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Review Article

Peels of Edible Plants as Treasure Trove of Remarkable Nutraceutical Properties: Prospects for Medical Nutrition Therapy

Adeoye Bayo Olufunso[1*], Bolade Damilola Comfort[1], Adeyemi Funmilayo Elizabeth[1], Akinnawo Omowumi Olubukola[1], Adeshina Halliyah Celine[1], Adebayo Barakat Temitope[2], Onyeyiriuche Chinecherem Chibundo[1], Ajaere Sandra Onyinyechi[1], Akin-Akanbi Funmilayo Bimbola[3], Elum Israel Ikenna[1], Olatinwo Mercy Olajoju[4], Achor Corniluis Bangsi[1], Nwawubem Joy Chinasa[1], Adeoye Ayodeji David[5], Akano Oyedayo Phillips[5], Adetunji Opeyemi Adebola[6], Aanu-Bakare Grace Olajumoke[7]

[1]Department of Biochemistry, School of Basic Medical Sciences, Babcock University, Ilisan-Remo, Ogun State, Nigeria
[2]Department of Biochemistry, Faculty of Basic Medical Sciences, Ladoke Akintola University of Technology (LAUTECH), Ogbomoso, Oyo State, Nigeria
[3]Department of Chemical Pathology, Faculty of Basic Clinical Sciences, Ladoke Akintola University of Technology, Ogbomoso, Oyo State, Nigeria
[4]Department of Biochemistry, Faculty of Basic Medical Sciences, University of Ibadan, Oyo State, Nigeria
[5]Department of Physiology, School of Basic Medical Sciences, Babcock University, Ilisan-Remo, Ogun State, Nigeria
[6]Department of Anatomy, School of Basic Medical Sciences, Babcock University, Ilisan-Remo, Ogun State, Nigeria
[7]Department of Food Science, University of Ibadan, Oyo State, Nigeria

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Abstract: ***Background***: Despite the valuable bioactive compounds and potential health benefits, the peels of various plants, such as mango, pomegranate, yam, banana, red potato, pineapple etc, are commonly discarded. Recent discoveries have highlighted the pharmacological importance of these peels, which could have many therapeutic properties. ***Objective***: This review aims to highlight the importance of edible peels in preventing and managing illnesses. The pharmacological features and nutritional contents of these peels are explored. ***Method***: A comprehensive literature review was conducted, focusing on recent research that investigates the bioactive compounds, nutritional composition, and pharmacological effects of fruit peels. This information was retrieved from databases such as Pubmed, Science Direct, Google Scholar and Research Gate. ***Results***: This review's findings showed that some fruits' peels contain higher levels of phytochemicals, antioxidants, and essential minerals. Recycling plant peels can effectively reduce waste and implement efficient waste management practices. These by-products have been reported to contain abundant bioactive compounds that can be used in diverse industrial applications to enhance health and provide nutritional advantages. ***Conclusion***: The pharmacological properties of edible peels emphasise their importance as natural therapeutic substances and functional foods. This review advocates for incorporating these by-products in dietary guidelines and medicinal therapies. Future research should focus on elucidating the processes by which the bioactive compounds in these peels exert their effects and exploring their potential therapeutic applications. This will help facilitate their integration into diets designed to enhance overall health.

Keyword: Peels, Plants, Antioxidants, Nutraceuticals, Disease.

INTRODUCTION

There has been an increasing interest in recent years to investigate the nutritional and medicinal properties of food components that are commonly discarded, including edible peels [1]. Traditionally, the peels of fruits and vegetables have been considered as discarded material. Nevertheless, these leftover parts are unexpectedly abundant in vital nutrients, antioxidants, and bioactive substances. With the increasing emphasis on sustainable food practices, researchers are now acknowledging the substantial impact that these peels can have on enhancing health and reducing disease [2]. Several studies have reported that different fruits and

***Corresponding Author:** Adeoye Bayo Olufunso
Department of Biochemistry, School of Basic Medical Sciences, Babcock University, Ilisan-Remo, Ogun State, Nigeria

tubers produce edible peels with different pharmacological and nutritional profiles [3]. Recent research has underlined the presence of bioactive compounds in the peels of many plants, including mango (*Mangifera indica*) [4], pomegranate (*Punica granatum*) [5], yam (*Dioscorea spp*.) [6], banana (*Musa spp*.) [7], cassava (*Manihot esculenta*) [8], etc. The peels contain phytochemicals, which have been demonstrated to be an inexpensive source of functional foods for preventing or managing certain diseases [2]. The edible outer layers of many plants are a somewhat underused resource for enhancing human welfare. Their comprehensive profiles of significant nutrients and bioactive compounds suggest they might significantly contribute to nutrition and preventive medicine [9].

Meanwhile, Edible peels are currently being reassessed as powerful functional foods due to their rich content of vitamins, minerals, and phytochemicals [10-12]. These inherent bioactive compounds are highly reputed for counteracting oxidative stress [13, 14], promote metabolic well-being [15, 16]. Notably, their nutraceutical potency in lowering the likelihood of chronic ailments such as diabetes [17-19], neurological disorders [20-23], and cardiovascular disorders [24, 25], is attracting interest among the scientific community.

Common fruit wastes, such as pomace, peels, rind, and seeds have significant potential across various industries. For instance, they can be harnessed in the food industry to develop edible films and enhance probiotic products. Additionally, they offer opportunities in other sectors, such as the production of nanoparticles, carbon dots, microbial media, biofilms, biochar, and biosorbents. Utilizing these low-cost horticultural by-products to create value-added products represents an innovative and sustainable approach to waste management. This approach reduces environmental impact and opens up new avenues for industrial applications. Different types of waste generated from fruit and vegetable processing are useful in the development of edible films, probiotics, and other high-value products [26, 27].

With a focus on their benefits to health and disease prevention, this research aims to carefully investigate the pharmacological properties and nutritional contents of these edible peels [28, 29]. Using these peels allows increasing nutritional intake and health advantages given the growing desire for natural and health-enhancing products. Moreover, it solves environmental issues by lowering food waste [30]. This work aims to underline the pharmacological relevance of these peels, thus providing a foundation for future studies and useful applications in health and nutrition.

Citrus Peel

Citrus peels, rich in bioactive compounds such as flavonoids, essential oils, carotenoids, and polyphenols, exhibit a wide range of pharmacological properties that have been extensively studied in various disease models. These peels are particularly notable for their potent antioxidant activity, which is attributed to compounds like hesperidin, naringin, and polyethoxylated flavones (PMFs) such as nobiletin and tangerine [31]. These antioxidants help neutralize free radicals, thereby reducing oxidative stress and mitigating the risk of neurodegenerative diseases like Alzheimer's and Parkinson's by inhibiting amyloid-β accumulation and reducing neuroinflammation [32, 33]. In cardiovascular models, citrus peel flavonoids improve lipid profiles and enhance endothelial function, offering cardioprotective benefits [34]. Metabolically, these peels show promise in managing diabetes and obesity by improving insulin sensitivity and reducing body weight [35]. Citrus peels also exhibit significant anticancer properties, with bioactive compounds inducing apoptosis and inhibiting cancer cell proliferation across various cancer types (Nassarawa *et al*., 2024). Their anti-inflammatory effects are well-documented, with flavonoids and other compounds reducing pro-inflammatory cytokines and mediators, thus alleviating inflammation [36]. Additionally, citrus peels possess strong antimicrobial properties, effectively combating bacterial and fungal pathogens, which underscores their potential in food preservation and as natural antimicrobial agents [37].

Carica Papaya

Carica papaya peel exhibits diverse pharmacological properties across various disease models, demonstrating significant potential as a source of bioactive compounds with therapeutic applications [38]. The peel contains a rich array of phytochemicals, including flavonoids, phenolic compounds, and carotenoids, which contribute to its potent antioxidant activity [39]. In cardiovascular disease models, papaya peel extracts have shown promise in reducing oxidative stress and improving lipid profiles, potentially offering cardioprotective benefits [40]. Studies on diabetes models have revealed the hypoglycemic effects of papaya peel, suggesting its potential in managing blood glucose levels [40]. The peel's antimicrobial properties have been demonstrated against various pathogens, indicating its potential use in treating infectious diseases (Kokila *et al*., 2016; Balavijayalakshmi *et al*., 2017; Easmin *et al*., 2024). In cancer models, papaya peel extracts have exhibited anticancer activities, showing the ability to induce apoptosis and inhibit the proliferation of cancer cells [44]. The anti-inflammatory properties of papaya peel have been observed in various inflammation models, suggesting its potential in managing inflammatory conditions [45]. Additionally, papaya peel extracts have shown wound healing properties, which could be beneficial in dermatological applications [46, 47]. In neurodegenerative disease models, the antioxidant and anti-inflammatory properties of papaya peel extracts suggest neuroprotective potential, though more research is needed in this are [48]. In an animal model, *Cacarica papaya* peel meal-based diet curtailed

abnormal sperm morphology and improved the mean ejaculate volume in rabbits [49].

Pomegranate Peel

In a comprehensive review by Ain *et al*.,, (2023), the pomegranate (Punica granatum) peel was reported as a possible therapeutic agent, showing a broad range of pharmacological effects in many illness types. In the past, pomegranate peel has been seen as a byproduct of the agricultural sector. Interestingly, it may be a treasure trove of bioactive chemicals with a wide range of pharmacological effects, according to recent research. The incredible bioactivity of pomegranate peel is largely due to the abundance of vitamins, dietary fibre, polyphenols, and antioxidants [51]. Particularly against bacterial infections like *Ralstonia solanacearum* which is a major challenge for tomato farmers, pomegranate peel polyphenols demonstrated remarkable antimicrobial properties [52]. This study has shown that the ethyl acetate peel extracts of *P. granatum* exhibit noteworthy antibacterial properties against pathogenic plant bacteria, suggesting its potential agricultural significance. In a previous study by [53], pomegranate peel extract was reported as a promising approach to oral candidiasis treatment, and making it a potential natural alternative due to its strong antifungal properties. This is in agreement with the research study by Reyad *et al*., (2021), who reported pomegranate peel extract as a potential anti-candida agent. Additionally, a study by El-Kady and colleagues (2021) demonstrated the efficacy of the ethanolic plant extract in killing *G. ambia* cysts in their *in vitro* study. This study revealed that pomegranate peel extract is efficacious in managing G. lamblia infections. This implies that it may serve as a feasible treatment alternative for giardiasis. This report agrees with the research work of Elkholy *et al*., (2022). In their study, the therapeutic and prophylactic effects of the methanolic extract of pomegranate peel were investigated. Their results revealed that the methanolic extract of these peels could help prevent and manage *G lamblia* infection. The phytochemicals present in pomegranate peel extract were also reported to increase collagen content, hydroxyproline levels, and wound contraction. This reveals that it may possess wound-healing properties [51]. Zhang *et al*., (2022) reported that the plant peels also help to enhance the growth factors required for tissue healing and demonstrated a substantial healing effect on a minipig second-degree burn model. This is potentially linked to the increased levels of protein and gene expression of Vascular endothelial growth factor A (VEGF-A) and Transforming growth factor beta 1 (TGF-β1). A comprehensive review by Siddiqui *et al.*, (2024) revealed that several studies, in vivo and in vitro, have shown pomegranate peel's anti-inflammatory effects [59]. According to Du *et al*., (2018), the peel polyphenols have been proven to downregulate lipopolysaccharide (LPS)-induced inflammatory mediators in macrophage cell lines. In another study carried out to evaluatee the hepatoprotective effect of the peel extracts, the extract was reported to reduce oxidative stress and inflammatory responses and modulate COX2 [61]. The molecular docking analysis of the major phytochemicals of the peel extract also confirmed its ability to inhibit COX-1 & COX-2 enzymes [62], also decreased iNOS production via inhibition of NF-κB pathway [63]. Several studies have reported the use of pomegranate peel powder as well as ethanolic extract as a potential dietary supplement for gastric and peptic ulcers. These studies have shown that the peel powder downregulated inflammation markers and increased mucus secretion in experimental animals, thereby protecting the mucosa of the upper gastrointestinal tract of the animals [64, 65]. Pomegranate peel extracts have been demonstrated in studies to increase antioxidant enzyme levels and lower lipid peroxidation, therefore promoting possible cardiovascular advantages. Gallic acid (GA), a polyphenol found in pomegranate peel, has been reported to possess anti-inflammatory, antimutagenic, and anticancer. It can induce cell death in several cancer cell lines by acting as a pro-oxidant. Pomegranate peel polyphenols are reported as a potent alternative for preventing and treating cervical [66], and ovarian [67], cancer through apoptosis induction, cell cycle arrest, and inhibition of DNA synthesis [68]. The diverse phytochemical composition of pomegranate peel extracts, which includes polyphenols, catechins, flavonoids, tannins, and anthocyanins, contributes to its wide range of effects [69].

Mango Peel

Extensive research on the pharmacological effects of mango (*Mangifera indica*) peel across a variety of diseases has shown encouraging therapeutic potential [70, 71]. In a review, Alaiya & Odeniyi, (2023) summarized the antimicrobial properties of mango plant extracts. The extracts from mango peel were reported to exhibit strong antibacterial action. In a study, mango peels were reported to show inhibitory activity against Gram-positive and Gram-negative bacteria, which suggests that the peels possess antioxidant and antimicrobial properties [73]. Some research suggests that the bioactive chemicals and polyphenols found in the peels can combat bacterial infections. Because it contains a high concentration of phenolic compounds, the peel is a powerful antioxidant that can effectively lower oxidative stress in various diseases [74, 75]. A recent study was conducted by Mistry *et al*., (2023) on experimental rats to investigate the anti-diabetic activity of mango peels. The administration of mango peel extract to alloxan-induced diabetic rats demonstrates antidiabetic, glycogenesis, and hypolipidemic properties. These findings suggest potential advantages for glucose tolerance and insulin sensitivity [77]. The mango peel is reported by Plaitho *et al*., (2024) to contain secondary metabolites such as α-carotene, quercetin, β-carotene, phenolic compounds, and lutein, which possess antioxidant potential. Studies have also shown that mango peel has anti-inflammatory properties, both in *in vivo* and *in vitro* experiments, and they may reduce

inflammatory markers. The findings suggest that mango peel might be beneficial in treating inflammatory illnesses. Mangiferin, one of the major components of mango peel, has been noted for its antioxidant, antidiabetic, anticancer, antimicrobial, and anti-inflammatory effects [78-80]. Studies in animal models have shown that mango peels' extracts decreased serum total cholesterol and triglyceride levels [76], and may increase levels of antioxidant enzymes [81], therefore implying prospective benefits for cardiovascular health. In cancer research, scientists have found several bioactive compounds in mango peel that have proven to induce apoptosis, modulate oxidative stress, and stop the spread of cancer cells. The anticancer property is attributed to its phytochemicals such as mangiferin, gallotannins, gallic acid, pyrogallol, methyl gallate and quercetin [82, 83]. In animal studies, extracts from mango peels have shown wound healing properties, such as promoting collagen deposition and hastening wound closure [84-85].

Water Melon

The rind of watermelon (*Citrullus lanatus*) has been investigated for its potential therapeutic applications [86]. It has demonstrated a broad spectrum of pharmacological activities across various disease models, suggesting its potential use as a practical therapeutic agent [87]. The peel's rich phytochemical profile, comprising terpenoids, alkaloids, flavonoids, saponins, tannins, and other compounds, underlies its extensive range of biological effects. The aqueous extract of watermelon peels also showed anticancer activity in different cancer cell lines [88]. Antimicrobial studies on watermelon peel extracts have shown strong antibacterial action. Polyphenols and other bioactive compounds present in these extracts may be effective against numerous bacterial illnesses [89, 90]. A research study by *Feizy et al*., (2020) reported the antioxidant properties of the peel and its free radical scavenging activity. Neglo and colleagues (2021) also reported that watermelon peels have a high total phenolic content. Several studies reported that the watermelon rind showed promise in protecting the animals from NSAID-induced ulcers [92, 93]. Additionally, it possesses qualities that can protect the stomach from ethanol-induced ulcers [94]. The watermelon peel extract has demonstrated notable laxative properties in animal studies, effectively promoting intestinal movement [95]. Using Eddy's hot plate approach in animal models, pain treatment studies have demonstrated the aqueous extract of *C. lanatus* peels (AECL) to be rather effective [96]. Research on watermelon rind has been focused mostly on its possible benefits in managing inflammatory diseases. Furthermore, the peel's abundant phytochemicals make it a promising natural remedy for managing diabetes, hypertension, and cardiovascular disorders [97]. While more research is needed, watermelon peel shows promise as a natural source of therapeutic agents for various health issues due to its diverse pharmacological properties. Further investigation is required to explore its medicinal potential fully [98].

Pineapple Peel

The pineapple (*Ananas comosus*) peel exhibits a broad range of pharmacological properties, showing tremendous potential for therapeutic applications across various diseases, making it a promising area for further research and exploration (Mehraj *et al*., 2024). A study published by Ajayi *et al*., (2022), the peel extract of pineapple showed moderate antimalarial effects, but more notably, it exhibited substantial antinociceptic and anti-inflammatory properties, likely due to its ability to suppress pro-inflammatory molecules. Based on another study by Ajayi *et al*., (2021), the peel extract has been found to positively impact cognitive function in rats fed a high-fat diet (HFD). Specifically, it reduced the negative effects of HFD on spatial memory and learning, as measured by the Y-maze test (YMT) and novel object recognition test (NORT). This suggests that peel extracts may help mitigate the decline in cognitive abilities associated with a high-fat diet. Furthermore, their study demonstrated that the peel extract demonstrated anxiolytic-like activity in the elevated plus maze (EPM) test, indicating that it may have a calming effect and reduce anxiety-like behavior. This is a significant finding, as anxiety disorders are often comorbid with metabolic disorders. In addition to its cognitive and anxiolytic effects, the extract also improved lipid profiles and reduced the risk of atherogenicity (plaque buildup in arteries) in both normal diet (ND) and HFD-fed rats. This suggests that peel extract may have a protective effect against cardiovascular disease. The extract also enhanced antioxidant status in both serum and brain tissue by reducing malondialdehyde (a marker of oxidative stress) and increasing glutathione and catalase (antioxidants). This indicates that peel extract may have a protective effect against oxidative stress and inflammation. The peel extract also reduced HFD-induced brain acetylcholinesterase activity and IL-6 levels, suggesting that it may reduce neuroinflammation and inflammation in the brain. This correlates with an earlier study by Erukainure *et al*., (2011) which reported that the pineapple peel possess protective effect against alcohol-induced oxidative stress in brain tissues of albino rats. In a review by [103], pineapple peels reported to have therapeutic potential as a natural antimicrobial agent, useful for food preservation and as a lead for discovering new drugs to fight infectious diseases, making them a valuable addition to processed foods and instant drinks. Methanolic extracts of pineapple revealed four major polyphenolic compounds including catechin, epicatechin, gallic acid, and ferulic acid, which exhibited antioxidant properties. Although these compounds showed individual antioxidant capacities, their interactions did not produce synergistic effects [104]. A study by Chalchisa & Dereje, (2021) successfully produced vinegar from pineapple peels using yeast (*Saccharomyces cerevisae*) and *Acetobacter aceti* bacteria. This research demonstrates the potential for

converting waste pineapple peels into a valuable product, promoting environmental sustainability and waste reduction while generating added economic value. A study was carried out to determine the phytochemical constituents and proximate analysis of dry pineapple peel and oil derived from ripe pineapple peels [106]. This study demonstrates the importance of pineapple peel as a valuable resource for phytochemicals and nutrients. Furthermore, the pineapple peel could help those with irritable bowel syndrome (IBS) and relieve constipation. The great concentration of vital nutrients in the peel—calcium, potassium, vitamin C, dietary fiber—increases its therapeutic value [107]. Further research can explore the potential applications of pineapple peel extracts in food, cosmetics, and pharmaceutical industries [108].

Potato Peel

Potato peel, often discarded as waste, has been reported by different studies as a surprising source of diverse pharmacological properties, revealing its remarkable therapeutic promise. In a recent review by Hidayat *et al*., (2024), some of the secondary metabolites in potato peels, including flavonoids, phenols, and glycoalkaloids. These compounds have numerous health benefits. The potato peel is a valuable source of high-added-value bioactive compounds, including polyphenols, glycoalkaloids, and polysaccharides, which can be extracted and utilized to create sustainable and economically beneficial solutions. By recovering these compounds, the food industry can reduce environmental waste and increase profitability, making potato peel a promising resource for developing new products and applications [110]. In antimicrobial studies, potato peel extracts have shown efficacy against various pathogens, with polyphenols and glycoalkaloids playing a key role in their antibacterial and antifungal activities [111, 112]. The anti-inflammatory properties of potato peel have been observed in both in vitro and in vivo models, with extracts reducing inflammatory mediators [109]. A recent study found that potato peel extract accelerated incision wound healing, with results comparable to those of povidone-iodine and triamcinolone acetonide, two established treatments. This suggests that potato peel extract gel is a promising natural and safe alternative for wound healing therapy, offering a potential new solution for effective and gentle treatment of wounds without the need for synthetic ingredients [113]. In cancer research, solasonine, a bioactive compounds of potato peel have demonstrated the ability to induce apoptosis and inhibit the proliferation of cancer cells, suggesting potential anticancer properties [114, 115]. Research has revealed that potato peel extracts possess cardiovascular benefits, as evidenced by enhanced lipid profiles and elevated antioxidant enzyme levels in animal studies. The peel's abundant phytochemicals, including phenolic compounds and glycoalkaloids, make it a promising natural remedy for managing diabetes and obesity, with studies demonstrating improved glucose tolerance and increased insulin sensitivity, highlighting its potential as a valuable adjunct therapy [116-118].

Apple Peel

Every year, millions of pounds of apple peels are discarded in processing industry. These waste peels are surprisingly rich in phenolic compounds, which have been shown to have numerous health benefits and potential in preventing chronic diseases [119]. The diverse array of phytochemicals present in the peel, including flavonoids, phenolic compounds, and antioxidants, collectively contribute to its broad range of biological activities and potential health benefits, making it a valuable and versatile natural resource. In a review by Popiolek-Kalisz & Glibowski, (2023), it was reported that apple peel supplementation has promising results in *in vitro* and animal model studies, demonstrating a positive impact on lipid profiles, glucose levels, and blood pressure regulation. These findings suggest that apple peel may have potential in preventing Metabolic Syndrome (MetS), a cluster of conditions increasing the risk of chronic diseases. However, while the results are encouraging, further human clinical trials are necessary to confirm the efficacy and safety of apple peel supplementation in preventing MetS in humans. Apple peel extract has been found to have strong antiproliferative effects against human prostate and breast cancer cells, inhibiting their growth and clonogenic survival. APE treatment causes cell cycle arrest and decreases proliferative markers, while increasing maspin, a tumor suppressor protein. These findings suggest that APE has potential anticancer properties, supporting the inclusion of apple peels in the diet. Further in vivo studies are needed to fully understand APE's mechanisms and preventive effects against cancer [121]. A study by Mueller *et al*., (2013) highlighted the potential anti-inflammatory benefits of apple peel constituents, specifically triterpenoids and β-damascone, in the context of Inflammatory Bowel Disease (IBD). The findings suggest that these compounds may play a role in mitigating inflammation, making them promising candidates for use as nutrient supplements in the treatment of IBD. This discovery opens up new avenues for exploring the therapeutic potential of apple peel-derived substances in managing IBD and potentially other inflammatory conditions. Polyphenols extracted from apple peels have shown exceptional antioxidant properties and a capacity to inhibit the oxidation of low-density lipoprotein (LDL) in laboratory tests, indicating potential benefits in preventing cardiovascular disease. A study by Al-hamdani (2015) on elderly women found that consuming dried apple peel powder or dried ginger powder tablets for 5-6 weeks led to significant improvements in cardiovascular health. The apple peel group showed a reduction in high cholesterol (from 100% to 80%), triglyceride levels (from 96% to 80%), and blood sugar levels (from 96% to 64%), as well as improved appetite and comfort. Similarly, both groups experienced improvements in blood pressure profiles and

lipid profiles. These findings suggest that dietary plants like apple peel may be a natural and effective alternative to chemical medications for managing blood pressure and lipid levels, highlighting the potential benefits of incorporating these plants into one's diet. Another study by Tian and colleagues (2018) in mice found that apple peels exhibited significantly more potent cardioprotective effects than polyphenolic extracts of apple flesh. Analysis revealed that apple peel extracts contained substantially higher amounts of total phenolics and total flavonoids compared to apple flesh extracts, which may explain their stronger efficacy. This research demonstrates the potential cardioprotective effects of apple polyphenols, highlighting apple, particularly its peel, as an excellent source for exploring preventive agents against cardiovascular disorders. In another study, it was reported that polyphenolic extract from apple peel may be a potential preventive and therapeutic agent for mitigating vascular dysfunction and liver damage caused by a high-cholesterol diet. The experiment results suggest that apple peel extract could be a valuable natural remedy for alleviating the harmful effects of high cholesterol on cardiovascular health and liver function [125]. Apple peel flavonoids have been found to have anti-cancer properties, inhibiting the growth of various breast cancer cells, including triple-negative, estrogen receptor-positive, and HER2-positive cells, while leaving non-malignant cells unaffected. These flavonoids work by blocking cell cycle progression, reducing migration and invasion, and decreasing Akt signaling. Higher concentrations of apple peel flavonoids were selectively toxic to cancer cells, inducing cell death through reactive oxygen species accumulation. Notably, intratumoral administration of apple peel flavonoids suppressed tumor growth in mice. These findings suggest that apple peel flavonoids have potential as a natural therapeutic agent for breast cancer treatment, offering a promising alternative or complementary approach to conventional therapies [126-128]. Researchers discovered that quercetin, a flavanol in apple peel, has dual effects depending on its concentration. At high levels, it inhibits cell growth, while at low levels, it promotes neural development. In vivo studies confirmed quercetin's pro-neurogenic effects, enhancing neuronal survival and differentiation without affecting proliferation [129]. Additionally, a compound called 3,5-dihydroxybenzoic acid was identified in apple flesh, which increased neural precursor cell proliferation and neurogenesis. In their study, it was demonstrated that both quercetin and 3,5-dihydroxybenzoic acid support neural development by promoting cell survival, differentiation, and exit from the cell cycle, highlighting the potential neuroregenerative benefits of apple-derived compounds [129].

Banana Peel

Banana peels have shown tremendous potential for therapeutic applications, demonstrating a diverse array of pharmacological effects in various disease models [132]. The peels' rich composition of bioactive compounds, including phenolics, flavonoids, carotenoids, and antioxidants, underlies their extensive range of beneficial actions. These naturally occurring elements work synergistically to exert anti-inflammatory, antimicrobial, antioxidant, and other protective effects, making banana peels a promising natural remedy for a range of health conditions. Studies have demonstrated that banana peel extracts possess antibacterial properties, exhibiting efficacy against a broad spectrum of illnesses. The presence of polyphenols in banana peels is particularly noteworthy, as these compounds have been shown to play a crucial role in combating microbial infections (Hikal *et al*., 2021). Accumulating evidence from extensive studies on cardiovascular disease models demonstrates the cardioprotective effects of banana peel extracts. Notably, these extracts have been shown to significantly reduce lipid peroxidation, particularly in experimental models. Furthermore, hydroethanolic extracts of banana peels have been found to exhibit antihyperlipidemic and cardioprotective potentials in diabetic rats. These beneficial effects are likely mediated by improvements in glycemic control, β-cell function, tissue insulin sensitivity, and antioxidant defense mechanisms. The findings suggest that banana peel extracts may have therapeutic potential for preventing or managing cardiovascular complications associated with diabetes [134, 135]. A study provides evidence that banana fruit and its peel exhibit hepatoprotective and hypoglycemic effects in diabetic rats with hepatotoxicity [136]. Researchers have been drawn to banana peels because of their rich bioactive chemical profile, prompting us to delve into the antioxidant and antimicrobial properties of this overlooked resource [137]. A review article highlights the potential of banana peels as a natural source of antioxidants and a valuable ingredient in pharmaceutical applications, offering a promising natural solution for combating various diseases (Hikal *et al*., 2022). Banana peels possess remarkable anti-inflammatory properties, making them a valuable natural remedy for everyday use as a home-based first-aid solution to manage, reduce, and treat inflammation and infections [139].

CONCLUSION

Edible peels are often dismissed as mere waste but hold remarkable nutraceutical properties that can significantly contribute to medical nutrition therapy. The rich concentration of essential nutrients, antioxidants, and bioactive compounds found in these peels presents a unique opportunity to enhance dietary interventions and support overall health. By integrating edible peels into our nutrition strategies, we not only reduce food waste but also unlock their potential to combat chronic diseases and improve metabolic health. This review underscores the need for further research, encouraging the medical and nutritional communities to embrace the therapeutic potential of edible peels as a valuable component of a holistic approach to health and well-being.

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