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CHARACTERIZATION &OPTIMIZATION OF VALUE ADDED PRODUCT BY THE INCORRPORATION OF BANANA PEEL POWDER

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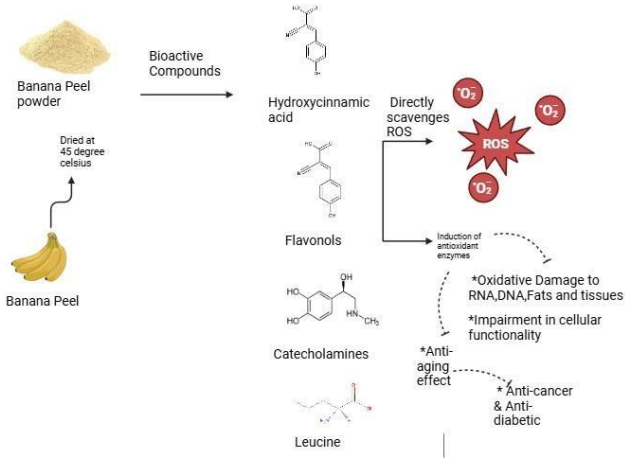
ABSTRACT :

The edible banana belongs to the herbaceous plant family Musaceae, which also includes the species Musa. It is one of the most important fruit crops in the world and is grown extensively in tropical nations for its numerous culinary uses. Extracts from powdered banana peels have a strong ability to scavenge free radicals. 40% of a banana's weight is made up of its peel, a waste product that is high in nutrients, bioactive substances, and antioxidants. Banana peel is an inexpensive source of natural antioxidants, dietary fiber, and carbohydrates that can be used efficiently in the food, pharmaceutical, and other sectors.

Key words: Banana peel powder, antioxidants, free radicals, bioactive compounds



INTRODUCTION

The widespread availability, high acceptability, low cost, and abundant supply of bananas make them well-known tropical fruits that play a major role in food security. The immense nutritional content of bananas has led to their current status as a dessert fruit and a staple starch crop in many regions. 125 million tons of bananas were produced worldwide in 2022. Bananas are sold as fresh fruits but are also utilized in a variety of processed foods. However, the process of preparing bananas generates a significant quantity of biomass; in fact, the peel accounts for 35–40% of the total weight. Up to 35,000 tons of peel biomass are produced each year from the 89,000 tons of this banana that are grown in the northern region alone.

Banana peel (BP) is a valuable resource due to its high content of bioactive components and dietary fiber. Because of the remarkable antibacterial, antimicrobial, and antioxidant properties of some of these natural components, BP is a promising candidate for use in pharmaceutical and nutraceutical applications. The peel has been utilized as a medicinal treatment for many different maladies throughout history, including burns, anemia, gastrointestinal problems, ulcers, inflammation, diabetes, respiratory disorders, and irregular uterine flow. The fact that BP contains a high concentration of dietary fiber and phenolic compounds further enhances its potential health benefits, which include its antioxidant capacity, antibacterial, antibiotic, and prebiotic characteristics .

Dietary fiber, which is abundant in banana peels, has been demonstrated to reduce the incidence of diabetes, colon cancer, irritable bowel syndrome, and constipation. Dietary fiber is a non-starchy polysaccharide that the body's digestive enzymes cannot readily absorb or break down. Dietary fiber affects the digestive system's capacity to absorb fluids since it is indigestible and cannot be absorbed by the body

Fiber should have better technical qualities in addition to its health advantages to encourage long-term consumption of foods high in fiber. Because it has a neutral flavor and can hold onto water while cooking, fiber is ideal for making meat items [4]. By determining the amount of dietary fiber and other bioactive ingredients present in banana peels and analyzing the amount of peel produced during processing, the study seeks to close this information gap.

NUTRITIONAL COMPOSITION OF BANANA PEEL POWDER

S.No.	Nutritional parameters	Values (g/100g)
1.	Starch	3.5-6.3
2.	Dietary fibre	29.52-47.3
3.	Crude fat	2.24-11.6
4.	Crude protein	5.5-7.87
5.	Ash	9-11
6.	Carbohydrate	59.51-76.58
7.	Moisture	7.50-11.5

Table:1 Nutritional composition of Banana peel [5,6]

Fruit peels' chemical composition is the primary determinant of their use in nutritional supplements. Similar to its pulp cousin, banana peel is high in organic material (lipids, fiber, carbs, and protein) and a significant source of a variety of bioactive compounds with a variety of applications. Table 1 provides an overview of the nutritional elements included in banana peels.

Fatty acids

Nutraceuticals and functional meals are considered to include essential fatty acids (EFAs). EFAs are the building blocks of cells, tissues, and organs and are essential for the synthesis of several physiologically active compounds [7]. Numerous investigations have demonstrated the importance of EFAs in a wide range of metabolic processes. The anti-inflammatory, anti-arrhythmic, antithrombotic, and antiatherogenic properties of EFAs may offer a cardioprotective benefit. Additionally, due to their complex association with cellular membrane fluidity and lipoprotein concentrations, EFAs may reduce the risk of major diseases such as diabetes, cancer, osteoporosis, cardiovascular disease (CVD), and other health-promoting effects [8]. In Table 2, the EFAs present in ripe and unripe banana peels from several cultivars are shown.

Polyunsaturated fatty acids, such as linoleic acid (Omega-6) and α-linolenic acid (Omega-3), which account for more than 40% of all fatty acids, are abundant in banana peels, according to recent studies. Linoleic acid supplementation has been linked to decreased liver fat and a marginally better metabolic state without any signs of inflammation [9]. Conversely, clinical studies have demonstrated that -linolenic acid lowers inflammation in obese people. PUFAs, such as linoleic (omega-6) and α-linolenic (omega-3), are abundant in banana peels.

Table:2 Essential Fatty acid in Banana peel [10,11]

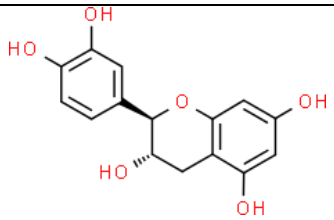
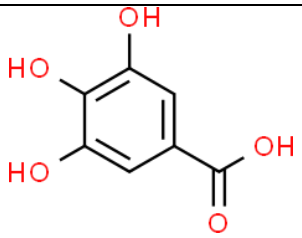
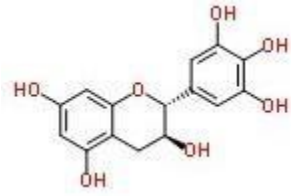
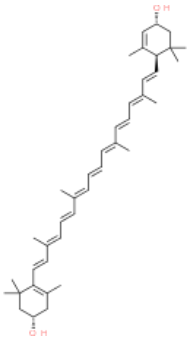
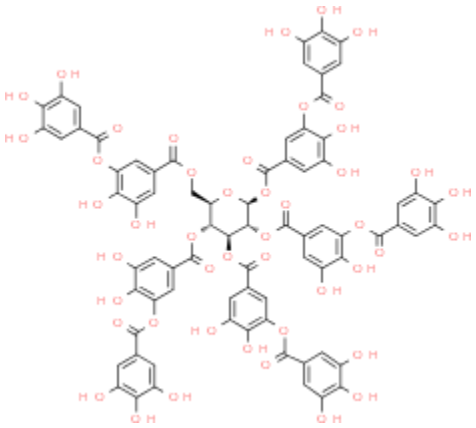
Banana Peel	Ripe Banana variety	Unripe Banana variety
Saturated fatty acid		
Lauric acid	0.8	0.4
Palmitic acid	3.3	2.7
Monounsaturated fatty acid		
Oleic acid	5.3	4.8
Polyunsaturated fatty acid		
Linolenic acid	2.3	2.0

Amino Acids

The main components of proteins and the nitrogenous backbones of hormones and neurotransmitters are amino acids. Since the majority of the 18 amino acids—nine essential and nine non-essential—are found in banana peels at different stages of development, banana peels can be regarded as a good supply of amino acids [12]. Essential amino acids such as leucine and lysine are rich in plantain peel. Long-term health benefits of dietary leucine consumption

have been proposed, including a decrease in diet-induced weight gain, hyperglycemia, and hypercholesterolemia. This discovery suggests that specific lysine conjugates may be used to treat cancer since, when paired with phototherapy, they cause malignant cells to self-destruct while sparing healthy ones

Table:3 Various Bioactive compounds present in Banana peel powder

Bioactive Compound	Structure	Molecular Formula
Catechin		**C15H14O6**
Gallic acid		**C7H6O5**
Gallocatechin		**C15H14O7**
Lutein		**C40H56O2**
Tannic acid		**C76H52O46**

Dietary Fiber

Cardiovascular disease (CVD), which has been linked to a two to fourfold increased mortality rate, is the leading cause of death among diabetic people. Most diabetes patients are advised by their doctors to limit or avoid eating fruits that are high in nutrients, like bananas, as this might cause hyperglycemia and weight gain[14]. Conversely, there has been a lot of interest in investigating the antihyperglycemic effect of banana fruit in light of recent research on its antidiabetic potential. About 20% of pulp's starch is hydrolyzed, which helps sucrose, glucose, and fructose build up throughout maturation and make the pulp sweeter and more pleasant[15]. On the other hand, unripe peels only contain around 3% starch, which may render the inner peel tasteless due to its low sugar content even after ripening.

Research has suggested that dietary fibre consumption decreases both total and LDL cholesterol levels. Furthermore, the same study's findings indicate that Musa paradisiaca's soluble dietary fibre has a larger potential to absorb cholesterol than its insoluble counterpart at the tested dosages (50–250 mg of dietary fibre)[16].

Free radicals, which are produced when low-density lipoprotein (LDL) oxidizes, destroy the oxidized LDL and trigger the expression of pro-inflammatory genes, which attract monocytes to the vascular endothelial cells of a damaged blood vessel wall [17]. Therefore, treating atherosclerosis and CVDs requires preventing LDL oxidation. The methanol and ethyl acetate extracts from Musa paradisiaca have been shown in tests to effectively and dose-dependently block LDL oxidation, with corresponding IC 50 values of 169.52 and 217.45 μ values g/mL [18].

Table:3 Amino Acids in Banana Peel [19,20]

Amino acid	Banana peel(g/100g protein)
Leucine	**0.01**
Lysine	**6.71**
Histidine	**3.96**
Glycine	**13.02**
Threonine	**6.10**
Aspartic Acid	**9.06**
Alanine	**0.85**

PHARMACOLOGICAL PROPERTIES

Banana peels have been found to contain bioactive compounds such as flavonoids, tannins, alkaloids, glycosides, anthocyanins, and terpenoids [21], which have a range of biological and pharmacological effects, such as antibacterial, antihypertensive, antidiabetic, and anti-inflammatory properties. Secondary plant metabolism generates bioactive compounds with strong medicinal potential because of their antioxidant properties. Phenols and carotenoids are the most common phytochemicals found in fruits and vegetables, and they are linked to several health benefits, including the prevention of diabetes, obesity, cancer, and cardiovascular disease.

Source of antioxidant

According to several epidemiological studies, dietary antioxidants reduce the incidence of conditions like diabetes, cancer, and cardiovascular disease (CVD), which are often associated with oxidative stress [23]. By scavenging free radicals and reducing oxidative stress, dietary antioxidants prevent food from oxidizing, making them a viable alternative to synthetic antioxidants, whose use is strictly regulated due to potential health risks [24]. Because of their low cost and the large amounts of plant biowastes they generate, their use in the food industry can be expanded to include the development of new functional foods that use them as antioxidants.Compared to other fruits, banana peels have higher concentrations of phenolics, which are significant secondary metabolites. Banana peel contains a variety of phenolic chemicals, including epicatechin, gallic acid, catechin, tannins, and anthocyanins[25]. Furthermore, banana peel contains five times as much gallocatechin as pulp, suggesting that the peel is a rich source of antioxidant chemicals[26].

Multi-mechanistic antioxidant tests are used to assess the antioxidant capacity of banana peel fractions and extracts. They are essential for evaluating the ferric-reducing antioxidant power (FRAP) assay's measurement of the metal ion chelation-reducing capacity and the ability of the chemical constituents in banana peel extracts to scavenge free radicals such as 2,2-diphenyl-1-picrylhydrazyl (DPPH) and 2,2′-azinobis-(3-ethylbenzthiazoline-6-sulphonate[27].

Antimicrobial agent

Historically, a range of infectious diseases have been treated with herbal treatments, which have demonstrated promise in numerous instances. The majority of natural medicines are derived from plant parts, such as leaves, flowers, fruits, and stems [28]. These extracts could be used to develop novel antibacterial agents with distinct chemical structures and modes of action that would serve as a defense against drug-resistant microorganisms. A previous

study demonstrated that banana peel's antibacterial properties were effective against Salmonella enteritidis, Escherichia coli, Bacillus cereus, Bacillus subtilis, and Staphylococcus aureus [29].

The ethanol extracts of M. paradisiaca cv. Puttabale and M. acuminata cv. Grand naine demonstrated a broad spectrum of antibacterial activity against the microorganisms under investigation, with a particularly strong inhibitory efficacy against P. vulgaris and S. paratyphi, per this study [30]. Phytochemical study revealed biologically active compounds as tannins, terpenoids, flavonoids, and glycosides. It is possible to treat clinically dangerous bacteria using these chemicals [31]. Peel includes the potent antibacterial chemical 2-methyl-5-(1-methylethyl) phenol, which is likely the reason of this outcome. Furthermore, the presence of tannins has demonstrated some antibacterial activity against the three pathogens under study (E. coli, S. aureus, and P. aeruginosa)[32].

Anticancer agent

Fruit and vegetable extracts include a complex mixture of phytochemical substances that work in concert to prevent cancer more effectively than any one of their individual components due to their additive and synergistic actions. Furthermore, a useful, suitable, and easily accessible basis for cancer management and control is provided by food phytochemicals.

According to a number of studies, the extract from banana peels made using hexane solvent showed the highest toxicity to the human colon cancer cell line HCT-116, exhibiting a 64.02% cell suppression of cell multiplication. Another study showed that MCF-7 breast cell lines were significantly cytotoxically affected by the aqueous methanol extract of Nendran banana peel. It was discovered that the crude extract from banana peels could also be utilized to create gold nanoparticles that were cytotoxic to human lung cancer cells and prevented the growth of biofilms of the Gram-positive bacteria Enterococcus faecalis[33].

It was believed that the abundance of flavonoids in banana peel contributed to its anticancer properties. Flavonoids may inhibit the activities of ROS-scavenging enzymes, induce apoptosis, halt the cell cycle, and ultimately slow the growth of malignancies.

Anti-diabetic properties

The potential antidiabetic benefits of banana peel extract have been studied, especially in relation to oxidative stress, hyperlipidemia, and hyperglycemia in diabetes mellitus. The lignin, pectin, cellulose, and hemicellulose found in banana peels have been related to reducing blood sugar and averting hypercholesterolemia. The antioxidant qualities of banana peel extract, which lessen the oxidative stress associated with diabetes, are believed to be caused by the presence of dopamine and L-dopa. An alternative therapeutic option for type 2 diabetes could be banana peel extract. More thorough research involving pharmacological and chemical components is required to establish the optimal dosage and elucidate the precise mechanism behind its antidiabetic effects [34].

Methodology

Banana Peel Powder Formation

The bananas were acquired from a nearby market. The fruit was properly cleaned with tap water and then with distilled water before being separated into pulp and skins. The peels were chopped into small pieces and to decrease enzymatic browning soaked in a 0.5% (w/w) citric acid solution for 10 minutes. The solution was drained and dried to constant weight in a hot air oven at 45 ºC. Using a milling blender, the dry peel was grinded into a homogeneous powder that passed through a 40 mesh screen sieve. The banana peel powder was immediately packaged in polyethylene bags and refrigerated at 4±2 °C for analysis[34].

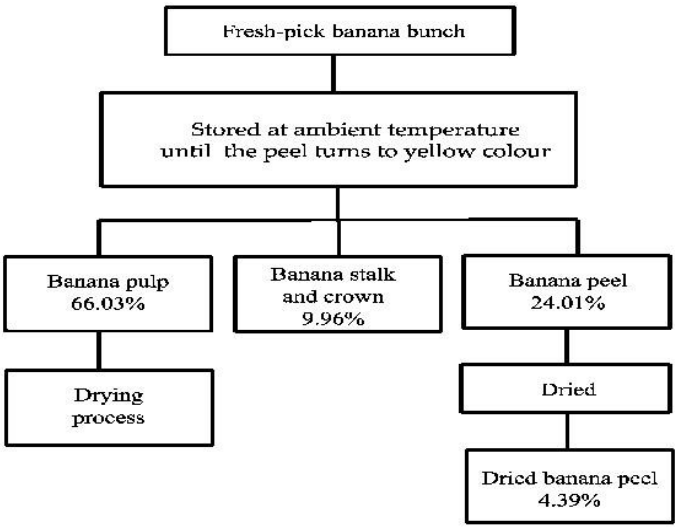


Figure:-1 Flow diagram of dried banana peel

Moisture Content

The moisture content was determined using the hot air oven method. We dried empty stainless steel moisture dishes with lids in an oven preheated to 100 ± 1°C for an hour. After that, the dishes and lids spent 30 minutes cooling in a desiccator. Precisely 10g Banana peel powder were added to the pre-weighed plates, which were then covered with the appropriate lids . After being dried at 105°C for three hours, the samples were chilled for half an hour in a desiccator. Until a steady weight was reached, the processes of drying, cooling, and weighing were repeated[34].

Total Phenolic Content(TPC)

The Folin-Ciocalteu technique was used to calculate TPC (2009). Each sample's 0.5 ml of methanolic solution was combined with the Folin-Ciocalteu (Prolabo) reagent. Additionally, add 4 milliliters of a 1 M sodium carbonate solution. Before being put in a cold water bath, the tubes spent five minutes in a water bath set at 45°C. A Shimadzu 1600 UV spectrophotometer was used to detect the absorbance at 765 nm. For each fraction, TPP was converted to milligrams of gallic acid equivalents per gram of dry weight (mg GAE/g DW).

Total Flavanoid Content(TFC)

To determine the total flavonoid content, the aluminum chloride assay was used. In a 10 ml volumetric flask with 4 ml of distilled water, a standard solution of quercetin (20, 40, 60, 80, and 100 g/ml) or an aliquot of extracts was added. The flask was filled with 0.30 ml of 5% NaNO2. Five minutes later, the 10% AlCl3 was added in 0.3 ml. After five minutes, two milliliters of 1M Purified water was used to raise the mixture's volume to 10 milliliters after NaOH was added. At 510 nm, the combination's absorbance in relation to a blank was measured. Quercetin equivalents, or mg of QE, were used to represent the amount of flavonoid total.

DPPH Method

The scavenging reaction between DPPH and an antioxidant (H-A) can be illustrated as follows:
The formula is D$PPH+H-A=DPPH-H+A$ (Purple) , (Yellow).

When DPPH and antioxidants came into contact, the stable DPPH radical was created.
The absorbance consequently shifted from the DPPH radical to the DPPH-H form. The level of discoloration reveals the antioxidant compounds' ability to contribute hydrogen by scavenging extracts [35].

Chemical properties	**Methanol**
TPC (mg gallic/ g dry weight)	**30.71±3.15**
TFC (mg catechin/g dry weight)	**12.82±2.05**
DPPH (mg Trolox/ g dry weight)	**52.38±2.04**

Table:4 Chemical properties of banana peel extract

BANANA PEEL APPLICATION IN FOOD INDUSTRY

Food product	**Banana peel variety**	**Composition level in food formula**	**Purpose**	**Effect of application**	**Reference**
Chicken sausage	**M. balbisiana**	**2%, 4% and 6% / flour basis**	**• To enhance the dietry fibre content**	**• Significant increase in WHC, TDF and ash content.**	**[36]**

Ground chicken patties		**with 2% M. paradisiaca water extract**	**• To assess the antioxidant activity of ground chicken patties aerobically stored for 8 days at 4 °C.**	**•Water extract from banana peels considerably lowers the scavenging activity of free radicals.**	**[37]**
Egyptian balady flatbread		**5% and 10% / flour basis**	**• To ascertain how the physicochemical and sensory characteristics of Egyptian Balady flatbread are affected by the substitution of banana peels**	**• The amount of fat, ash, and protein increased. But there was a noticeable drop in the amount of carbohydrates.**	**[38]**
Chappati		**5%, 10%, 15% and 20% / flour basis**	**• To incorporate flour from banana peels into a functional chapatti.**	**• The banana peel's overall phenolic and flavonoid content**	**[39]**
				the amount of powder-infused chapatti was significantly higher. Chapatti containing 20% banana peel had a 68.3% DPPH radical scavenging activity. Additionally, soft chapattis were produced by adding 5% and 10% banana peel flour to the dough.	
Cookies	**M. paradisiaca**	**5%, 10% and 15% / flour basis**	**• To create cookies using plantain peel flour that could help prevent and control diseases linked to a certain lifestyle.**	**• When compared to other formulations, cookies containing 10% banana peel flour are more appealing due to their improved color, flavor, and texture.**	**[40]**

Conclusion

With a variety of uses, bananas are a staple crop of global significance. Banana peels are a great source of protein, carbohydrates, vitamins, and minerals, but they are frequently disregarded. They consist of bioactive chemicals such as flavonoids, phenolic compounds, and carotenoids that have potent antibacterial and antioxidant properties. These traits might promote general wellness and aid in the prevention of diseases. The increasing production and consumption of bananas worldwide, which worsens environmental problems, makes it even more crucial to use banana peels properly.

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