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Banana Peel: A Nutritional Powerhouse with Many Uses

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ABSTRACT

A banana is a natural fibre with several medicinal uses. Banana peels contain various bioactive substances, including antioxidants, antimicrobials, and anticancer agents. Several secondary metabolites that have therapeutic efficacy are found, including phenolics, flavonoids, alkaloids, tannins, and saponins. Therefore, the purpose of this work is to identify the inhibitory zone and examine the antimicrobial test of 80% ethanol leaf extract of several banana peel species. The extract is produced using the Soxhlet extraction method, and the inhibitory zone is ascertained using the agar disc diffusion method. When tested at concentrations of 2.86 g/ml and 3.33 g/ml, respectively, the inhibition zone width of the ethanol extract of Musa acuminata and Musa paradisiaca is comparable to that of clindamycin ($p < 0.05$). The minimal inhibitory concentration of ethanolic extract of Musa acuminata has been demonstrated by several strains, including S. aureus and E. coli, which have 3% Zone inhibition with a diameter of 9.00 mm and 10% Zone inhibition with a diameter of 6.50 mm, respectively. The methanol extract of Musa acuminata has a minimum bactericidal concentration of 4% with a diameter of 1000 mm and 15% with a diameter of 700 mm when tested against strains such as S. aureus and E. coli. Using distinct extracts, our results clearly demonstrate the antibacterial activity of Musa acuminata and Musa paradisiaca. We thus draw the conclusion that banana peels have advantageous antibacterial, anticancer, antioxidant, and antiulcerogenic qualities.

Keywords: *Antioxidant, Anticancer, Sterilization, Therapeutic, Antifungal.*

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1. INTRODUCTION

The skin of a banana is its most distinctive feature. Animals such as cows, buffalo, goats, etc. eat it. Among its many uses, this fruit is a beneficial source of nutrients and possesses antibacterial, antifungal, anticancer, and antioxidant properties. Parabolic arches best describe the banana's form. The medicinal properties of banana trees extend to every part of the tree. Research has shown the existence of bioactive substances with anti-inflammatory, antibacterial, and anti-diabetic effects. The evidence demonstrates that bananas contain chemicals with medicinal properties [1]. In 2023, the worldwide banana market was valued at 64064.52 million USD [2]. In Among the many foods consumed and grown in India and across the world, bananas rank high. According to the Global Market Report of Banana, India would be the top banana producer in 2023 with 31.50 million tonnes. Excessive consumption during production might also result in waste. Every year, almost 3.5 million tonnes of banana peel go to waste, which is equivalent to around 30–40 percent of the banana's weight. The banana is widely employed in many different sectors, including those dealing with food, cosmetics, textiles, water purification, biochemical product manufacturing, and inorganic waste processing, among many others. Carbohydrates make up around 60–70% (w/w) of banana peel, whereas protein is between 2 and 3%, 3%, 3%, fibre is between 4 and 5%, 5%, 5%, lipids are between 4 and 5%, 5%, 5%, and moisture is 20%. On the other hand, cellulose makes up 7.6-9.6% of the dried banana peel, pectin 10-21%, hemicellulose 6.4-9.4%, lignin 6-12%, and other low molecular compounds 6-12%. The high concentration of carbon atoms in banana peel makes it an organic waste product that takes two years to break down [3]. The high concentration of organic compounds in banana peels makes them a potential hazard to soil and wildlife

when brunt's an alternative to ripe fruit, green fruit can be turned into compost or manure. The ground receives nutrients from them. The nutritional content of banana peels varies depending on the stages of maturation and the locations where they are grown. There is less fibre in the skin of ripe plantains than there is in unripe ones. In addition to their usage as an ointment for cellulitis, burns, dysentery, internal bleeding, swelling, poisonous bites, respiratory issues, and other conditions, bananas have a wide range of additional medicinal uses [4]. Traditional medicine makes direct use of bananas, for example in the healing of wounds, without the requirement for a manufacturing process or formulation. When applied topically or mixed with an ointment, the medical effects of banana peel extract include alleviation of pain, swelling, and itching due to the presence of pectin, an agent that gels, and enzymes like polyphenol oxidase found in banana skin. The banana peel contains several secondary metabolites, including tannins, alkaloids, phlobatannins, glycosides, terpenoids, and flavonoids. Some of the many biological and pharmacological effects of these phytochemicals include antibacterial, antihypertensive, anticancer, and anti-inflammatory properties [5].

Nevertheless, there are additional components found in banana peel that contribute to their antimicrobial properties. These include gallocatechins, dopamine, vitamin B6, magnesium, phosphorus, potassium, fibre, iron, and fatty acids. Banana peels are commonly employed in previous investigations since they are inexpensive. Researchers have found that banana peels inhibit some microorganisms. Recent research has shown that banana (*musa sapientum*) peel alcoholic extract had broad-spectrum antibacterial action. Both gram-positive and gram-negative bacteria are susceptible to their effects. It was found by Fairus Fadhilah that the Cavendish group (Musa acuminata), one of three banana species used in the experiment, had an impact on gram-negative bacteria when tested using the agar diffusion method. To test the banana peel's therapeutic efficiency, researchers used numerous bacterial strains, including pseudomonas aeruginosa (*P. aeruginosa*) and *Escherichia coli*, to identify parameters like minimum bactericidal concentration (MIC) and minimum inhibitory concentration (MIC) [7]. The human body is capable of readily developing resistance to antibiotics, which are chemical agents. For the purpose of conducting an antimicrobial experiment, EL Zawawy measured the inhibition zones of several bacteria on ethanol extracts. *Musa acuminata* peel ethanol extract was mixed with several strains, including E. coli, S. aureus, and *P. aureginosa*, at a concentration of 20 mg/ml, and diameters of 1.50 ± 0.50, 8.50 ± 0.50, and 3.00 ± 1.00, respectively. In their experiment, Noor and Apriasir found that a methanol extract of Musa acuminata (banana stem) inhibited Streptococcus mutans at a concentration of 81%, with a 15 mm inhibition radius. Antimicrobial activity and inhibitory concentration (IC_{50}) may be determined utilising methods like diffusion, two-fold serial dilution series, and broth microdilution. Section 8(a) One way to determine the test sample's relative inhibition (in percentage terms) is by

100% − {[(OD test sample-OD extract control) × 100%]/OD solvent control}. [8(b)]

2. BIOLOGICAL ACTIVITY OF BANANA PEEL

Antioxidants Action-

The antioxidant properties of the active chemicals found in banana peel have been demonstrated in a number of scientific investigations. The gallocatechol in banana peel is responsible for its antioxidant properties. The antioxidant action of banana peels comes from the secondary chemicals found in their extract, which include flavonoids, saponins, tannins, and alkaloids, among others. Damage to tissues and organs occurs when there are too many free radicals; flavonoids are potent antioxidants that lessen their number. Thus, its body must include free radicals. A plethora of research is conducted concurrently. The antioxidant properties of green and yellow banana peel extracts were examined in this study [8]. The antioxidant polyphenols and carotenoids found in banana peels help neutralise the free radicals that might cause cancer. Our antioxidant levels can be boosted and our risk of cancer can be decreased by eating the unripe peels.

Table-1Antioxidant contents of banana at Various Ripening stages

Content	Maximum	Minimum
Dopamine	865-1940	80-560
Rutin	16-23	11-16
Carotenes	0.43-1.2	0.28-0.78

Antioxidant activity is found in the peels of ripe and extremely mature bananas (*Musa paradisiaca*). In terms of activity, raw banana peels outperform both fully ripe and extremely ripe banana peels. The antioxidant activity of corticosteroids is positively correlated with their flavonoid content [9]. The banana peel extracts exhibited high levels of phenolic and flavonoid content, as well as antioxidant activity as measured by DPPH and ABTS radical scavenging activities. These results were in line with those of earlier investigations conducted by Suleria *et al.*, on other fruit peels.

Action Against Microbes

Banana peel contains phytochemicals that have antimicrobial and safety properties that make it a promising alternative to synthetic pharmaceuticals for treating microbial infections; these compounds do not pose any risks to humans or the environment, and numerous studies have examined these properties [12]. Using the same methodology as Greenwood, we

assessed the antibacterial activity of banana peel extracts [11]. A variety of bacterial species were tested for growth inhibition, including Staphylococcus aureus, Pseudomonas aeruginosa, Escherichia coli, and Saccharomyces cerevisiae. [13] Research on the medicinal uses of bananas in nations like Indonesia, which are major producers of the fruit, has shown that a plant extract from bananas has antibacterial effects against bacteria and fungus. Table 2 displays the outcomes of antimicrobial testing conducted on several banana varieties in Indonesia during the past decade.

Table 2- Plant extract of banana that showed antimicrobial properties

Banana types	Local name	Parts used	Solvent	Microbes affected	References
Musa acuminata	Pisangm+auli	Pseudo stem	Ethanol and methanol	Candida albicans	[12]
Musa paradisiaca	Pisang kepok	Fruit peel	Ethanol	Trichophyton rubrum	[13]
Musa balbisiana Colla	Pisang batu	Fruit peel	Ethanol	Candida albicans, Candida tropicalis	[14]
Musa Sp	Pisang	Fruit peel	Methanol	E. coli	[15]
Musa paradisiaca L	Pisang kapok kuning	Fruit peel	Methanol	Porphyromonas gingivalis	[16]
Musa paradisiaca var. sapientum	Pisang ambon	Pseudo stem	Water	Enterococcus faecalis	[17]
Musa x paradisiacal L.	Pisang Agung Semeru	Fruit peel	Distilled water	Candida albicans	[18]
Musa paradisiaca L	Pisang barangan	Fruit peel	Ethanol	Candida albicans	[19]

The antibacterial characteristics of banana plant data presented in Table 2 above highlight two key points. The first is that the local name of a banana variety is sometimes confused with the scientific nomenclature. Local names for cultivars vary, but the same name can refer to different cultivars [20]. It is necessary to further prepare crude plant extracts using various extraction and fractionation procedures to separate particular chemical entities before they may be considered practical and used as medication. Standardising all extraction and fractionation procedures will ensure that the therapeutically required sections are obtained while simultaneously eliminating any unwanted material [21]. Singh et al. came up with a novel strategy to combat periodontal diseases by utilising red, green, and yellow banana peels. Researchers found that red bananas had an inhibitory zone of 27 mm against P. citri and 18 mm against S. aureus. When tested against *Salmonella typhi* and *Aeromonas hydrophila*, green banana peel exhibited an inhibitory zone of 19mm. *A. hydrophila* showed a 20 mm inhibition zone against yellow banana peels, while S. aureus showed a 13 mm inhibition zone [22]. Table 1 and Table 2 provide the biologically active compounds and especially those with antioxidant and antimicrobial effects as shown in Figure-1

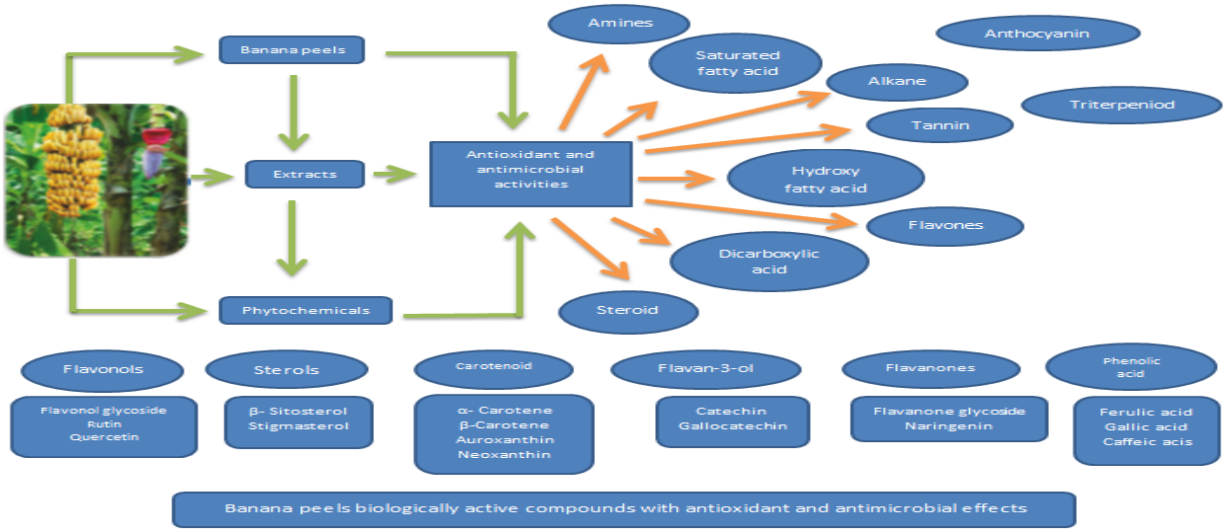

Figure-1: The important banana peel's phytochemical compositions with antioxidant and antimicrobial activities

Total chemical content which shows antimicrobial activity -

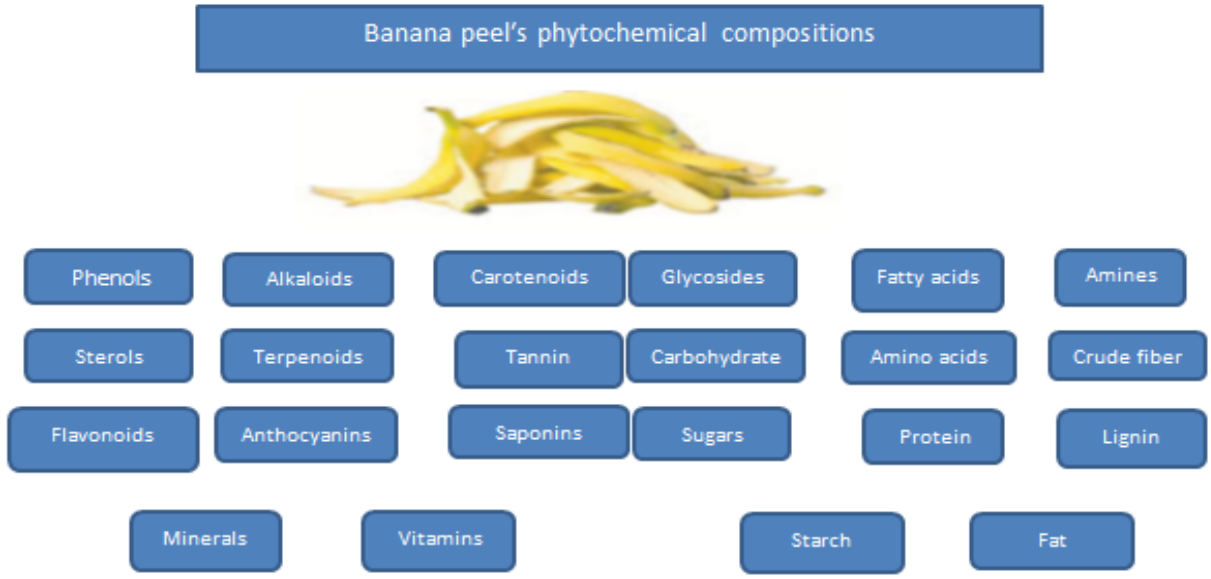

Figure-2 The chemical compositions of banana peels

According to research, banana peel (*Musa sapientum*) has a wealth of nutrients and minerals [23-24]. Scientists from Indonesia who conducted phytochemical screenings on banana plant extracts (genus Musa) and published their findings. Lycopene, flavonoids, saponin, alkaloids, tannin, terpenoids, and anthocyanins are among the bioactive substances identified. the eleventh There are a lot of phenolic and flavonoid chemicals in banana peels [25]. The Banana peel extracts from various growers had strong antioxidant activity, which was linked to the presence of flavonoids and phenolic components [26–29]. Plantain peel flowers from various cultivators had the highest levels of antioxidants and low levels of polyphenols [30]. The antioxidant properties of tanduk and nangka bananas, which are farmed in West Java, Indonesia, were mainly due to phenolic chemicals found in their peel extract [31]. Fatty acids, found in banana peel extract, were responsible for the antibacterial action [32]. Furthermore, there have been reports of antibacterial and antifungal activities in both the peel and pulp of fully ripe bananas [33]. Alisi *et al.,* conducted an initial phytochemical screening of banana peel and found glycosides, anthocyanins, tannins, flavonoids, and carbohydrates. Some have hypothesized that the peel's tannins, flavonoids, and saponins are responsible for its antibacterial properties. The findings of Lino *et al.,* indicate that the extract of *Musa sapientum* L., Musaceae, epicarp contains tannins but no flavonoids. The tannins in banana peel gel may be responsible for its antibacterial properties; these tannins can precipitate proteins in bacterial peptidoglycan. There is a correlation between the number of flavonoids and phenolic components in a material and its antibacterial action, as stated by Mahboubi *et al.* The GC-MS examination of the Musa acuminata leaf stalk revealed the following classes of chemicals: terpenoids (15.86%), phytosterol (18.53%), phenolic compounds (6.61%), hydrocarbons (5.54%), fatty acids (6.61%), and tocopherol (5.54%). There were about forty distinct chemicals found [34-36].

Test for phytochemicals

The natural, unripe banana peels and powder were subjected to phytochemical screening in order to detect any phytochemicals. The following tests were performed according to the standard protocol as outlined by Ehiowenwenguan *et al.*, alkaloids (*Dragendorff test*), flavonoids (*Shinoda's test*), tannins (*Lead acetate test*), saponins (*Frothing test*), cardiac glycosides (*glycoside test*), steroids (*Liebermann-Burchard test*), phenols, terpenoids, lignans, and volatile oil [37].

Minimum inhibitory concentration

The smallest concentration of an antibiotic that can prevent the development of microorganisms is called the minimum inhibitory concentration (MIC). It is useful for determining the antibiotic concentration required to suppress the pathogen. The broth micro-dilution technique was used to identify it. A 96-well sterile plate is used for the broth dilution procedure. All the wells were inoculated with 100 microlitres of material. To prepare the first row of plates, 100 microlitres of either sterile water, butanol, or 1% (V/V) dimethyl sulfoxide was pipetted in. A solution of 1% DMSO and 1% butanol was used as a negative control. A bacterial positive control was tetracycline, whereas a fungal positive control was nystatin. For one day, the culture tube was placed in an aerobic incubator set at 37 degrees Celsius. After incubation, we added twenty microlitres of a water-based solution of 3-(4,5-dimethylthiazol-2-yl)-2,5-diphenyl tetrazolium bromide (MTT) at a concentration of 0.2 mg/ml to every well and left it to continue incubating at room temperature for another half an hour. When bacteria are present, the colour blue is an indication of their existence. The minimum inhibitory concentration (MIC)

was determined to be the concentration at which MTT did not undergo transformation [38].

Inhibition Zone

Disc diffusion testing of Musa acuminata's antimicrobial activity on gram-positive and gram-negative bacteria revealed an inhibition zone of 30 mm for *S. aureus* and 18 mm for *S. pyogenes*, two gram-positive bacteria, and inhibition zones of 30 mm, 21 mm, and 12 mm, respectively, for *M. catarrhalis, E. aerogenes, and K. pneumoniae,* three gram-negative bacteria[39].According to Noor and Apria Sari *et al.,* showing 15 mm inhibition of Streptococcus mutans was observed at an 81% concentration in a methanol extract of mauli banana stems [Musa acuminata]. A methanol extract from the peels of susu, mas, and kayu bananas inhibits bacterial growth [40-43] At 20% concentration, the methanol extract of susu banana peels from Bali (specifically pisang, tanduk, dak, ketip, bali, raja, and susu) inhibited the growth of S. aureus with an inhibition diameter of 17.25 mm and E. coli with an inhibition diameter of 9.50 mm. We found that Staphylococcus aureus, *Vibrio alginolytices, Enterococcus faecalis, B. cepacia*, and Pseudomonas aeruginosa were tested for in a zone diameter of 7–26 mm, the ethanol extract of *M. paradisiaca* variety Tanduk prevented the development of all bacteria, whereas in a zone diameter of 7–12 mm, the aqueous extract of the same variety was able to suppress all bacteria with the exception of *B. cepacia*. Only one bacterium, S. aureus, measuring 9 to 15 mm in diameter, was inhibited by the dichloromethane and water extracts of M. paradisiaca variety Nangka. Disc diffusion and broth micro-dilution methods were used to test the sensitivity of three types of fungi (*C.albicans, tropicalis, and C. krusei*) to extracts of *M. paradisiaca* variety *Tanduk* and *M. paradisiaca* variety Nangka peels. Out of all the tested methods, only the ethanol and dichloromethane extracts of the *M. paradisiaca* variety *Tanduk* showed antifungal activity on fungal stains. Dichloromethane extract of the *M. Parasiaca* variety *Tanduk* inhibited solely C. krusei with an inhibition diameter of 10mm, whereas ethanol extract of the same variety inhibited both *C. tropicalalis* and *C. krusei* with diameters ranging from 8 to 10mm. A zone of inhibition ranging from 8–35mm was seen against all test species when the conventional antibiotics and antifungals nystatin, chloramphenicol, and tetracycline were applied. The ethanol extract of the *M. Paradisiaca* variety *Tanduk* inhibited Staphylococcus aureus with a zone diameter of 30 mm, whereas tetracycline had a 24 mm zone diameter and chloramphenicol a 25 mm zone diameter. This evidence demonstrates that banana peel extract has the potential to one day replace traditional antibiotics [42].

3. DETERMINATION OF MBC OR MFC

Using broth collected from the plate's well—where no visible microbe growth was observed—sterile MHA, TSA, or SPA agar plates were inoculated and left at 37^0C for 24 hours to determine the minimum bactericidal or fungicidal concentration. After incubation, the concentration did not reveal any signs of bacterial or fungal development [43].

4. CONCLUSION

Finally, this study shows that several banana species grown in different parts of the world exhibit antioxidant, anticancer, and antibacterial characteristics. A further antibacterial action is demonstrated by the ethanolic *Musa acuminata* extracts. Susu, Mas, and kayu banana peels, when extracted with methanol, suppress the growth of *Escherichia coli* and *Staphylococcus aureus*. Isolated from banana peel using various chromatographic techniques, the medicinal action of the medicine is due to secondary metabolites such as phenolic chemicals, alkaloids, flavonoids, tannins, saponins, glycosides, carotenoids, triterpenes, catecholamines, etc. Maximum concentration was necessary for the least inhibitory concentration of banana peel in various extracts. Similar inhibitory reactions to clindamycin and other antibiotics are also observed in the ethanolic extracts of *Musa acuminata* and *Musa paradisiaca*. At concentrations of 2.86 g/ml and 3.33 g/ml, respectively, the 80% ethanolic extracts of *Musa acuminata* and *Musa paradisiaca* demonstrate potential as future antibiotics and antimicrobials.

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