Banana peel extract has antimicrobial, antioxidant, anti-inflammatory, and wound healing potential - A review

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Abstract

Nutrients and bioactive compounds in fruits are essential to lead a healthy life. The consumption of fruit has increased worldwide to acquire prevention from disease. Banana peel wastes are highly seasonal and perishable but considered as environmental nuisance. Every year, considerable quantities of banana peels are equivalent to 40% of the actual weight of fresh bananas and often generated as waste. Recently, researchers gained huge attention on biomedical applications such as antimicrobial, antioxidant, anti-inflammatory, anti-cancer activity of banana peel to reduce the cost increase in healthcare industries. The current analysis recaps the biomedical applications and its utilisation as new biomaterial for wound healing applications.

Keywords: Banana peel, Wound healing, biomedical applications

Introduction

Bananas are one of the most popular fruits and contain a significant amount of nutrients. The peel accounts for around 35% of the total weight of the fruit. Each year, around 36 million tonnes of banana peel are generated [1]. It was discovered to be high in dietary fibre and phenolic compounds. The substance possesses significant antioxidant, antibacterial, and antibiotic activities. As such, it is an exciting new material with potential uses in the nutraceutical and pharmaceutical industries. It has long been used in India to cure a variety of diseases, including burns, anemia, diarrhoea, ulcers, diabetes, cough, snakebite, and excessive menstruation [2,3].

Banana is a hybrid of the genus Musa and the family Musaceae. The most widespread section is Eumusa, followed by Australimusa. The dessert cultivar is the banana, while the cooking plantain is the plantain [4]. Banana peel is high in fibre (50 %dry matter), protein (7 % dry matter), essential amino acids, polyunsaturated fatty acids, and potassium. The total phenolic content of banana peel (*Musa acuminata Colla* AAA) ranges between 0.90 and 3.0 g/100 gDW [5]. The banana peel contains cellulosic fibre, a material necessary for the manufacturing of paper and textiles that has lately found applications in the production of nanomaterials [6].

Banana peel waste is considered as agricultural bio waste and disposed of in huge amounts which poses an environmental nuisance. The decomposition of banana peels results in the release of toxic effluents like methane (greenhouse gas) twenty one times higher than carbon dioxide which leads to elevation of temperatures resulting in climatic changes [7]. Likewise, pig manure is also considered to be an environmental nuisance. To deal with it, Moyo et al (2022) used banana peel as co-substrate with pig manure and subjected to anaerobic digestion and investigated the solubilization of phosphorus. Biological dissolution of solid pig manure is eased to aqueous phase for higher solubilization of phosphorus, so that the phosphorus can be utilized as a slow release mineral fertilizer in agricultural fields [8].

Banana peels are often discarded as agri-wastes but it has great potential to be used as functional foods. In some regions of the world, banana peels are consumed as food and employed as medicine. It has huge potential in health promoting properties and it can be used as an essential source in the food industry [9]. Banana peels are well known for its phenolic compounds which are grouped as hydroxycinnamic acids, flavonols, flavan-3-ols and catecholamines. The banana peel incorporated food products naturally enhanced the nutritional content of the foods and reduced lipid peroxidation in meat based products [10].

The current review article aims to focus on the importance of banana peel and its applications in wound healing.

Bioactive compounds of banana peel

Bananas are a globally popular fruit that are consumed as a staple food. It is cultivated on a global scale and ranks as the fifth most significant agricultural food crop. The banana fruit includes a variety of bioactive chemicals, including phenolics, and phytosterols, carotenoids, and biogenic amines [11]. Consumption of fruits and vegetables lowers the risk of cancer and heart disease. Fruits and vegetables contain antioxidants like polyphenol, flavonoid, and tannin, which are known to be protective [12]. Increases in total phenol, total flavonoid, and total tannin were seen when the extraction solvent polarity was increased. TP, TF, and TT concentrations in a methanolic extract of banana peels were 17.89, 21.04, and 24.21 mg/g DW, respectively. This study discovered that the GAE content of banana peel was higher at 91.90 and 160.77 mg GAE/100 g dry matter in two stages of ripeness (ripe and green) [13].

It contains important amino acids such leucine, valine, phenylalanine, threonine, and calcium, magnesium, potassium, and phosphorus, as well as calcium, magnesium, potassium, and phosphorus. Total dietary fibre (43-49%), crude protein (6-7%), crude fat (3.8-11%), and starch (3.8-11%) are all abundant in banana peel (3%). It contains pectin (10-21%), lignin (6-12%), cellulose (7.6-9.6%), and hemicellulose (6.4-9.4%) [14].

A modest increase in protein and lipid content in the banana skin enhances soluble sugar, reducing starch; hemicellulose signals fruit development. The chemical components present in starch were not consistently affected by the ripening stage since starch is converted into reducing sugar [15].

Biomedical applications of banana peel

Antioxidant activity

Kumari et al. 2020 studied the revitalizing effect of banana peel extracts by antioxidant activity. The DPPH and ABTS free radicals were effectively scavenged by the acetone extract of banana peel. Free radical scavenging activity increased correspondingly as extract concentrations increased from 10 µg/ml to 100 µg/ml. At 100 µg/ml of extract, the highest antioxidant activity was 71.21 0.91 and 86.78 0.88 respectively. The extract's IC_{50} in DPPH was 36.2 % and 44.6 % in ABTS, indicating that it has considerable redox potential and antioxidant capabilities. Around 40% of radical scavenging activities were calculated. The ability of banana peel extract to promote cellular function by removing free radicals is confirmed by the 40% reduction in radical ions [16].

Shanthy et al. 2011, investigated the antioxidant activity and protective effect of Banana Peel on Human Erythrocyte Oxidative Hemolysis at various stages of ripening. Banana peel is a common by-product of the pulp industry and contains a variety of bioactive substances such as polyphenols, carotenoids, and other antioxidants. According to the results of this study, unripe banana peels have higher antioxidant efficacy than ripe and leaking ripe banana peels [17]. Gonzalez et al. 2010 reported that acetone:water extracts were much more effective in inhibiting lipid peroxidation or scavenging free radicals in the -carotene/linoleic acid system. The banana peel contains a high concentration of dopamine and L-dopa, two catecholamines known for their antioxidant action [18].

Antimicrobial activity

Various industries, including biosorbent, cosmetics, pulp, organic fertilisers, biofuel, paper, and environmental cleanup, can benefit from banana (*Musa acuminata*) peel applications. Banana peels can also be used as a conventional and inherent drug for the treatment of many diseases [19-22]. Hanafy et al., studied the antimicrobial activity of Pomegranate peel, orange peel, banana peel extract and reported that there were no significant differences between banana peel extracts and the positive control in their ability to kill the pathogen *S. typhimurium*. Banana peel ethanol extract inhibited *E. coli* growth similarly to pomegranate methanolic extract (20.3 mm), whereas banana peel methanolic extract inhibited *P. aeruginosa* growth significantly more than the positive control, but significantly less than the methanolic and ethanolic pomegranate peel extracts (both 20.3 mm). The antifungal activity results showed that banana extracts had no antifungal effect against *Aspergillus flavus* and *Aspergillus niger*. Orange and banana peel methanolic and ethanolic extracts had little effect on several infections [23].

In addition to having antibacterial effects against microbes, the banana peel has not been fully investigated. *Porphyromonas gingivalis* and *Aggregatibacter actinomycetemcomitans* were found to be resistant to the antibacterial activity of banana peel extract in a study by Kapadia et al. in 2015. (*A. actinomycetemcomitans*). *P. gingivalis* and *A. actinomycetemcomitans* had inhibitory zones of 15 mm and 12 mm, respectively, against an alcoholic extract of banana peel in the well diffusion method. *P. gingivalis* and *A. actinomycetemcomitans* were

sensitive to 31.25 µg/mL dilutions in the serial broth dilution procedure [24].

Taweechat et al., 2021 studied the properties and application of banana starch film incorporated with banana peel extract. The antibacterial activity was done at three different concentrations of banana peel extract such as 1%, 2%, 3%. The banana starch film was incorporated with each concentration. E. coli O157: H7 and *S. aureus* TISTR 1466) food-borne pathogenic bacteria were not inhibited by the control film and the BSF at a concentration of 1 % w/w banana peel extract. On the other hand, only *E. coli* (O157:H7) was inhibited by BSF at concentrations of 3 and 5 % w/v banana peel extract, with inhibition zones measuring 0.1 and 0.2 mm, respectively. Banana peel extract's phenolic compounds were found to be primarily responsible for the BSF's antimicrobial activity. As a result of using a lower concentration of banana peel extract on the films, the inhibitory zone in this investigation had significantly lower values [25].

Anti-inflammatory activity

Inflammation is normally a localized, protective response to trauma or microbial invasion that destroys, dilutes, or walls off the injurious agent and the injured tissue [26]. Nitric oxide (NO) is a powerful mediator of organ inflammation and a free radical engaged in physiological and pathological processes such as nonspecific host defences, vasodilatation and acute and chronic organ inflammation. NO produced by activated inflammatory cells is cytotoxic, killing bacteria, viruses, and tumour cells. While it aids in host defence, it also causes acute and chronic inflammation [27].

In existing research work, Water extract of fresh ripe peel exhibited the most potent NO-inhibitory activity with an IC_{50} value of 6.68 + 0.34 µg/ml, followed by 95% EtOH extract of dried unripe banana peel (IC_{50} = 36.62 + 3.68 µg/ml) and 50% EtOH extract of dried ripe peel (IC_{50} = 54.69 + 1.71 µg/ml), respectively [28]. Varalakshmi et al. 2020 reported the anti-inflammatory activity of ethanolic extract of banana peel. The results revealed that the maximum percentage inhibition was noted as 78.22% at 500 µg/mL concentration [29].

Camberos et al reported that the methanol and hexanoic extract of banana peels increased the wound healing activity in male wistar rats by thickening and adding collagen fibres and cellular infiltration of fibroblasts [30]. Atzingen et al studied the anti-inflammatory property of the 10% banana peel gel extract and the result showed increase in anti-inflammatory activity on post operative day 14. This study revealed that the anti-inflammatory response is proportional to the reduction in healing time [31].

Ferreira et al (2022) synthesized and characterized novel and natural polymeric membranes composed of green banana peel extract,chitosan and Andiroba oil. Though chitosan is composed of great technical and biological properties, it lacks anti-microbial and anti-inflammatory properties. To compensate for that, green banana peel extract and andiroba oil is used due to their excellent natural wound healing properties. The synthesized polymeric membranes are found to be hydrophilic in nature with contact angle less than 90 degree. The presence of plant constituents in both banana peel and

andiroba oil showed discrete peaks in XRD results. The Differential Scanning Calorimetry (DSC) results demonstrated the influence of both the plant materials helped to increase the crystallinity of the polymeric membrane. The presence of essential properties such as absorption capacity , fluid retention, cellular adhering capacities of green banana peel extract and andiroba oil in the membrane transformed its capacity to treat epithelial lesions which ultimately aided in wound healing [32].

Anticancer activity

Breast cancer is the high occurring malignancy in women and leads to death due to metastasis. Reactive oxygen species cause oxidative stress which plays a major role in metastatic cascade. Treatment with chemotherapeutic agents like doxorubicin (DOX) also causes side effects. Therefore, the natural products with less side effects created a huge impact in gaining attention among researchers. Rusmiati et al (2021) studied the effect of Extract ethanol red Banana Peel (ERBP) on the metastatic ability of breast cancer cells MCF-7 and also reported the cell death in combination of DOX with ERBP. The anticancer activity results revealed that with or without DOX , the red banana peel extract at a single dose of 100µg/ mL effectively reduced the viability of breast cancer cells and inhibited its metastasis process [33].

Ruangtong et al (2020) synthesized zinc nanoparticles using banana peel extract as a reducing and capping agent. The use of banana peel extract as a reducing agent resulted in rod or sheet zinc nanostructures. The green synthesized zinc nanostructures showed potent anticancer activity against skin cancer cells (A431), liver cancer cell (HepG2), colorectal cancer cell (SW620) without damaging the normal cell line (Vero) [34].

WOUND HEALING ACTIVITY

Animal study

Wounds are the damage caused by a myriad of destructive factors. Wound healing process initiates with the bleeding process, and it is divided into four phases namely hemostatic phase, inflammation, proliferation and remodeling [35,36]. The presence of flavonoids and tannins in natural products can affect wound healing. The flavonoids and tannins' role is to inhibit the formation of inflammatory mediators, so that the inflammation process goes through normally and it aids in acceleration of wound healing process [37,38].

Generally flavonoids and tannins are highly found in Saba banana peel. Therefore it can be used as an accelerating agent in the wound regeneration process. Achmad et al (2021) reported the wound healing activity of saba banana peel extract (Musa paradisiaca) by creating incision wounds in male mice. Three treatment groups were divided based on the specified inclusion and exclusion criteria. Based on the results, the banana peel extract and povidone iodine group healed the wound within 9 days. The average healing diameter found for saba banana peel was 1.88mm and povidone group to be 2 mm. This study concludes that saba banana peel can be used as a potential wound healing agent in accelerating wound healing [39,40].

Meliawaty et al (2021) studied the efficacy of ambon banana peel gel extract (Musa paradisiaca var.Sapientum (L) kunt) on gingival mucosal wound healing in wistar rats. 10% banana peel gel extract was used for the treatment group. An incision on maxillary gingival mucosa was made upto 3mm wide in the horizontal direction with depth of 0.25mm. The study results

showed that the treatment group with 10 % ambon banana peel extract had a significant difference with a p value less than 0.05 which was compared with positive (Povidone) and negative (aquades) control groups. The study concludes that the 10% ambon banana peel extract influenced the wound healing process in the gingival mucosa of wistar rats [41,42].

Wound dressing materials

Researchers gained huge interest to design wound dressing material with natural products to promote the process of wound healing. A lignin based wound dressing like banana peel in chitosan film was developed for better wound dressing applications. In Particular,banana peels were used due to their skin regeneration properties. Different concentrations of banana peel were added to chitosan as matrix filler. The addition of banana peel as lignin helped to reduce swelling of water in wound dressing. The antimicrobial activity results showed *Staphylococcus aureus* to be the most sensitive strain recorded in wound dressing. Therefore banana peel mediated chitosan film can be regarded as potential and therapeutic wound dressing material [43,44].

Alborzi et al (2021) prepared a novel chitosan wound dressing and tested its physical and mechanical properties by incorporation of potato starch, banana peel powder and sesame oil. The mechanical properties of 7 wt % banana peel powder showed excellent mechanical properties. Also the SEM results revealed that banana peel powder was well intercalated within the polymeric matrix. The antibacterial activity of the wound dressing also showed potential antibacterial activity against *S. aureus* and *E. coli* when banana peel powder was added to the composition. The animal studies results exposed the acceleration in formation of blood vessels and angiogenesis due to the banana peel powder infused novel chitosan wound dressing [45].

Conclusion

There has been a huge demand for the use of herbal medicine all over the world. The herbal drugs created attention among researchers due to the side effects associated with allopathic drugs. Numerous studies had revealed the wound healing actions such as anti-inflammatory, anti-oxidant, anti-microbial, cellular regeneration activities. Further studies are needed to explore the various phenolic constituents and banana peels to be associated with various drugs or biomaterials for creating novel wound dressing biomaterials that aid in future wound healing applications.

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