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Review article

Exploring the Protective Potential: A Review of Antioxidant Properties in Banana Peels

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ABSTRACT

In recent years, the interest of researchers in agricultural waste has increased, and instead of being ignored, the waste has become attractive to study and benefit from. Banana peels have attracted the attention of researchers due to their bioactive chemical components, and this review article focuses on the antioxidant and antimicrobial activity of banana peels, which can be used as good sources of natural antioxidants and for pharmaceutical purposes in the treatment of various diseases. Banana is an edible fruit of the Musa family (Musaceae) cultivated in tropical and subtropical regions. Banana peel is used as supplementary feed for livestock in their agricultural areas. Its massive by-products are an excellent source of valuable raw materials for other industries by recycling agricultural waste. The aim is to use banana by-products in various food and non-food products and as sources of natural bioactive compounds. It can be concluded that banana peel can be successfully used in food, medicine and other fields. Therefore, banana residues can provide new avenues and research areas for the future.

Keywords: Antioxidant or Antimicrobial Activity, Chemical Composition of Banana Peels, Nutritional value Banana Peels.

INTRODUCTION

Banana (Musa spp., family Musaceae) is one of the most important fruit crops grown for its edible fruits in tropical and subtropical regions. Global banana production is 116 million tons in 2019, and banana fruits are available year-round. The average weight of the fruits is 125 grams, of which about 75% is water and 25% dry matter [1]. The size and color of banana fruits varies from yellow, purple and red when ripe. However, almost all culinary bananas have seedless fruits, although wild types have many fruits with large, hard seeds. The fruits are eaten raw, boiled or dried and ground into flour and used in baking [1, 2]. Ripe or green bananas are also used.to prepare various foods and produce starch Bananas can be easily damaged during transport to market, and some ripe bananas are damaged and lost [1]; banana peel and plant parts are included in animal feed [1,2].

The dessert banana, the most common and edible, belongs to the species M. acuminata or hybrid Musa x paradisiaca or *M.*sapientum (M. acuminata x M. balbisiana) Morton [3].The most important banana variety is the Cavendish, whose bananas are exported from tropical and subtropical regions. Bananas are an important source of vitamin B6, vitamin C and potassium.

The World banana production is divided into two groups according to use: Bananas, whose ripe fruit is eaten as a dessert. It accounts for 56 percent of world banana production and 97 percent of exports [4-6]. Culinary bananas include bananas and other culture subgroups such as “Pisang Awak” in Asia and account for 44 percent of global banana production [4, 5]. Ripe fruits are eaten fresh as a dessert or fried, fried, dried or roasted. It can also be processed in vinegar,

chips or starch. Underground stems and male flowers can be eaten as a vegetable [6]. It is estimated that 30-40% of the total banana production is rejected because it does not meet the quality requirements. Green fruits rot more easily than ripe fruits, so they are wasted fruits and available for livestock [6, 7]. The leaves are also used to wrap food, make clothes and polish the floor. Banana waste includes small, damaged or rotten fruit, banana peels, leaves, stems and pseudoparts. Fresh bananas and dried bananas can be supplemented with different crops and additives such as molasses, grass, legumes and rice bran. Bananas and banana leaves, whole pseudostems or stalks can be chopped fresh, eaten straight or cut with molasses [8].

Banana peels

Banana peel is the outer shell (cover) of the banana fruit. It is a by-product of domestic use and banana processing [6]. It is used as animal feed. However, there is concern about the effects of the tannin in the peels on the animals that eat it [9, 10]. Banana peel is also used in cooking, water purification, preparation of many biochemical products and production of inorganic waste [8, 11]. Banana peel is sometimes used as feed for cattle, goats, monkeys, poultry, rabbits, fish, zebras, and many other species [1]

Nutritional value of banana peel-

The nutritional value of banana peels varies according to the variety and degree of ripeness, because banana peels contain less fiber than dessert banana peels and the lignin content increases with ripening (7-15% dry matter). Dried banana peels contain 6-9% protein and 20-30% fiber. The green skins of plantains contain 40% starch, which turns into sugars after ripening. Green banana peels contain much less starch (about 15%) than green banana peels, while ripe banana peels contain up to 30% free sugars [9]. While banana peels are used in water purification they are used to produce ethanol, cellulose and lactase (polyvase oxidase) as fertilizer and for fertilization [16].

Chemical composition of banana peel-

Banana peel (Musa sapientum) has been shown to contain many nutrients and minerals. Crude protein 1.95±0.14%, crude fat 5.93±0.13% and carbohydrates 11.82±2.17% were found in banana peel. The mineral composition of the banana peel was phosphorus, iron, calcium, magnesium and sodium. Zinc, copper, potassium and manganese were found in very low mg/100 g concentrations **(Figure 1).**

However, Nagarajaiah and Prakash reported lower iron content in their study compared to Hassan et al. They reported the highest iron content in three banana varieties namely Pachabale (10mg/100g), Nendranba (4mg/100g) and Yelakkiba (3.33mg/100g). The content of polyphenols varied from 200 to 850 mg tannic acid equivalent per 100 g. They also reported phosphorus concentration similar to Hassan et al.2018 for Yelakkibale. However, phosphorus content was lower in both Pachabale and Nendranba respectively. Interestingly, their calcium content in Yelakkibale was very high (244.68/100 g), five times higher than Hussein et al. [17] mentioned, 204.80 mg/100 g for Nendranba and 166.54 mg/100 g for Pachaba. Another interesting detail is vitamin C, concentrations of tannins, phytic acid, total oxalate and water-soluble oxalate were significantly higher in Yelakkibale than Nendranbale and Pachabale. Vitamin C content was 17.83 mg/100 g in Yelakkibale and ten times lower in both Nendranbale and Pachabale. The tannin content in Yelakkibale was 1073mg/100g, followed by Nendranbale with 1114mg/100g and Pachabale with 517mg/100g.

The chemical composition of six banana and plantain peels was studied by Emaga et al.The results show that cultivars did not consistently affect chemical constituents. However, fruit ripening was accompanied by an increase in the concentration of soluble sugar and at the same time a decrease in starch. Degradation of starch by endogenous enzymes may explain the increase in soluble sugar content. They attributed starch degradation to the action of endogenous enzymes, which may explain the increase in soluble sugar content. They noted significant amounts of amino acids such as leucine, valine, phenylalanine, and threonine. Potassium was the most important mineral. Figure 2 shows the chemical structure of the amino acids in banana peel: leucine, valine, phenylalanine and threonine [15].

Previous reports suggested that banana peels are rich in chemical compounds with antioxidant and antimicrobial activity. The amount of phenolic compounds found in banana peel (Musa acuminata Colla AAA) varies between 0.9 and 3.0 g per 100 g of dry weight Also, Someya et al. identified gallocatechin as 160 mg/100 g dry weight. Ripe banana (Musa acuminata Colla AAA) peel also contains other compounds: anthocyanins (delphinidin and cyanidin) and catecholamines on the other hand, carotenoids such as β-carotene, α-carotene and various xanthophylls, 300–400 μg

lutein equivalent per 100 g and sterols and triterpenes such as β-sitosterol, stistigmasterol, campesterol, cycloalarcanolcanthenol and cycloalarcanthenol. 24-methylenecycloartanol [11].

For 15 banana cultivars grown in Brazil, the phenolic content of ripe peels ranged from 29.02 to 61.00 mg GAE/100 g and from 60.39 to 115.70 mg GAE/100 g for unripe ones. In addition, the phenolic content of eight Malaysian banana cultivars was 20.47 mg bile acid equivalent (GAE) per 100 g [18]. Mahmoud et al. reported that the total phenolic content was 88.31 mg tannic acid equivalent (TAE) per 100 g M. paradisiaca bark (dry basis). Vipa and Chidchom concluded that the tannin content was 5800mg TAE/100g bark (dry matter) in the ripening stage and 1130mg TAE/100g bark (dry matter) in the ripening stage. Also, Anal et al. Obtained a flavonoid (196 mg/g quercetin equivalent) from banana peel extract. In a study by Behiry et al. they reached and detected a large amount of rutin (973.08 mg/100 g dry extract, Musa paradisiaca). Kanazawa and Sakakibara reported that Cavendish banana peel extract contains naringenin, flavonone glycoside, and flavonol glycoside. In addition, Subagio et al. identified lutein, α- and β-carotene, auroxanthin, violaxanthin, neoxanthin, β-cryptoxanthin, isolutein and α-cryptoxanthin compounds from banana peel extracts. Plantain banana peel flour contains a total phenolic content of 7.71 mg GAE/g and, in addition to other phenolics, contains ferulic acid (0.38%) and caffeic acid (0.06%) as phenolic compounds identified in banana peel excerpt. Compounds such as catecholamines and anthocyanins. Figure 3 shows the chemical compositions of banana peel [12].

Biological Activity of Banana Peel

Antioxidant activity

Several studies have shown the antioxidant effect of banana peels due to the active compounds it contains. Someya et al. Evaluated banana peel that had antioxidant activity due to its content of gallocatechin. Ariani and Akhmad explained that the antioxidant activity was due to the secondary compounds of banana peel extract such as alkaloids, flavonoids, tannins and saponins. Flavonoids are also powerful antioxidants that can reduce free radicals, because free radicals damage organ tissues and cause various diseases. Therefore, flavonoids as antioxidants are necessary to combat the effects of free radicals in the body. Another study was conducted by Mokbel and Hashinaga, who investigated the antioxidant activity of green banana and yellow peel crude extracts. The results showed that water-acetone and ethyl acetate extracts of green bark had better antioxidant activity than water-acetone and ethyl acetate extracts of yellow bark. These results agree with Jayaprakashani et al. and Tepe et al. And the highest efficiency was the aqueous acetone extract compared to all other extracts, followed by the ethyl acetate extracts. Sundaram et al. reported that raw, ripe and very ripe banana peels (Musa paradisiaca) have antioxidant activity, with raw banana peels being the most active compared to ripe and very ripe peels. They added that there is a positive correlation between the flavonoid content of corticosteroids and their antioxidant activity. Also, Alamsyah et al. reported that banana (Musa paradisiaca) peels have antioxidant activity with an IC50 of 64.03 ppm [14].

Baskar et al. based their study on 9 local banana peel cultivars in Coimbatore, India. The results showed that banana peel extract had significant antioxidant activity. Research shows that extract from this variety of banana can be useful in the treatment of free radical diseases. Abou El-Enein et al. reported that acetone extract of banana peel (Musa paradisiaca L.) had the highest antimicrobial and antioxidant activity at 600 ppm and the phenolic profiles of banana peel acetone extract were chrysin, quercetin and catechin. Ariani and Nurani also showed that ethanolic extract of raw banana tree (Musaparadisiacaformatipic) has an extreme antioxidant activity with an IC50 value of 4.44 ppm. Azim et al. reported that the high content of phenolic and flavonoid compounds in banana peel increases the ability to act as antioxidants and eliminate free radicals [13].

Antimicrobial Activity

Phytochemical compounds and antimicrobial activity of banana peel have been done several times to evaluate the use of the waste in the treatment of microbial infection as possible alternatives to synthetic drugs because phytochemicals are safe without toxic side effects and environmental damage. Lin et al. found that tannins in banana peel extract have antimicrobial activity due to their astringent activity and can precipitate proteins that can affect bacterial peptidoglycan. Thus, banana aqueous extracts have an inhibitory effect on gram-positive bacteria. In a study by Mokbel and Hashina the ethyl acetate extract of green banana peel found significant antimicrobial activity against Staphylococcus aureus, Bacillus subtilis, Bacillus cereus, Salmonella enteritidis and Escherichia coli, while the activity

of yellow peel extracts was low. The data showed that malic acid had strong antibacterial activity compared to β-sitosterol, succinic acid and palmitic acid; in comparison, 12-hydroxystearic acid had low antimicrobial activity. The study shows that the isolated compounds inhibited the growth of food poisoning bacteria in vivo [19].

Ehiowemwenguan et al. investigated the antibacterial activity of ethanolic extract and aqueous extract of banana peel. They concluded that the ethanol extract had the lowest MIC value compared to the aqueous extract. In addition, they found that the organic extract of banana peel contains glycosides, alkaloids, flavonoids and tannins. In comparison, the aqueous extract contains only glycosides and alkaloids. Rita et al. reported that an ethanolic extract of Musa sapientum bark inhibited 6 bacterial species. However, ethanolic extract of Musa acuminata bark has antibacterial activity reported that the n-butanol extract of yellow Kepok banana peels inhibited the growth of S. aureus and E. coli with MICs of 0.5 and 0.1%, respectively, with total flavonoids and phenolic concentrations of 0.06 and 0.15%. Ananta et al. It has been shown that milk, gold (lady's finger) and banana peels have an antibacterial effect on E.coli and S. aureus, where lady's finger was the most active. Susanah et al. found a positive correlation between flavonoid content or phenolic and antibacterial activity.

Several studies have shown the antimicrobial activity of banana peels. Ighodaro found banana peel extract to be inhibitory against S. aureus, Escherichia coli and Proteus mirabilis. Also, Chabuck et al. came to the conclusion that banana extract had two Gram-positive (S. aureus and Streptococcus pyogenes), four Gram-negative (Enterobacter aerogenes, Klebsiella pneumoniae, E. coli and Moraxella catarrhalis) and one yeast (Candida albicans). Kapadia et al. in vitro study. found that the antibacterial activity of alcoholic extract of banana peel against Gram-negative anaerobes such as Porphyromonas gingivalis, Aggregatibacter actinomycetemcomitans and P. gingivalis is associated with periodontal disease, acute periodontal abscess and regenerative process failure. A. actinomycetemcomitans is also associated with aggressive periodontitis, refractory periodontitis and also in the periodontitis lesion of Papillon-Lef`evre syndrome. Kapadia et al. observed antibacterial activity of alcoholic extract of banana peel. The results showed P inhibition zones of 15 mm and 12 mm. gingivalis and A. actinomycetemcomitans respectively secondary metabolites such as flavonoids, tannins, phlobatannins, alkaloids, glycosides and terpenoids present in banana peel. The presence of secondary metabolites may be responsible for the antibacterial activity of banana peel. Kapadia et al. showed that 70% isopropyl alcohol had inhibition zones of 8 mm and 10 mm P. gingivalis and A. actinomycetemcomitans, respectively. In comparison, alcoholic extract of banana peel showed zones of inhibition of 15 mm and 12 mm with P. gingivalis and A. actinomycetemcomitans, respectively. In MIC, 70% isopropyl alcohol showed the least susceptibility to P. gingivalis and A. actinomycetemcomitans up to 31.25 $\mu g \cdot mL^{-1}$ and 250 $\mu g \cdot mL^{-1}$ respectively, while banana peel alcohol extract showed up to 31.g sensitivity. ML-1 against both strains. These results supported previous studies and showed that banana peel extract was sensitive to both but not antibacterial against P. gingivalis at lower concentrations. Okorondu et al. showed that methanol extract of M. paradisiaca bark had higher antibacterial activity against human pathogenic bacteria Escherichia coli, Pseudomonas aeruginosa, Staphylococcus aureus and Salmonella typhi than ethanol, water and chloroform extracts. Ighodaro and McDonnellandRussell also found that the organic solvent had greater antibacterial activity than the aqueous solution because isopropyl alcohol was used to dissolve the more active compounds of the banana peel. According to Singh et al. represents a new approach.

They studied three different colored banana peels: red, green and yellow against different periodontal pathogens. They found that red bananas had a maximum zone of inhibition of 27 mm against Planococcus citri and 18 mm against S. aureus. The inhibition zone of green banana peel was 19 mm against Salmonellatyphia and Aeromonashydrophila. Yellow banana peel showed 20 mm against A. hydrophila, followed by 13 mm against S. aureus. Aldeanetal showed that an aqueous extract of banana peel had antibacterial activity against Gram-positive and negative gingivitis bacterial isolates, including Streptococcus species.

Prakash et al. showed that peel extracts of three banana cultivars contained some phytochemicals such as phenols, terpenoids and saponins and had antifungal activity against A. nigeri but did not inhibit A. flavus or Penicillium spp. Some reports also found that gallic acid from banana peel had potential antifungal activity against four tested Canidaspp

yeasts The same results were reported by Oliveira et al. and S´olon et al. where gallic acid had antimicrobial activity against various bacterial and fungal species. Borges et al added that ferulic acid and gallic acid have antimicrobial activity against some pathogenic bacteria.

Sumathy found that yellow banana peel has antifungal and antimicrobial properties against various gram-positive and negative bacteria. Lin et al. concluded that banana peel inhibited the growth of enterobacteria and pyogenic bacteria. Also, Aldean et al. found that banana peel inhibited Clostridium sporogenes, as did Bankar et al. and Fapohunda et al Noticed a strong activity of banana peel extract against K.pneumoniae, E.aerogenes and E.coli [20].

Figure 1: Mineral composition of banana peel [18].

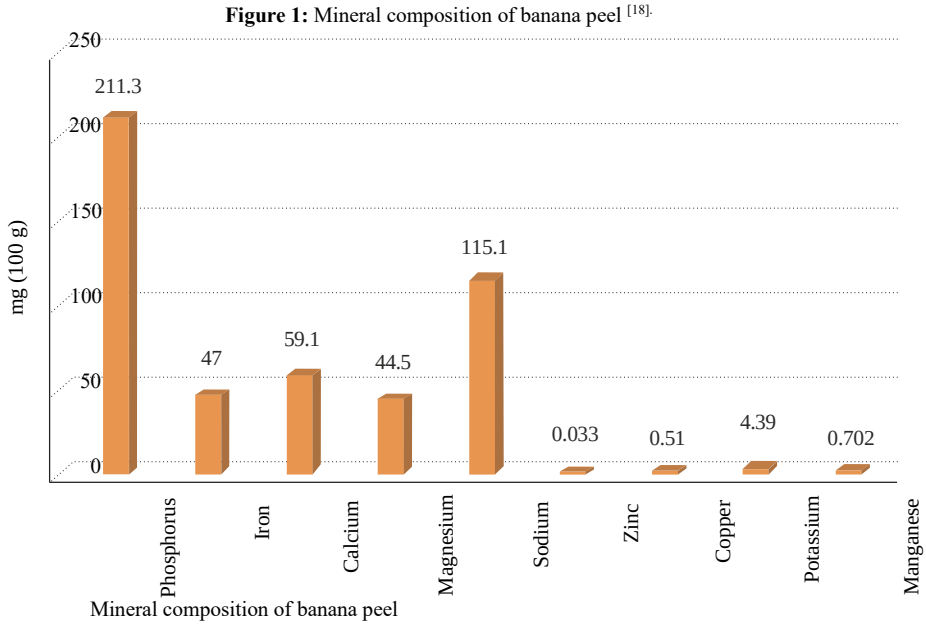


Figure 2: The chemical structures of some amino acids found in a banana peel: leucine, valine, phenylalanine, and threonine.

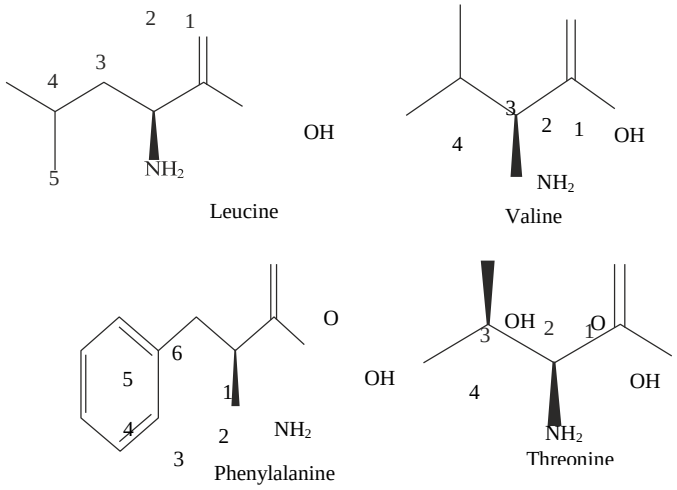


Figure-3: The Chemical composition of Banana peels

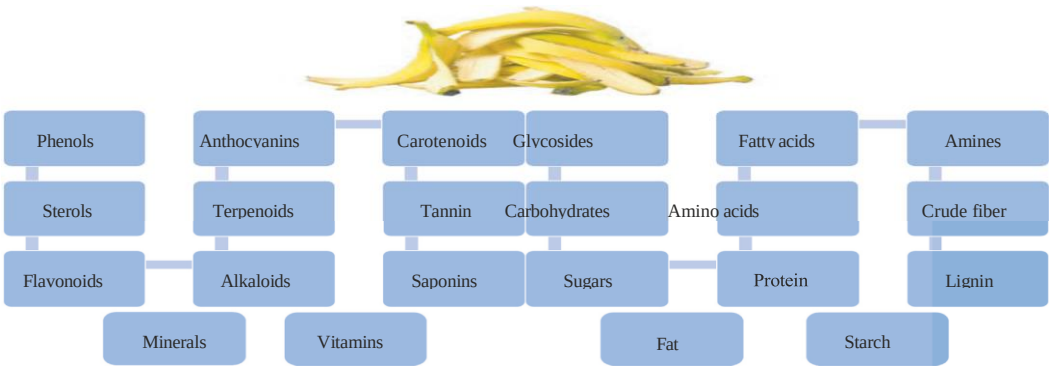
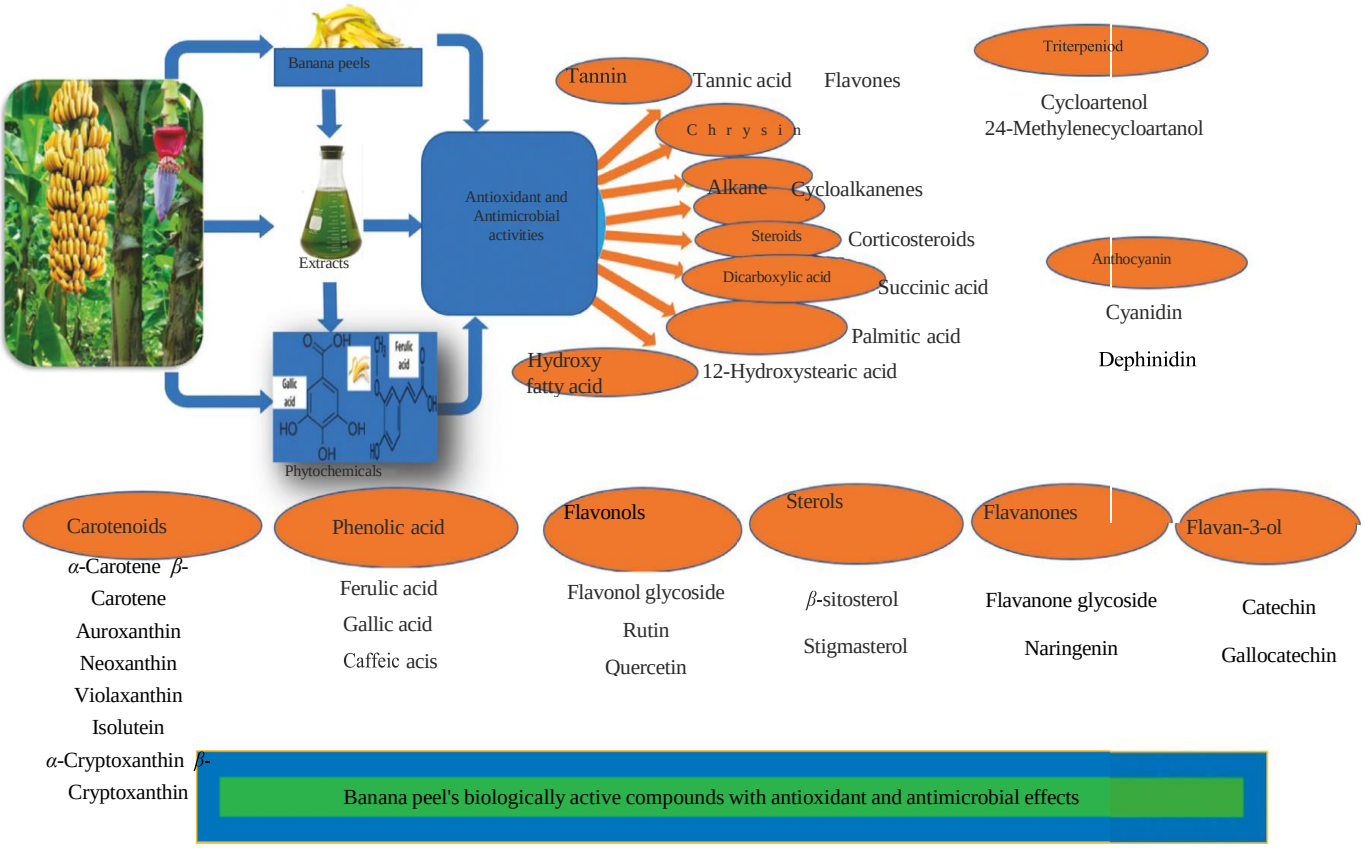


Figure 4: Scheme for the important banana peel's phytochemical compositions with antioxidant and antimicrobial activities.



CONCLUSION

One of the benefits that people have received from the work of scientists studying plant waste is that the banana peel has been able to attract attention as a functional and nutritional source. This work focused on the biological activity of banana peel as an antioxidant and the antimicrobial activity contained in the biologically active compounds. Phenolic compounds, alkaloids, flavonoids, tannins, saponins, glycosides, carotenoids, sterols, triterpenes, and catecholamines isolated from banana peel have been reported to have antioxidant and antimicrobial activities. It turns out that banana peel is very encouraging for future research. Future research is needed to determine the biologically active compounds, potency and many benefits that banana peels are expected to possess, rather than a neglected waste.

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