidase and phenylalanine ammonia lyase in banana peel during low temperature storage; 2003.
17. Arora A, Choudhary D, Agarwal R, Singh VP. Compositional variation in β-carotene content, carbohydrate and antioxidant enzymes in selected banana cultivars. J Food Sci Technol 2008;43:1913–2.
18. Shan B, Cai Y, Brooks JD, Corke H. The *in vitro* antibacterial activity of dietary spice and medicinal herb extracts. Int J Food Microbiol 2007;117:112–9.
19. Anagnostopoulou MA, Kefalas P, Papageorgiou VP, Assimopoulou AN, Boskou D. Radical scavenging activity of

various extracts and fractions of sweet orange peel (Citrus sinensis). J Food Chem 2006;94:19–25.
20. Colak MS, Yapici MB, Yapici NA. Determination of antibacterial activity of tannic acid in pickling process. Rom Biotechnol Lett 2010;15(3):5325-30.
21. Ahmad I, Beg AZ. Antimicrobial and phytochemical studies on 45 Indian medicinal plants against multi-drug resistant human pathogens. J Ethnopharmacol 2001;74(2):113-23.
22. Jahan M, Warsi MK, Khatoon F. Concentration influence on antibacterial activity of banana blossom extract-incorporated Chitosan-polyethylene glycol (CS-PEG) blended film. J Chem Pharm Res 2010;2(5):373-8.
23. Puigjaner DE, Vendrell M, Ludevid MD. Differential Protein accumulation in banana fruit during ripening. Plant Physiol 1992;98:1157-62.
24. Elstner EF, Schempp H, Preibish G, Hippeii S, obwald W. Biological source of free radical. In free radical in the environment, Medicine and toxicology 9 Nohl, H., Esterbauer, H. and Rice-Evan, C., eds), London: Richelieu Press; 1994. p. 13-45.
25. Chiriboga J. Some properties of an oxalic oxidase purified from barley seedlings. Biochem Biophys Res Commun 1963;11(4):277-82.
26. Leek AE, Halliwell B, Butt VS. Oxidation of formate and oxalate in peroxisomal preparations from leaves of spinach beet (Beta vulgaris L.)'. Biochimica Biophysica Acta 1972;286:299-311.
27. Dahiya T, Yadav S, Chauhan N, Handa P, Pundir CS. Strawberry fruit oxalate oxidase-Detection, Purification, Characterization and Physiological Role. J Plant Biochem Biotechnol 2010;19:67-76.
28. Kanauchi M, Milet J, Bamforth CW. Oxalate and oxalate oxidase in malt. J Industrial Brewing 2009;115(3):232–7.
29. Beauchamp CO, I Fridovich. Superoxide dismutase: improved assays and an assay applicable to acrylamide gels. Anal Biochem 1971;44:276-87.
30. Rubio MC, James EK, Clemente MR, Bucciarelli B, Fedorova M, Vance, *et al*. Localization of superoxide dismutases and hydrogen peroxide in legume root nodules. Mol Plant–Microbe Interact 2004;17:1294–305.
31. Swart S, Logman TJJ, Smit G, Lugtenberg BJJ, Kijne JW. Purification and partial characterization of a glycoprotein from pea (Pisum sativum) with receptor activity for rhicadhesin, an attachment protein of Rhizobiaceae. Plant Mol Biol 1994;24:171–83.
32. Fridovich I. Superoxide radical and superoxide dismutase. Acc Chem Res 1972;5:321.
33. Fridovich I. Superoxide radical and superoxide dismutase. Biochem Soc Trans 1973;1:48.
34. Baker JE. Superoxide dismutase in ripening fruits. Plant Physiol 1976;58:644-7.
35. Zhang P, Whistler RL, BeMiller JN, Hamaker BR. Banana starch: production, physicochemical properties, and digestibility. Carbohydr Polym 2005;59:443-58.
36. Emaga TH, Andrianaivo RH, Wathelet B, Tchango JT, Paquot M. Effects of the stages of maturation and varieties on the chemical composition of banana and plantain peels. Food Chem 2007;103:590-600.
37. Arawande JO, Amoo IA, Lajide L. Effects of citric acid and methanol extracts of banana and plantain peels on stability of refined soybean oil. Ethnobotanical Leaflets 2010;14:706-14.
38. Ullah J, Hamayoun M, Ahmed T, Ayub M, Zarafullah M. Effect of light, natural and synthetic antioxidant; 2003.
39. Carrasquero A, Salazar M, Nava PB. Antioxidant activity of grape seed extract on vegetable oils. J Sci Food Agric 1998;77:436-67.