

A Comprehensive Review on the Functional Properties of Banana Peel

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Abstract-

This review looks at how banana peel, which is mostly treated as waste, actually holds many useful properties. Studies show that it contains good amounts of nutrients and several bioactive compounds that can help in health-related areas. Banana peel has been found to show antimicrobial, antioxidant and even anticancer effects, which makes it useful in food, medicine and cosmetic industries. Along with this, its ability to support skin health and reduce environmental waste adds more value to it. As new methods of extraction and processing continue to improve, the practical use of banana peel is likely to increase even more in the future. Overall, this review highlights that banana peel is not just a waste material but a promising natural resource with multiple applications.

Keywords-

Banana peel; nutrients; bioactive compounds; antimicrobial activity; antioxidant properties; skincare benefits; waste reduction; natural resource; sustainable uses; industrial applications.

INTRODUCTION-

Banana (*Musa* spp., Musaceae family) is one of the main fruit crops cultivated for its edible fruits in tropical and subtropical regions. The global production of bananas is 116 million tonnes during 2019, and the banana fruits are obtained throughout the year. The fruit average is 125 grams, of which approximately 75% is water and 25% dry matter content. Banana fruits vary in size and colours when ripe, from yellow, purple, and red. However, almost all culinary bananas have fruits without seeds, although wild types have fruits with many large and hard seeds¹.

The banana peels waste is normally disposed in municipal landfills, which contribute to the existing environmental problems. However, the problem can be recovered by utilizing its high-added value compounds, including the dietary fibre fraction that has a great potential in the preparation of functional foods².

Peel has traditionally been used as a remedy for a variety of ailment such as burns, anaemia, diarrhoea, ulcers, inflammation, diabetes, cough, snakebite and excessive menstruation³. Peel is high in dietary fibre and phenolic compounds, and it has high antioxidant, antibacterial and antibiotic

activities⁴. Hence, it is a material with much potential, which promotes its use in the nutraceutical and pharmaceutical industries.

The rapid increase in world population and the trend towards the use of environmentally friendly and viable agricultural by-products offer a steady platform for the continuation of innovation in the development of banana by-products and waste goods. With regard to nutritional quality, banana peel has shown excellent uses in different food items such as bakery, culinary products and meat products primarily because of its various bioactive compounds with potential health-promoting effect⁵. Thus, the nutritional value information and bioactive compounds of banana peel are critically analysed and summarised in this review, and the current applications of this by-product, particularly in the food industry, are outlined.

This review paper focused on the nutritional composition of banana peel, which rationalised its application in several food products. This review aimed to fill the existing gap, for example, the bioactive compound of banana peel and its effect on the pharmacological activity and the anti-nutrient compounds that need to be considered, and to improve our understanding of the potential utilisation of banana peel.

Nutritional composition of banana peel-

The utilisation of fruit peels in nutrient supplementation primarily relies on their chemical composition. Similar to its pulp counterpart, banana peel contains rich organic content (lipids, fibre, carbohydrate and protein) as a key source of many bioactive compounds with various functionalities. Nutritional compositions, which are found in banana peel⁶, are summarised in Table 1.

The nutritional value of banana peels varies based on the cultivar and maturity stage, as the plantain peel contains less fiber than dessert banana peels, and lignin content increases with ripening (from 7 to 15% dry matter). Dried banana peels contain 6–9% protein and 20–30% fiber. Green plantain peels contain 40% starch that is transformed into sugars after ripening. Green banana peels contain much less starch (about 15%) than green plantain peels, while ripe banana peels contain up to 30% free sugars.

Table.01-

Amino acids	BPP g/100g protein	FAO/WHO (1985) g/100g protein
Threonine	2.82	4.7
Valine	2.01	6.6
Histidine	4.61	-
Tyrosine	1.97	6.0
Lysine	7.16	7.0
Methionine	2.52	6
Tryptophane	7.39	-
Phenylalanine	9.56	9.3
Isoleucine	9.50	5.4
Leucine	10.97	8.6
TOTAL I.A. As	58.51	
Dispensable amino acids (D.A. As)		
Asparagine	0	
Arginine	11.10	

Serine	8.26	
Glycine	7.32	
Alanine	8.51	
Cysteine	6.30	
TOTAL D. A. As	41.49	
BPP: BANANA PEEL POWDER		

Pharmacological Activity of Banana Peel

Antioxidant Activity -

Antioxidants are substances that remove free radicals from the body. One of the best sources of antioxidants is banana peel. Utilizing a variety of antioxidant tests, banana peel extracts were discovered to have a significant antioxidant capacity⁷. Extracts from banana peels can be utilized in food products as a natural preservative to enhance the quality and shelf life of the food due to their powerful antioxidant and antibacterial properties. Various types of dishes have been effectively enhanced with the use of banana peel extracts⁸. Antioxidants in our diet can reduce oxidative stress and scavenge free radicals, potentially preventing certain diseases and aiding existing treatments. Dietary antioxidants are therefore a potential substitute for synthetic antioxidants, whose usage is closely controlled due to the potential health hazards they provide.

They can also prevent food from oxidation. Compared to other fruits, phenolic compounds are significant secondary metabolites that are abundant in banana peels. The banana peel is rich in a range of phenolic compounds, such as gallic acid, catechin, epicatechin, tannins, and anthocyanins⁹. Banana peel has five times more gallic acid than pulp, indicating that peel is a main source of the antioxidant molecule. Dopamine, ferulic acid, and caffeic acid are only a few examples of the individual phenolic chemicals in banana peel that have powerful antioxidant properties.

Antimicrobial Activity -

Several works have been done to evaluate banana peel's phytochemical compositions and antimicrobial activities for using the waste for the treatment of microbial infection as possible alternatives to synthetic drugs due to those phytochemicals are safe without toxic side effects and environmental hazards^{10,11}. The results of Lino et al.¹² found that tannins present in banana peel extract have antimicrobial activity due to their astringent action, with the ability to precipitate proteins, which may affect the bacterial peptidoglycan. So, aqueous banana extracts have an inhibitory effect on Gram-positive bacteria.

In the study of Mokbel and Hashinaga¹³, ethyl acetate extract of green banana peel recorded significant antimicrobial activities against *Staphylococcus aureus*, *Bacillus subtilis*, *Bacillus cereus*, *Salmonella enteritidis*, and *Escherichia coli*, while yellow peel extracts recorded low activity. The data indicated that malic acid exhibited solid antibacterial activity compared to β -sitosterol, succinic acid, and palmitic acid; in comparison, 12-hydroxystearic acid recorded low antimicrobial activity. This study indicated that isolated compounds inhibited the growth of food poisoning bacteria in vivo.

Anticancer agent -

Given their additive and synergistic effects, the complex mixture of phytochemical constituents found in fruit and vegetable extracts is more effective at preventing cancer than their individual components. In

addition, edible phytochemicals provide a readily available, suitable and attainable basis for cancer control and management. In a study by Dahham¹⁴, the banana peel extract prepared from hexane solvent exhibited the highest toxicity towards HCT-116 (colorectal carcinoma cell line from humans) with 64.02% cell inhibition of cell proliferation. In a separate study, Durgadevi et al¹⁵ demonstrated that the aqueous methanol extract of Nendran banana peel had a significant cytotoxic activity against MCF-7 breast cell lines. Vijayakumar et al¹⁶ demonstrated that banana peel crude extract could also be used to synthesise gold nanoparticles that inhibited the biofilm formation of Gram-positive bacteria *Enterococcus faecalis*, which were cytotoxic to human lung cancer cells.

It was postulated that the flavonoids content in banana peel contributed to its anticancer properties. Flavonoids could inhibit the ROS-scavenging enzyme activities, induce apoptosis, arrest cell cycle and subsequently suppress tumor production. The proposed mechanism of action of flavonoids as an anticancer agent is depicted in Fig. 4. In another study by Phacharapiyangkul et al¹⁵, the ferulic acid that is highly identified in sucrier banana peel potentially act as antimelanogenesis by regulating the growth factor of vascular endothelial expression, initiating nitric oxide synthase, and acting as a suppressor gene of tumor.

Dermatologist effect

There are different skincare benefits of bananas. There is a certain antimicrobial activity in fruit peels which acts against *Staphylococcus* and *Pseudomonas* species¹⁷ as well as high potassium (K) content which is making it the ideal treatment against acne prone-skin. This peel acts as a healing agent by reducing the spread of bacterial skin cells and promoting the healing of pimples and other skin imperfections. It contains antioxidants such as dopamine, ascorbic acid and flavonoids and has anti-ageing benefits¹⁸. Additionally, it contains vitamin C, which is reported to prevent melanin synthesis, a pigment that causes the skin to darken when exposed to sunlight.

Thus, the skin-lightening and soothing properties of banana peel can be associated with antimelanin synthesis and/or degradation because of its anti-inflammatory properties¹⁹. Potential skin protection, with an skin protection factor (SPF) value 10.67 was demonstrated by the banana peel ethanol extract with bisulphite immersion²⁰.

Future trends and applications

Utilization of banana and its by-products especially blossom is still not properly done owing to its outstanding nutritional, medicinal and pharmacological properties. Yet more emphasis on research on by-products of banana plant could be done so that it could be explored in field of food and nutrition. It can lead to the production of many beneficial food products which could be useful to many consumers. In addition, research on toxicological issues should also be addressed to attend the needs of this growing market. Future perspectives open new research directions to identify specific bioactive compounds and their mechanisms of action present in banana blossom. Various researches have analysed the potentials of banana blossom but many other aspects are yet to be explored²¹.

Current trends in banana bioactive utilisation

A number of essential bioactive compounds in bananas have been reported by different researchers. Banana holds adequate quantity of valuable bioactive compounds for health promotion. Several studies have established and verified antioxidant activity of these compounds and efficaciously used bananas in treatment of diseases and promotion of wellbeing. Bananas are being currently used to produce variety of

food items which are of benefit to human health. Moreover, bananas are being composited with other food products to improve the micro and macro-nutrient values, especially for food low in micro and macro-nutrients²².

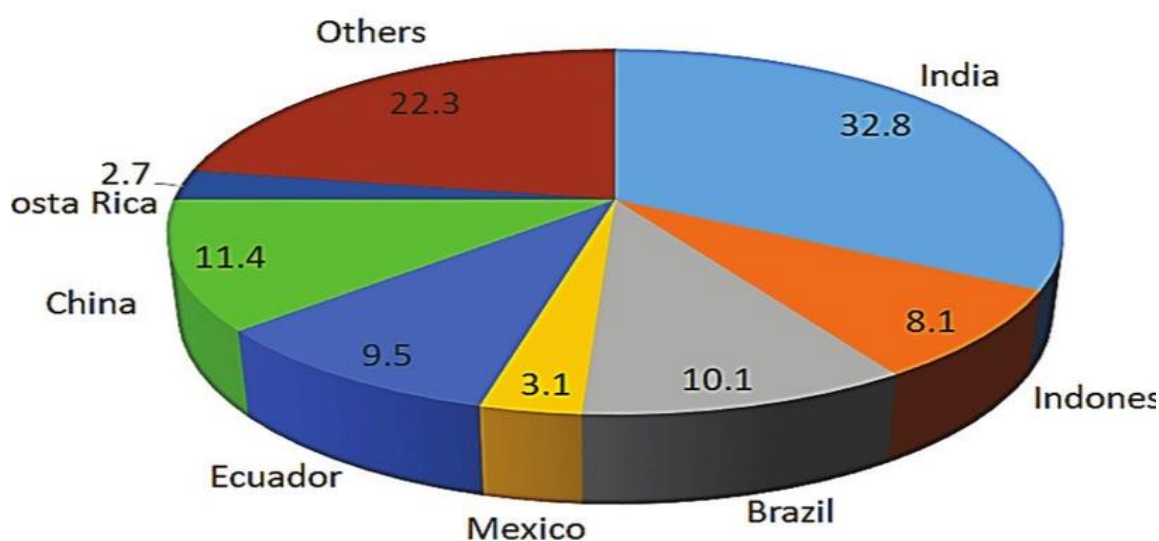
Health benefits

Banana is a ready to eat and a most affordable fruit for human consumption, which works to build good health, due to its immense nutritional and medicinal value. Banana pulp was observed to contain bioactive compounds, like phenolic acids and flavanoids with high antioxidant potential and antitumour activity²³. Eating bananas provides high quantity of potassium to the body, which is beneficial for the muscles. Owing to its high iron content, banana is mainly recommended for anemic patients and was also proven to be beneficial in controlling blood pressure as it has low salt and high potassium content. Serotonin in banana helps to overcome or prevent depression by changing mood and relaxing the body. Banana fruit contains resistant starch which has lower digestibility, unlike the high glycemic indexed cereal starches. Resistant starch present in banana is suitable for the diet of heart patients and diabetic people, owing to its hypocholesterolemic action and positive effects in the human intestine.

Plantains are very good food for sugar patients as these have low carbohydrate content and higher nutritive value when compared with potatoes²⁴. Banana has proven to be beneficial in the treatment of diabetes, due to their antihyperglycemic effect in many animal trials²⁵. Consumption of carotenoid rich banana protects against vitamin A deficiency disorders and chronic diseases, which are more visible and a growing problem throughout the world²⁶. Consumers are more health conscious and prefer fresh fruits and vegetables rich in antioxidant compounds, vitamins, dietary fiber and minerals.

Antioxidant compounds of fruits reduce risk of neurodegenerative disorders, retards aging process and helps in lowering the incidence of degenerative diseases, such as heart disease, arteriosclerosis, inflammation, arthritis, cancer and brain dysfunction²⁷. Dopamine, ascorbic acid and other antioxidants present in banana reduce the plasma oxidative stress and enhance the resistance to oxidative modification of low density lipoproteins. Norepinephrine and dopamine present in banana elevates blood pressure and serotonin inhibits gastric secretion by stimulating the smooth muscle of the intestines²⁸. Pharmacological investigations by many researchers suggested that banana was effective and advantageous in the treatment of diseases of the gastro-intestinal tract. Banana fruit has antibacterial activity due to the presence of β -sitosterol, malic acid, 1,2-hydroxystrearric acid and succinic acid. Antimicrobial activity of banana has been explored by many medicine practitioners in healthcare systems for the treatment of bacterial infections. Gastro-protective effect of different banana varieties grown and consumed in the northeast of Thailand was investigated by. Their findings indicated that antipeptic ulcer effect of some banana varieties while histological examination of the ulcerated area. Extensive investigations have been carried out by many researchers to explore antiulcerogenic and ulcer healing activities of banana. A natural flavonoid leuco-cyanidin was responsible for anti-ulcerogenic properties of unripe plantain banana. reported protective effect of this natural flavonoid to gastric mucosa from aspirin-induced erosions²⁹

Banana production across the world



(Fig, Banana production across the world.)

Application of banana peel in the food industry

Banana peels have garnered attention in various industries, including the food industry, for their potential applications. While they are commonly discarded as waste, banana peel contains valuable nutrients and compounds that can be utilized in innovative ways. According to Zaini et al, banana peel contains a number of bioactives that may have health-promoting properties. Banana peel has been used as a herbal medicine for the treatment of various ailments, such as burns, coughs, ulcers and diarrhoea. For example,, banana peels have been applied to promote wound healing caused by burns. Ferulic acid, which is often derived from banana peels, is used as a favouring agent to enhance flavour and taste in the food. Banana peels are a rich source of dietary fiber, containing both soluble and insoluble fiber. Adding dehydrated and ground banana peels to food items like bread, muffins, pancakes, and smoothies can enhance their fiber content, promoting better digestion and offering a healthier choice for the customers. Banana Peel Powder (BPP) has been employed as a favouring component in commercial food production. Extracts obtained from banana peels can be used as a natural food colouring agent in various food products, including beverages, confectionery, and dairy products, as an alternative to synthetic food dyes [90]Banana peels can be processed into powder or puree and used as a functional ingredient in baked goods like cakes, cookies, and pastries. They can add moisture, texture, and a subtle banana flavor to the products while also enhancing their nutritional profile. Banana peels contain pigments such as carotenoids and anthocyanins, which can impart natural colors ranging from yellow to red. Extracts obtained from banana peels can be used as a natural food coloring agent in various food products, including beverages, confectionery, and dairy products, as an alternative to synthetic food dyes³⁰.

Conclusion

All the points discussed, it becomes clear that banana peel is much more useful than it seems at first. Something we usually throw away actually has many nutrients and properties that can support health and different industries. Its antimicrobial, antioxidant and even skin-related benefits show that it can be used

in food, medicine and cosmetic products. As methods for extracting and processing its compounds improve, there is a good chance that even more practical uses will be discovered.

Overall, banana peel is not only helpful for human health, but it also plays a part in reducing waste and supporting environmental sustainability. Because of these reasons, it stands out as a natural material with strong potential for future research and industrial development.

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