



E-ISSN: 2709-9385

P-ISSN: 2709-9377

JCRFS 2024; 5(1): 83-88

© 2024 JCRFS

[www.foodresearchjournal.com](http://www.foodresearchjournal.com)

Received: 19-11-2023

Accepted: 26-12-2023

**Prathiksa Pramanik**

Researcher, Department of Food and Nutrition, Swami Vivekananda University, Barrackpore, West Bengal, India

**Srijita Chatterjee**

M.Sc., Department of Home Science, University of Calcutta, West Bengal, India

**Oikantika Sinha**

M.Sc., Department of Nutrition and Dietetics, Midnapore City College, Vidyasagar University, West Bengal, India

**Ushasee Garai**

Department of Food and Nutrition, JD Birla Institute, Jadavpur University, West Bengal, India

**Correspondence****Prathiksa Pramanik**

Researcher, Department of Food and Nutrition, Swami Vivekananda University, Barrackpore, West Bengal, India

## Banana peels: Nutritional composition and medicinal benefits

Prathiksa Pramanik, Srijita Chatterjee, Oikantika Sinha and Ushasee Garai

**Abstract**

Banana peel is a natural source of bioactive compounds, which possess a wide range of biological activities, including anticancer, anti-inflammatory, and itch-relieving properties. This review aims to provide an overview of the bioactive constituents in banana peel and their potential for medicinal applications. The antioxidant and antimicrobial properties of banana peel are mainly based on their phenolic and flavonoid contents. Furthermore, banana peel's antibacterial and antifungal properties are demonstrated in various applications, including the formulation of a semisolid jelly, which exhibits superior scavenging activity compared to commercial products, highlighting the substantial antioxidant capacity of the peel. Moreover, the antiaging and radioprotective properties of the banana peel may be harnessed for pharmaceutical formulations aimed at cancer prevention or treatment. Besides, the antioxidants and anti-inflammatory compounds in the peel may offer benefits for skin health, by helping combat skin ageing, reduce acne, and alleviate skin irritations when applied topically. In this review, we will focus on the antioxidant, antibacterial, and skin-protective potentials of the dietary fibres contained within banana peel, which may be exploited in the development of skin-friendly and eco-friendly skincare products.

**Keywords:** Antioxidant activity, banana peels, biological activities, medical health benefits, phenolic and flavonoid contents, food waste

**Introduction**

Naturally, food wastes are flung away but it carries lots of bioactive and nourished constituents which positively improve health conditions. Especially, Polyphenols and carotenoid of banana peels have ability to remove harmful compounds from human body. Apart from that, essential antioxidant rich phenolic elements have extensive antimicrobial, anti-carcinogenic properties as well as it promotes better antioxidant status (Gopalakrishnan *et al.*, 2023) <sup>[10]</sup>. Banana peels are completely edible.

**Health advantages of Banana Peels****Acts as an antioxidant**

Among communities of fruits and vegetables, banana is the regarded as superficial fruit. In human cell, develop oxidative compensation which is the caused of reactive oxygen species and hamper the concentration of lipid, protein, nucleic acids profile therefore dopamine, rutin, carotenes, dopa ascorbic acids, tocopherol, catecholamine are some anti-oxidative constituents of banana peels which mitigate intricate ailments. Furthermore, banana peels have great antioxidant efficacy rather than mashed state of banana. Banana peels improve oxidative damage that is caused of obesity, diabetes, Cardiovascular disorder (Nisha & Mini, 2014) <sup>[24]</sup>. Noteworthy, various mechanical antioxidant examination are utilised to examine the efficacy of peel's antioxidant ability. Results have revealed that, peels have extensive antioxidant capability to remove harmful pathogens which have analysed by DPPH (2, 2-Diphenyl-1-picrylhydrazyl) and ABTS (2, 2-azino-bis-3-ethylbenzothiazoline-6-sulphonic acid) assay besides peels have an extreme efficacy as the obstructor of lipid peroxidation (González-Montelongo *et al.*, 2010) <sup>[9]</sup> simultaneously, DPPH, 2, 2'-azinobis-3-ethylbenzthiazoline-6-sulphonate and metal ion chelating reducing ability are measured through FRAP assay (Zaini *et al.*, 2022) <sup>[38]</sup>. Secondary metabolites including alkaloid, flavonoid, saponin, tannin are better antioxidant resources of banana peels (Ariani & Riski, 2018) <sup>[4]</sup>. Flavonoid remove the free radicals which are caused of harmful diseases. Authors have reported about the antioxidant constituents of green banana peels and yellow banana peels and outcome have that, water, ethyl acetate and acetone extraction of green banana

peels have good antioxidant properties rather than peels of yellow banana (Mokbel & Hashinaga, 2005) [20]. Precisely, banana peels have better antioxidant attributes and remove the harmful free radicals due to existence of phenolic and flavonoid constituents. Phenolic compounds like gallic acid, catechin, epicatechin, tannin, anthocyanin in banana peels promote good antioxidant status (Sidhu & Zafar, 2018) [28]. Noteworthy, peels containing gallic acid has five times inflated antioxidant activity than pup of banana so it is sure about that, banana peels have extensive antioxidant property (Someya *et al.*, 2002) [29]. Authors have also revealed that, greater than 40 constituents of banana peels have different phenolic contentment, that means totally peels carry 47mg of gallic acid equivalent (GAE)/g dry matter (Vu *et al.*, 2019) [35]. The phenolic constituents are categorised into four classes including flavanol, hydroxy cinnamic acids, flavan-3-ols and catecholamine. Phenolics have good antioxidant status. Moreover, moderate concentration of reactive oxygen species have essential function to maintain the equilibrium specifically signal transduction in cells (Valko *et al.*, 2007) [32]. Apart from that, rutin and myricetin are super most phenolic constituents of banana peels (Tsamo *et al.*, 2015) [31]. Precursor component of carotenoid is vitamin A which present in banana peels adequately and have good antioxidant, anticancer and anti-obesity properties. According to Sundaram *et al.*, 2011 [30], flavonoid and antioxidant capability are underneath in yellow banana peels rather than green banana peels. Green coloured peels while transform into yellow coloured banana peels therefore, decreasing the concentration of naringin, rutin, norepinephrine and dopamine. According to Vu *et al.*, 2019 [35], ripening banana has escalated antioxidant capability however, when it is excessive ripened, therefore, lesion the antioxidant capacity it indicates that, antioxidant attributes are very much interlinked along with phenolic constituents rather of chlorophylls and carotenoids.

#### Act as an anticarcinogen

Bioactive constituents of banana peels have great antioxidant properties besides it stop the cell augmentation. Moreover, it has good cancer mitigating efficacy. Hexane concentrated banana peels have better anticarcinogenic efficacy opposed to HCT-116 malignant of colon (Mondal *et al.*, 2021) [21], result has highlighted that, 64.02% suppressions of cells augmentation. Aqueous and methanolic extraction from nendran (Green) banana peels which have good anticancer tasks opposed to MCF-7 breast cancer cell lines (Durgadevi *et al.*, 2019) [8]. Extracted banana peels may be utilised to generate gold nano particles that suppress the biofilm evolution of gram-positive microbe *Enterococcus faecalis*, this is very much cytotoxic to lung cancer of human (Vijayakumar *et al.*, 2017) [33]. Among thousand types of bananas, *Musa acuminata* 'Dwarf Cavendish' (Yellow) is very much popular around the global super market. It has anticancer properties especially against breast cancer. More over fragmented DNA and ferulic acids have great antiproliferative efficacy and anti-cytotoxic impacts opposed to HeLa cervical cancer

following secreted through peels of banana utilising the pathogenic bacteria *Staphylococcus aureus*. Apart from that. Hydroalcoholic extraction of *M. Cavendish* has great efficacy against colorectal cells Caco-2 in colon (Mondal *et al.*, 2021) [21]. Precisely, peels of banana have great effects to mitigate cancer. Presence of flavonoid into banana peels have good anticancer attributes. Flavonoid has capability to remove the manifestation of reactive oxygen species which trigger apoptosis, apprehends cell cycle as well as stop the development of tumour (Zaini *et al.*, 2022) [38]. Noteworthy, sucrier peels of banana containing ferulic acids has good anticarcinogenic status through modulating the growth factor of vascular endothelium appearance, beginning the functions of nitric oxide synthase which is functioned as a restrainer gene of tumour (Phacharapiyangkul *et al.*, 2019) [27].

#### Act as an antimicrobial constituent

Authors have conveyed that; gram positive and gram-negative microbes are impervious to antipathogenic microbial factors of banana peel (Chabuck *et al.*, 2013) [7]. These peels stop the growing and proliferation of pyogenic microbes (Lino *et al.*, 2011) [18]. Aqueous extracted banana peels have good effect on both gram positive and gram-negative microbes which are caused of gingivitis together with species *Streptococcus* (Aldean *et al.*, 2010) [10]. Authors have noted that, secondary metabolites like flavonoid, tannin, phlobatannins, alkaloid, glycosides and terpenoids which have better antimicrobial efficacy especially against *Staphylococcus aureus* (Hafez & Eissawy, 2018; Kapadia *et al.*, 2015) [11, 15]. In accordance with Chabuck *et al.*, 2013 [7], yellow banana peels have good capability opposed to gram positive and gram-negative microbes. Tannin is caused of strong astringent flavour have satisfactory potentiality to remove pathogens which helps to sediment the protein and active to modify the peptidoglycan (Lino *et al.*, 2011) [18]. These peels have capability opposed to multidrug impenetrable microbes simultaneously, suppress the activity of *Bacillus subtilis*, *Bacillus cereus*, *Salmonella enteritidis* and *Escherichia coli* (Mokbel & Hashinaga, 2005) [20]. Ethanol extraction of *Musa paradisiaca* and *Musa acuminata* have utilised to test antimicrobial potentiality against various microbes especially *Proteus vulgaris* and *Salmonella paratyphi*. Outcome has revealed that, due to presence of antioxidant constituents like glycosides, flavonoid, terpenoid, tannin in banana peels, it is good to remove pathogens (Krishna *et al.*, 2013) [17]. Methanolic extraction of *Musa acuminata* peels are very much strong opposed to pathogenic microbes like *E. coli*, *S. aureus*, *L. casei*, *Bacillus sp.*, *P. aeruginosa*, *S. cerevisiae* in congregation of 300 mg/ml (Niamah, 2014). According to Mordi *et al.*, 2016, 30 mg/ml of extracted methanolic concentration of banana peels have lots of antibacterial activities. As a cause of 2-methyl-5-(1-methylethyl) phenol in banana peels so that it has antimicrobial constituents. Due to existence of tannin in banana peels, it has good antimicrobial potentiality (Aboul-Enein *et al.*, 2016) [1].

**Table 1:** Diverse phytochemicals or extracted bioactive compounds from the banana leaf [Source: Hashim *et al.*, 2023] <sup>[12]</sup>

Sl. No.	Phytochemicals categories	Phytochemicals subtypes	Quantity	
1.	Essential amino acids	Threonine	2.82 g/100 g	
		Valine	2.01 g/100 g	
		Histidine	4.61 g/100 g	
		Tyrosine	1.97 g/100 g	
		Lysine	7.16 g/100 g	
		Methionine	2.52 g/100 g	
		Tryptophan	7.39 g/100 g	
		Phenylalanine	9.56 g/100 g	
		Isoleucine	9.50 g/100 g	
2.	Non-essential amino acids	Leucine	10.97 g/100 g	
		Asparagine	0 g/100 g	
		Arginine	11.10 g/100 g	
		Serine	8.26 g/100 g	
		Glycine	7.32 g/100 g	
		Alanine	8.51 g/100 g	
3.	Minerals	Cysteine	6.30 g/100 g	
		Copper	1.35 mg/100 g	
		Iron	5.06 mg/100 g	
		Manganese	10.38 mg/100 g	
		Zinc	11.6 mg/100 g	
		Calcium	17.85 mg/100 g	
		Magnesium	49.32 mg/100 g	
		Sodium	58.16 mg/100 g	
4.	Bioactive compounds: Flavan-3-ols	Potassium	38.22 mg/100 g	
		Phosphorus	22.64 mg/100 g	
		Gallocatechin, Glutathione, Norepinephrine, Naringin, Salsolinol, L-Dopa	-	
		Bioactive compounds: Flavanol	Rutin; Quercetin-deoxyhexose hexoside; Myricetin-deoxyhexose-hexoside; Laricitrin-3-rutinoside; Syringetin-3-rutinoside; Kaempferol-7-rutinoside	-
		Bioactive compounds: Triterpenic	31-Norcyclolaudenone, Cycloeculalenone	-
		Bioactive compounds: Carotenoids	Trans- $\alpha$ -carotene, Trans- $\beta$ -carotene, $\alpha$ -Cryptoxanthin, $\alpha$ -Cryptoxanthin, Violaxanthin, Auroxanthin, Neoxanthin	-
		Bioactive compounds: Sterols	$\beta$ -Sitosterol, Stigmasterol, Campesterol	-
		Bioactive compounds: Triterpenes	Cycloeculalenol, Cycloartenol, 31-Norcyclolaudenone	-
		Bioactive compounds: Cycloartane-type triterpenes	3-Epi cycloeculalenol, 3-EpicycloMusalenol, 24-Methylene Pollinastanone, 28-NorcycloMusalenone	-
		Bioactive compounds: Fatty acids	Methyl palmitate; Methyl Linoleate; Methyl petroselinic acid; Methyl stearate; 5-Cholene, 3, 24-dihydroxy; 5-Dihydroergosterol; 4,8,13-Duvatriene-1, 3-diol; Henicosyl formate	-
		Bioactive compounds: Active amines	Serotonin, Tyramine, Norepinephrine	-
		Bioactive compounds: Polyamines	Putrescine, Spermidine, Spermine	-

**Table 2:** Medicinal benefits of phytochemical compounds of banana peel

Sl. No.	Categories	Medicinal benefits and responsible compounds	References
1.	Traditional medicinal usage	Historically employed banana peel as a herbal remedy for various ailments, including burns, cough, ulcers, and diarrhoea. For instance, banana peel has been utilised to facilitate wound healing in burn injuries and as a poultice for wounds, offering relief from pain and inflammation. Furthermore, the application of banana peel on skin warts and rubbing the inner side of the peel on mosquito bites have demonstrated effectiveness in reducing swelling and irritation. These applications suggest the presence of potent antibiotic and antibacterial properties within banana peel, warranting further investigation into the bioactive substances responsible for these effects. Unripe banana peel has also been employed in the treatment of diarrhoea, effectively reducing stool frequency and serving as an oral rehydration solution. Additionally, green banana peel has been associated with anticid effects against stomach ulcers, partly attributed to leucocyanidin, a flavonoid within the peel that thickens the stomach's mucous membrane layer. The medicinal potential of banana peel extends to addressing conditions such as depression, anaemia (due to its high iron content), and blood pressure regulation (owing to its high potassium and low sodium content). Moreover, banana peel is a rich source of fructooligosaccharides, acting as a prebiotic that nourishes beneficial gut bacteria, enhancing nutrient absorption and overall digestive health. When appropriately treated and processed, banana peel exhibits significant promise for a wide range of medicinal applications.	(Vu <i>et al.</i> , 2018) <sup>[34]</sup>
2.	Potent antioxidant function	Banana peel contains phenols, carotenoids, flavonoids, saponins, and tannins. The primary contributor to its antioxidant activity is phenol, which correlates strongly with total phenolic content. Analysis has confirmed the presence of various antioxidants, including estragole, hexadecanoic acid, ethyl ester, epicatechin, and gallocatechin, as well as enzymes like ascorbate peroxidase, catalase, peroxidase, and superoxide dismutase. High levels of dopamine, L-dopa, and catecholamines further enhance its antioxidant properties. Isolated bio-components from banana peel exhibit significant antioxidant potential, comparable to gallocatechin and ascorbic acid. The choice of solvent for extraction is crucial,	(Mohd Rasidek <i>et al.</i> , 2016; Aboul-Enein <i>et al.</i> , 2016) <sup>[19, 1]</sup>

		with methanol yielding the highest dopamine content. Factors such as plant species, maturation stage, extraction conditions, and extract concentration influence antioxidant yield and activity. The antioxidant activity of banana peel is demonstrated in various applications, including the formulation of a semisolid jelly, which exhibits superior scavenging activity compared to commercial products, highlighting the substantial antioxidant capacity of banana peel.	
3.	Fungal reduction activity	Its antifungal properties are attributed to bioactive compounds like tannin, alkaloids, saponin, and flavonoids. It effectively combats various fungi, including <i>Aspergillus niger</i> , <i>Aspergillus flavus</i> , <i>Penicillium digitatum</i> , <i>Fusarium oxysporum</i> , <i>Candida albicans</i> , <i>Saccharomyces cerevisiae</i> , and <i>Penicillium citrinum</i> , making it suitable for use as a preservative against spoilage-inducing fungi like <i>Aspergillus oryzae</i> and <i>Rhizopus stolonifer</i> . Banana peel exhibits superior antifungal activity compared to the peels of other fruits, such as carrot, goldenberry, kiwi, watermelon, tangerine, lemon, and orange. Furthermore, its aqueous extract surpasses the antifungal activity of orange, cashew, and pineapple peels. Antifungal activity is significantly influenced by factors like solvent type, extraction time, temperature, and species, with optimization resulting in improved yield and enhanced antifungal activity. Solvent selection for the extraction process plays a pivotal role in determining antifungal activity.	(Olakunle <i>et al.</i> , 2019) [25]
4.	Antibacterial activity	The peel considers as a promising source of antibacterial agents, is evident in its activity against both Gram-positive bacteria like <i>Staphylococcus aureus</i> , <i>Bacillus subtilis</i> , and <i>Bacillus cereus</i> , and Gram-negative bacteria, including <i>Escherichia coli</i> , <i>Salmonella enteritidis</i> , and <i>Pseudomonas aeruginosa</i> . Additionally, it exhibits activity against <i>Salmonella typhi</i> , <i>Micrococcus luteus</i> , <i>Klebsiella pneumoniae</i> , and periodontal pathogens such as <i>Porphyromonas gingivalis</i> and <i>Aggregatibacter actinomycetemcomitans</i> . Notably, fresh banana peels demonstrate a higher zone of inhibition against bacteria compared to dried peels. The antimicrobial activity of banana peel extract can be attributed to the presence of fatty acids, including malic acid, $\beta$ -sitosterol, succinic acid, and palmitic acid. Malic acid, in particular, exhibits robust antibacterial activity. However, it is essential to acknowledge that the antibacterial activity of banana peel is lower when compared to standard antibiotics like chloramphenicol. The choice of solvent for extraction significantly influences antibacterial activity, with different solvents yielding varying outcomes. The antibacterial potential of banana peel also varies with its colour, with different-coloured peels demonstrating higher activity against specific organisms when compared to standard antibiotics. Furthermore, the drying process of the peel plays a crucial role in retaining maximum bioactive components, ultimately enhancing its antimicrobial activity. Microwave irradiation has been identified as the most effective drying method for preserving bioactive components that contribute to both antibacterial and antioxidant activities.	(Youssef <i>et al.</i> , 2018; Aboul-Enein <i>et al.</i> , 2016) [37, 1]
5.	Anti-inflammatory activity	Banana peel exhibits anti-inflammatory activity through various mechanisms. It contains bioactive compounds, including polyphenols and flavonoids, which can inhibit the production of pro-inflammatory cytokines and enzymes. These compounds act by downregulating signalling pathways like NF- $\kappa$ B, which play a pivotal role in triggering inflammation. Additionally, the antioxidant properties of banana peel help neutralise free radicals and reduce oxidative stress, which is often associated with inflammation.	(Hong <i>et al.</i> , 2023) [13]
6.	Hypoglycaemic effect	The hypoglycaemic effect of banana peel is attributed to its dietary fibres, which exhibit several functional properties as antidiabetic agents. These fibres are known to reduce food intake and lower blood sugar levels. They also contribute to the improvement of liver and pancreas function, playing a significant role in glucose metabolism. Furthermore, banana peel dietary fibres enhance the abundance of beneficial intestinal flora, fostering a healthier gut environment. This, in turn, positively impacts the IRS/PI3K/AKT pathway, a critical signalling pathway associated with insulin sensitivity. In the context of type 2 diabetes (T2DM), these combined effects of banana peel dietary fibres have the potential to aid in the management of blood glucose levels and overall metabolic health.	(Wang <i>et al.</i> , 2022) [36]
7.	Protection for cardiovascular health and other metabolic diseases	The peel contains bioactive compounds like polyphenols, flavonoids, and dietary fibre, which can collectively contribute to these benefits. The dietary fibre in banana peel aids in weight management by promoting feelings of fullness, reducing overeating, and regulating body weight, thus helping to combat obesity. Furthermore, the polyphenols and flavonoids in banana peel possess antioxidant properties, which can help reduce oxidative stress and inflammation, key factors in the development of cardiovascular diseases and obesity-related complications. These compounds may also support healthy blood pressure levels and lipid profiles. Therefore, the incorporation of banana peel in dietary strategies may hold potential for mitigating cardiovascular and metabolic health issues, providing a natural and functional approach to disease prevention and management.	(Bucalen, 2023) [6]
8.	Activity against carcinogenic cytotoxicity	Researchers are investigating plant-derived secondary metabolites for their anticancer potential, with flavonoids and phenols playing significant roles in this endeavour. The antioxidant properties of banana peel are advantageous for early-stage tumor intervention without harming healthy cells. Ferulic acid, a phytoconstituent from banana peel, synthesised using <i>Staphylococcus aureus</i> , exhibits notable cytotoxicity, making it a candidate for cancer treatment. Studies comparing banana peel extract with the standard thymoquinone on MCF 7 (breast carcinoma) cell lines reveal moderate cytotoxicity of the peel extract. Furthermore, the rich phytoconstituents in banana peel contribute to improved haematological parameters and enhanced haemoglobin production. Biochemical investigations demonstrate the anticancer and radioprotective effects of banana peel, including amelioration in red blood cells, white blood cells, haemoglobin, haematocrit, and mean corpuscular volume. Additionally, biomarkers such as carcinoembryonic antigen and malonaldehyde show significant reductions, reinforcing banana peel's potential as a potent anticancer agent.	(Kamal <i>et al.</i> , 2019; Korni <i>et al.</i> , 2023) [14, 16]
9.	Digestive health promotion	Banana peel's dietary fibre promotes regular bowel movements, aiding in food transit through the digestive tract. It also encourages the growth of beneficial gut bacteria, which play a crucial role in nutrient absorption and digestive health. Additionally, the short-chain fatty acids produced during fermentation help nourish the colon's lining and support overall gastrointestinal well-being.	(Parihar & Chaudhary, 2023) [26]
10.	Anti-ageing	The antioxidants and anti-inflammatory compounds in banana peels may offer benefits for skin health, by	(Bhavani <i>et</i>

	activity	helping combat skin ageing, reduce acne, and alleviate skin irritations when applied topically.	al., 2023) [5]
11.	Against chronic skin inflammation like psoriasis	Research into the anti-psoriatic potential of <i>Musa mysore</i> AAB (Poovan Banana) peel extract using human keratinocyte cell lines, through MTT assay, suggests that the extract can reduce the viability of select psoriatic cell lines.	(Korni <i>et al.</i> , 2023) [16]
12.	Treatment against hyperpigmentation	The treatment with Sucrier banana peel extract led to a dose-dependent reduction in tyrosinase activity and cellular melanin content. It also decreased melanogenesis-related proteins like microphthalmia-associated transcription factor and tyrosinase protein after 24 hours of incubation with alpha-melanocyte-stimulating hormones. These findings suggest that Sucrier banana peel extract contains effective agents for skin tone brightening by inhibiting the melanogenesis process through the p38 signalling pathway.	(Korni <i>et al.</i> , 2023) [16]
13.	Protection against radiation	Study shows ethanol extract of banana peel powder, when combined with radiation exposure, enhances P53 expression, suggesting potential radioprotective effects (in rodents).	(Kamal <i>et al.</i> , 2019) [14]
14.	Nutraceuticals application	Banana peel, a rich source of bioactive compounds, has garnered attention in the practical application of the medicinal industry as a valuable nutraceutical. Its versatile properties hold promise in various healthcare aspects. The peel's teeth-whitening potential, owing to its nutrient content and gentle abrasiveness, can find applications in dental hygiene products. Additionally, the bioactive compounds in banana peel, which demonstrate anticancer potential, may be harnessed for pharmaceutical formulations aimed at cancer prevention or treatment. Moreover, the peel's effectiveness in addressing skin issues, such as heel fissures and wound healing, can be leveraged for the development of eco-friendly and skin-friendly skincare products. Furthermore, banana peel's anti-inflammatory and itch-relief properties may inspire the creation of topical solutions for insect bites and skin irritations. Its application in the medicinal industry presents a unique avenue for the utilization of natural resources to improve human health and well-being.	(Bhavani <i>et al.</i> , 2023; Adetuyi <i>et al.</i> , 2022) [5, 2]

## Conclusion

Banana peels offer a treasure trove of health benefits, serving as potent antioxidants, anticarcinogens, and antimicrobial agents. Rich in polyphenols, carotenoids, and other bioactive compounds, banana peels exhibit remarkable efficacy in combating oxidative damage, inhibiting cancer cell proliferation, and suppressing microbial growth. With diverse medicinal applications, including anti-inflammatory and hypoglycemic effects, banana peels represent a valuable resource for promoting overall health and well-being. Harnessing the potential of banana peels could pave the way for innovative nutraceutical and pharmaceutical interventions.

## References

- Aboul-Enein AM, Salama ZA, Gaafar AA, Aly HF, Abou-Ellella F, Ahmed HA, *et al.* Identification of phenolic compounds from banana peel (*Musa paradisiaca* L.) as antioxidant and antimicrobial agents. *J Chem Pharm Res.* 2016;8(4):46-55.
- Adetuyi BO, Ogundipe AE, Ogunlana OO, Egbuna C, Estella OU, Mishra AP, *et al.* Banana peel as a source of nutraceuticals. In: *Food and agricultural byproducts as important source of valuable nutraceuticals.* Cham: Springer International Publishing; c2022. p. 243-250.
- Aldean AAM, Al-Jumaily EF, Al-Safar MA. The effect of banana skin on the bacterial infections of the chronic gingivitis patients. *Al Mustansiriyah J Pharm Sci.* 2010;7(1):145-149.
- Ariani N, Riski A. Aktivitas Ekstrak Etanol Kulit Buah Pisang Kepok Mentah (*Musa paradisiaca* forma typica) Terhadap Pertumbuhan *Candida albicans* Secara *in Vitro*. *J Pharmascience.* 2018;5(1):39-44.
- Bhavani M, Morya S, Saxena D, Awuchi CG. Bioactive, antioxidant, industrial, and nutraceutical applications of banana peel. *Int. J Food Prop.* 2023;26(1):1277-1289.
- Bucalen FCK. Antioxidant and anti-atherosclerotic potential of Banana (*Musa spp.*): A review of biological mechanisms for prevention and protection against atherosclerosis. *Avicenna J Phytomed.* 2023;13(3):240.
- Chabuck ZAG, Al-Charrakh AH, Hindi NKK, Hindi SKK. Antimicrobial effect of aqueous banana peel extract, Iraq. *Res Gate Pharm Sci.* 2013;1:73-75.
- Durgadevi PKS, Saravanan A, Uma S. Antioxidant potential and antitumor activities of Nendran banana peels in breast cancer cell line. *Indian J Pharm Sci.* 2019;81(3):464-473.
- González-Montelongo R, Lobo MG, González M. Antioxidant activity in banana peel extracts: Testing extraction conditions and related bioactive compounds. *Food Chem.* 2010;119(3):1030-1039.
- Gopalakrishnan K, Sharma N, Shahada C, Sudheer S. Utilization of banana peel waste and its application: A review. *Pharma Innov. J.* 2023;12(5):2544-2548.
- Hafez AMATA, Eissawy MM. Effect of banana peel extract on sensory and bacteriological quality of marinated beef. *Arch Nutr. Public Health.* 2018;1:1-11.
- Hashim M, Hamid Z, Gul Z, Akbar A. Functional, nutritional and medicinal potential of banana peel. *Pure Appl. Biol. (PAB).* 2023;12(1):470-490.
- Hong YH, Kao C, Chang CC, Chang FK, Song TY, Houg JY, *et al.* Anti-Inflammatory and T-Cell Immunomodulatory Effects of Banana Peel Extracts and Selected Bioactive Components in LPS-Challenged *In Vitro* and *In Vivo* Models. *Agriculture.* 2023;13(2):451.
- Kamal AM, Taha MS, Mousa AM. The radioprotective and anticancer effects of banana peels extract on male mice. *J Food Nutr. Res.* 2019;7:827-835.
- Kapadia SP, Pudukalkatti PS, Shivanaikar S. Detection of antimicrobial activity of banana peel (*Musa paradisiaca* L.) on *Porphyromonas gingivalis* and *Aggregatibacter actinomycetemcomitans*: An *in Vitro* study. *Contemp. Clin. Dent.* 2015;6(4):496.
- Korni RD, Boddepalli T, Elusuri J, Panda J. Banana Peel: A potential waste product with numerous pharmacological activities. *GSC Biol. Pharm Sci.* 2023;23(2):160-174.
- Krishna V, Girish Kumar K, Pradeepa K, Santhosh Kumar SR. Antibacterial activity of ethanol extract of *Musa paradisiaca* CV. *Puttable and Musa acuminata*

- CV. Grand naine. *Asian J Pharm Clin. Res.* 2013;6(2):169-172.
18. Lino PB, Corrêa CF, Archondo ME, Dellova DC. Evaluation of post-surgical healing in rats using a topical preparation based on extract of *Musa sapientum* L., *Musaceae*, epicarp. *Rev Bras Farmacogn.* 2011;21:491-496.
  19. Mohd Rasidek NA, Mad Nordin MF, Shameli K. Formulation and evaluation of semisolid jelly produced by *Musa acuminata* Colla (AAA Group) peels. *Asian Pac J Trop Biomed*; c2016.
  20. Mokbel MS, Hashinaga F. Antibacterial and antioxidant activities of banana (*Musa*, AAA cv. Cavendish) fruits peel. *Am J Biochem Biotechnol.* 2005;1(3):125-131.
  21. Mondal A, Banerjee S, Bose S, Das PP, Sandberg EN, Atanasov AG, *et al.* Cancer preventive and therapeutic potential of banana and its bioactive constituents: A systematic, comprehensive, and mechanistic review. *Frontiers in Oncology.* 2021;11:697143.
  22. Mordi RC, Fadiaro AE, Owoeye TF, Olanrewaju IO, Uzoamaka GC, Olorunshola SJ, *et al.* Identification by GC-MS of the components of oils of banana peels extract, phytochemical and antimicrobial analyses. *Res J Phytochem*; c2016.
  23. Niamah A. Determination, identification of bioactive compounds extracts from yellow banana peels and used *In Vitro* as antimicrobial. *Int. J Phytomed.* 2014;6:625-632.
  24. Nisha P, Mini S. *In Vitro* antioxidant and antiglycation properties of methanol Extract and Its Different Solvent Fractions of *Musa paradisiaca* L. (Cv. Nendran) Inflorescence. *Int J Food Prop.* 2014;17(2):399-409.
  25. Olakunle OO, Joy BD, Irene OJ. Antifungal activity and phytochemical analysis of selected fruit peels. *J Biol Med.* 2019;3(1):040-043.
  26. Parihar PS, Chaudhary S. An Ecofriendly Approach of Using Fruit and Vegetable Peels and its Various Uses or Benefits; c2023.
  27. Phacharapiyangkul N, Thirapanmethee K, Sangiamsuntorn K, Panich U, Lee CH, Chomnawang MT, *et al.* Effect of sucrier banana peel extracts on inhibition of melanogenesis through the ERK signaling pathway. *Int. J Med Sci.* 2019;16(4):602.
  28. Sidhu JS, Zafar TA. Bioactive compounds in banana fruits and their health benefits. *Food Qual. Saf.* 2018;2(4):183-188.
  29. Someya S, Yoshiki Y, Okubo K. Antioxidant compounds from bananas (*Musa Cavendish*). *Food Chem.* 2002;79(3):351-354.
  30. Sundaram S, Anjum S, Dwivedi P, Rai GK. Antioxidant activity and protective effect of banana peel against oxidative hemolysis of human erythrocyte at different stages of ripening. *Appl. Biochem Biotechnol.* 2011;164(7):1192-1206.
  31. Tsamo CVP, Herent MF, Tomekpe K, Emaga TH, Quetin-Leclercq J, Rogez H, *et al.* Effect of boiling on phenolic profiles determined using HPLC/ESI-LTQ-Orbitrap-MS, physico-chemical parameters of six plantain banana cultivars (*Musa* sp.). *J Food Compos Anal.* 2015;44:158-169.
  32. Valko M, Leibfritz D, Moncol J, Cronin MT, Mazur M, Telser J, *et al.* Free radicals and antioxidants in normal physiological functions and human disease. *Int. J Biochem Cell Biol.* 2007;39(1):44-84.
  33. Vijayakumar S, Vaseeharan B, Malaikozhundan B, Gopi N, Ekambaram P, Pachaiappan R, *et al.* Therapeutic effects of gold nanoparticles synthesized using *Musa paradisiaca* peel extract against multiple antibiotic resistant *Enterococcus faecalis* biofilms and human lung cancer cells (A549). *Microb. Pathog.* 2017;102:173-183.
  34. Vu HT, Scarlett CJ, Vuong QV. Phenolic compounds within banana peel and their potential uses: A review. *J Funct. Foods.* 2018;40:238-248.
  35. Vu HT, Scarlett CJ, Vuong QV. Changes of phytochemicals and antioxidant capacity of banana peel during the ripening process; with and without ethylene treatment. *Sci. Hortic.* 2019;253:255-262.
  36. Wang M, Yang F, Yan X, Chao X, Zhang W, Yuan C, *et al.* Anti-diabetic effect of banana peel dietary fibers on type 2 diabetic mellitus mice induced by streptozotocin and high-sugar and high-fat diet. *J Food Biochem.* 2022;46(10):e14275.
  37. Youssef MA, Eman AA, Abeir ME. Evaluation the bioactive compounds extracted from dried banana (*Musa* sp.) peels which obtained by different drying methods. *Curr. Sci. Int.* 2018;7(2):135-148.
  38. Zaini HM, Roslan J, Saallah S, Munsu E, Sulaiman NS, Pindi W, *et al.* Banana peels as a bioactive ingredient and its potential application in the food industry. *J Funct. Foods.* 2022;92:105054.