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# ECOFRIENDLY UTILIZATION OF BY PRODUCTS FROM BANANA PEEL IN FOOD PRODUCTION AND OTHER INDUSTRIAL APPLICATIONS. A REVIEW

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**ABSTRACT**

The banana (*Musa Sapientum*) is a member of the Musaceae family. The nutritional value of this fruit and its peels is significant. Every year, 36 million tonnes of banana peel are produced. Starch, bioactive substances, anti-oxidants, pectin, cellulose, minerals, phenolic acids, flavonoids, carotenoids, biogenic amines, and other phytosterols are all found in banana skin. Lipids, carbs, protein, dietary fibers, and a variety of other essential components are also present. It contains anti-nutritional elements such as hydrogen cyanide, oxalate, phytate, and saponin, but only in trace amounts, with the exception of saponin. Banana peel can be used to make buns, bread, pasta, confectionaries, and gluten-free items in the culinary sector. It's also utilized as bio substrate, as well as for medical uses, livestock feed, fertilizer, and bio substrate. Peel can also be used for various reasons, such as removing Cr (IV) and producing bio-Ethane and bio-methane.

## 1. Introduction

*Musa Sapientum*, also known as banana, is a member of the Musaceae family. It originated in the tropical reign of southern Asia and is currently farmed across the tropics. *Musa Sapientum* can reach a height of 2-8 meters and has leaves that are around 3.5 meters long. Its pseudostem produces the single bunch of bananas before it dried and replaced by fresh ones. Fruits grow in a cluster that hangs from the ceiling, with twenty fruits per tier and three to twenty tiers each bunch. The skin protects the fruit (Anhwange and colleagues, 2009).

The banana is a popular fruit that is well-known for its nutritional value. (Aurorae and colleagues, 2009). Climacteric fruit is a type of fruit. This fruit is consumed fresh and processed into various items on a small and industrial scale. (Vu *et al* 2016.). Banana carbohydrate (both starch and non-starch) has a poor digestion, making it a great ingredient for food preparations. A total of 102 million tonnes of bananas are produced each year. Because banana peel accounts for 35% of the total weight of the fruit, about 36 million tonnes of banana peel are produced each year. (Vu *et al* 2016.). The banana is said to have originated in Southern Asia's tropical regions, and it is currently grown all over the world. Anhwange (2008, Anhwange, Anhwange, Anhwange, Anhwang described that banana is the most popular fruit, its world fruit production is accounting for 16.8%, with in apple, orange, and each accounting for 11.4

percent.(Pereira and Maraschin 2015). Banana production has been increased dramatically in last 20 years, in 2013. (Vu *et al* 2018). Asia is the world's largest banana. From 46 million tonnes in 1993 to 105 million tonnes in 2013, there has been a steady increase. (Vu and colleagues, 2018). Asia is the world's top banana producer, accounting for over 57.3 percent of worldwide output, with America, Africa, Oceania, and Europe following closely after. They generate the least, accounting for less than 0.3 percent of world output. Production has increased as a result of increased demand, population growth, expansion of agricultural areas, and productivity. (Vu *et al* 2018).

The major player of the banana industry is Pakistan, containing a land area of 349000 ha, with a total output and productivity of 29.7 million tons/ha, respectively. In Sindh province, 90 percent of the land is in the country's South East Asia. (Memon *et al.,* 2015). According to FAO figures, Asia is the world's greatest banana producer, accounting for 54.4 percent of global banana production, with an average banana intake per capita of 12 kg. Banana is one of the world's most significant food crops, behind rice, wheat, and maize. (Khoozani *et al* 2019.)

Banana peel is the most common byproduct, accounting for about 40% of the fruit total weight. (Agama-Acevedo *et al.* 2016, Agama-Acevedo *et al*. Until today, banana peels were discarded as waste, contributing a significant amount of organic material to landfills. Since the banana peel has been mostly focused by researcher, he has begun extracting and isolating key components for use in food enrichment and other applications. (Agama-Acevedo et al. 2016, Agama-Acevedo *et al*. Peel contains starch, bioactive substances, pectin, cellulose, and a variety of vital minerals and components. (Singh *et al.,* 2016). Several substances, including phenolics, flavonoids, phytosterols, carotenoids, biogenic amines, and other phytochemicals are found in in peel (Pereira and Maraschin 2015). The peel of a banana has higher nutritional fibre. Dietary fiber is a non-digestible carbohydrate polymer, which can be divided into two categories according to its water solubility: soluble fiber (pectin and some hemicellulose) and insoluble fiber (cellulose, lignin, and resistant starch). (Khoozani *et al* 2019). Burns, diarrhea, ulcers, inflammation, diabetes, cough, snake bites, and excessive menstruation are just a few of the problems that banana peel is used to treat. (Pereira & Maraschin 2015) Banana peels also include more dietary fibre and phenolic compounds, as well as anti-oxidants, anti-microbial, and antibacterial capabilities. Anjum, Sundaram, and Rai (Anjum, Sundaram, & Rai, 2014). The content of phenolic compounds in banana peel was 4.95-47 mg garlic acid equivalent/g dry matter (mg GAE/g DM). These chemicals have been associated to health advantages such as the prevention of cardiovascular illnesses, diabetes, cancer, and obesity (Hernández-Carranza *et al*., 2016). (Vu and colleagues, 2018). Gallocatechin, an antioxidant found in banana peel enriched with natural antioxidants. Gallocatechin is found in higher concentrations in banana peel (about 158 mg per 10 g dry weight) and has the strongest antioxidant effect against lipid auto oxidation. Someya and colleagues (Someya *et al*., 2002). Peel contains 0.9 percent, 1.7 percent, 59 percent, and 31.70 percent protein, fat, carbs, and crude fibre, respectively. The findings showed that banana peels are a rich source of carbs and fibre. Because it contains more fiber, it aids in the relief of constipation and enhances overall health. The banana peel moisture content is 6.7 percent. This is low value, and it could be because of the harvesting time (Vu and colleagues, 2018). The low score indicates that banana peel has a long shelf life without mold growth. The amount of ash in the product is 8.50 percent. The amount of organic matter in the soil is approximately 91.50 percent. Organic matter is a metric for a plant's nutritional worth (lipids, proteins, and carbohydrates).Vu and colleagues, 2018). Banana peels have a high nutritional value, indicating that they are a good source of nutrients. (Anhwange and colleagues, 2009)

The potassium content of *Musa Sapientum* peel is higher than that of other minerals (78.10 mg/g). The concentrations of peel calcium, sodium, manganese, iron, rubidium, bromine, strontium, zirconium, and niobium 19.20, 24.30, 76.20, 0.61, 0.21, 0.04, 0.03, 0.02, and 0.02, respectively. If the peels are properly developed and processed, they can be a good source of high-quality carbohydrates and minerals at a low cost. Vu and colleagues, 2018). Because of its high potassium concentration, peel can assist to maintain blood pressure and balance bodily fluids, as well as control kidney failure, cardiac difficulties, and respiratory difficulties. Because iron transports oxygen to cells, it is required for energy production, collagen formation, and the normal functioning of the immune system. Manganese aids in the development of skeletal and cartilage tissue. (Khoozani *et al* 2019.) Bromine, rubidium, strontium, zirconium, and niobium are non-essential minerals with concentrations ranging from 0.21 to 0.02 mg/100g. The results show that banana peel has relatively low non-essential mineral concentrations. (Anhwange and colleagues, 2009). The peel of a banana has more dopamine than the pulp. Dopamine is a bioactive molecule that regulates hormones in glycogen metabolism. (Khoozani *et al* 2019.)

Anti-nutrients are also detected in banana peel, indicating that hydrogen cyanide concentrations are 1.33 mg/g. Acids react with metal cyanides to produce hydrogen cyanide, which is exceedingly deadly. A large quantity of hydrogen cyanide can kill you in a matter of minutes, while smaller doses produce throat and chest stiffness, palpitation, and muscle weakness. However, they are present in the range of 0.5 to 3.5 mg/g and are listed as a safety limit. The oxalate content was nearly 0.51 milligrams per gram. (Kumar *et al*., 2012). Oxalate consumption is linked to kidney illness, which can lead to death, as well as a reduction in the availability of important minerals like calcium. When compared to the 0.7 mg/g reported for cocoyam, the result obtained is low. The amount of phytate in each gram was found to be 0.28 mg/g. (Anhwange and colleagues, 2009). This finding is low when compared to the maize and sorghum results of 146–353, 206–208mg/g, respectively. Saponin content was found to be 24 percent. Consumption of saponin can cause sensory system paralysis. It has been discovered that it inhibits pig and poultry growth while increasing cholesterol excretion in the body. When compared to the 3.00 percent described as the lowest safe amount for animals, particularly cattle, the result achieved is significantly high. Except for saponin, the anti-nutrient content of the peel has been studied and found to be minimal. This suggests that, if properly handled, the peels could be a useful source of feed for cattle. (Anhwange and colleagues, 2009).

Banana peel is used in traditional medicine.
For decades, the peel of a banana has been used as a herbal treatment to treat a number of ailments including burns, ulcers, coughs, and diarrhea. (Pereira & Maraschin, 2015).

For instance, burn wound healing has been healed by wrapping a ripe banana peel around the area to lessen pain as well as swelling (Pereira & Maraschin, 2015). Banana peel has been proved to be an excellent cure for reducing inflammation and swelling after mosquito bites. (Kumar et al., 2012)The banana peel's antibacterial and antibiotic characteristics, and further research into these biological activities and bioactive components is required. Unripe banana peels have also been shown to be useful in the treatment of diarrhea. The peel works as an antacid against stomach ulcers. (Kumar et al., 2012).

Flavonoid component leucocyanindin found in banana peel has been shown to thicken the stomach's mucous membrane layer.(Imam & Akter, 2011). Furthermore, the peel is used to prevent and treat a variety of illnesses, including depression (linked to the tryptophan concentration in bananas), anemia (high iron concentration increases hemoglobin production), and high blood pressure (peel high amount of potassium and low amount of salt). (Kumar *et al*., 2012; Kumar *et al*., 2012). Furthermore, the banana skin contains high fructose oligosaccharides, which are prebiotics

that feed healthy bacteria in the colon. (Kurtolu and Yildiz 2011) by creating vitamins and digesting enzymes, these beneficial bacteria boost the human body's ability to absorb nutrition. (Walker and Duffy 1998). As a result, banana peel has a lot of potential as a traditional medicine. (Vu *et al* 2018).

## 2. Livestock feed

Major nutritional components such as carbohydrates, proteins and lipids at higher concentration in banana peel and account for 91.50% of dry weight. Indigestible fiber is also present in material at high level. (Anhwange, 2008). More than 9 minerals are also present some anti-nutritive component is also present such as hydrogen cyanide but present in minor than safe limit (0.5-3.5mg/g). Banana peel is used as livestock feed and it contains similar quality of some ingredients with in soybean, cassava used for feeding pigs (Tartrakoon, Chalearmsan, Vearasilp, & ter Meulen, 1999).

## 3. Manure

Traditionally banana skin was used as manure by replenish the soil nutrients simply by decomposing. Banana skin produces many types of organic fertilizer because of higher demand of bio fertilizers and biological advances. (Kalemelawa *et al.,* 2012; Pangnakorn, 2006). Under aerobic and anaerobic conditions when banana peel is dumped with cow dung, poultry litter and earth worms then composed. This organic fertilizer contains high potassium (> 100g / kg) and nitrogen (> 2%), which is effective for all kinds of plants. (Pangnakorn, 2006).

## 4. Bio-substrate

By using polymer enzyme and acids cellulose can be hydrolyzed and has been used to produce sugars, organic acids, fuels and enzymes. As banana peel consists of high level of cellulose so it has been used as bio-substrate (Oberoi *et al.,* 2011). For edible mushrooms cultivation and wine production banana peel has been used as substrate. (Padam *et al.,* 2014). Banana skin has been used as substrate to produce xylitol, a sugar that has beneficial properties and used as alternative source of conventional sweetners. (Rehman *et al.,* 2013).

## 5. Utilization of banana peel in food industry. Production of buns

Substitution of refined wheat flour with banana peel fibers with, buns were prepared. The supplementation of refined wheat flour (30 g) with banana peel fibre up to 40 and 10% blend were prepared. Other ingredients that are include were sugar 5g, yeast 5 g, milk powder 5 g, water 20 ml and oil 10 ml or 5 g butter, 50 mg salt. (Budhalakoti, 2019). Refined wheat flour and banana peel fibre were sieved and a uniform blend was made. Luke warm water were used to dissolve yeast and little amount of blend mixture was added to it. (Budhalakoti, 2019) Proofing of this mixture is done at 30°C for 1 or 1/2 hours. Sugar was also added and remaining mixture was added to it and kneaded it to till soft smooth dough. Dough was again punched for few minutes. Dough was sheeted, rolled and molded. Then it was placed in greased sheet, covered with a wet cloth and allowed to rise in tin under 30°C.Water was sprayed on the bun surface before putting it on oven. Bun was baked at 200°C for 10 minutes. After 10 minutes, bun was taken out from oven and allowed to cool. Buns that contain 10% fiber were texturally acceptable and more palatable. (Budhalakoti, 2019)

### 5.1. Bread production from banana and banana peel flour

Processing of flour from banana and banana peel has similar steps. Due to high dietary fiber and bioactive compounds, these flours are used in food stuffs for remarkable functionalities. Bread that are produced from banana of banana peel flour has high value of starch, ash, protein and TDF. (Khoozani *et al.,* 2019). In term of minerals the bread has more value of Mg, K, Na, and Ca. and increase inTDF and RS were also shown to have increased by 9% and 5%, respectively, in the mucous membrane layer of the stomach. Adding GBPF and gluten to bread has the unfavorable effect of making it harder and stickier. Because of

the deficiency of stability in gluten structure, cohesion, elasticity, and chewiness decrease when supplementing is done at 30%. (Khoozani *et al.,* 2019).

### 5.2. Production of pasta

Pasta products, like other foods, play a significant role in people's diets. In comparison to white bread or rice, pasta has a low glycemic index, a long shelf life, and is simple to prepare. (Nilsson *et al.,* 2010)

In 2009 spaghetti made with semolina flour that was enriched with different substitution of GBPF. Textural results indicate an increase in adhesiveness and chewiness that was because of release of amylose from starch during cooking. Pasta made with GBPF consists of 42.54% RS2 and high percentage of polyphenols and antioxidants. (Agama-Acevado *et al.,* 2009). A combination of 15% sprouted flour and 15% GBPF provided best nutritional and technological attributes. (Krishnan and Parhabashankar 2010).

### 5.3. Confectionaries production

By addition of 60% GBPF in cake premix instead of wheat flour increases its shelf life over 4 months. The pH of the Premixture does not change. As well as harmful development, such as fungus and yeast. (Borges et al., 2010; Borges et al., 2010; Borges et al., 2010 Cakes prepared with fine GBPF particle sizes have superior nutritional characteristics without having a negative impact. (Segundo *et al.,* 2017). In biscuits manufacturing a prior treatment of mashed peel together with DF increases softness. Even at 75% substitution there were not significantly change in organoleptic properties such as color, flavor, after taste and mouth feel. (Joshi 2007).

### 5.4. As functional ingredient in yellow noodles

Banana peel noodles are prepared by substitution of wheat flour and green Cavendish banana peel flour which were characterized for physiochemical properties and in vitro starch hydrolysis. Cooked noodles were assessed for estimated glycemic index, vitro hydrolysis index, color, pH, and tensile strength. (Ramli *et al.,* 2009). Banana peel noodles has higher elasticity but same tensile strength as of control. GI of glycemic index of banana peel noodles was lower than the control. Partial substitution of banana peel into noodles may be useful to control starch hydrolysis of yellow noodles. (Ramli *et al.,* 2009)

### 5.5. Gluten free products

As the prevalence of gluten-related illnesses including celiac disease and dermatitis herpetiformis rises, so does the need for gluten-free products. If left untreated, it can lead to intestinal cancer, food shortages, and oxidative stress, thus choosing gluten-free goods with added nutritional value is crucial. (Wang *et al.,* 2017; Wang *et al*., 2018). The addition of 47 percent banana peel flour to a 100g pasta recipe resulted in pasta with more egg white and hydrocolloids. (Zandonadi and colleagues, 2012). Gluten-free bread and pastries are also available; however, their limited qualities necessitate further research into GF starch-based items. Bioactive substances are prevalent in GF diets; as most starchy foodstuffs lack technical features. Torres *et al*. (Torres et al., 2017).

### 5.6. Natural Preservative

Because of its antibacterial and antioxidant qualities, banana peel could be used as a natural preservative in food products. To improve the quality and shelf life of poultry meat and fish oil, for example, extracts were added. (Anal and colleagues, 2012)

Banana extracts were found to have preservation properties comparable to synthetic preservatives such as Butylated hydroxytoluene (BHT) and Butylated hydroxyanisole (BHA) (BHA). (Devatkal *et al*., 2014)

### 5.7. Other uses of banana peel

Heavy metals such as lead, chromium, copper, cadmium, and zinc are always a concern to humans, animals, and the environment. The skin of a banana has been reported to be an efficient heavy metal absorber. Synthetic colors are also

absorbed by banana peel (Castro *et al*., 2011). (Osma and colleagues, 2011)

Banana peel is a good source of extractable pectin, which can be used in the food sector for a variety of purposes. (Oliveria and colleagues, 2015) The main aromatic ingredient used in banana taste is Isoamyl acetate, which is also derived from banana peel. (2015, Ji et al.) In the food sector, banana flour is used as a carbohydrate source or a thickening ingredient. Alkarkhi et al. (Alkarkhi *et al*., 2011). Because banana starch is regarded superior to maize starch, it has a higher market value. Padam *et al*. (Padam et al. 2014) Selective removal of Cr (VI) from industrial wastewater:

Banana peel a commonly produced fruit waste used for the removal of Cr (VI) from industrial waste water. Chromium is waste water from metal fishing and chromo plating industries. (Torres *et al.,* 2017) By ingestion of high level of Cr (IV) causes glomuler damage, tubular and kidney damage. So its removal is essential from waste water. Maximum acceptable limit for drinking water by WHO is 0.05mg/l. Banana peel is used as economical sorbent. (Memon *et al.,* 2008) Initial metal ion concentration, parameters pH, contact time and temperature were investigated and efficient absorption 95% within 10 min were determined. (Torres *et al.,* 2017) Optimal absorption occurs at pH 2 and binding metal ion was pH dependent. By using 5ml of 2M $H_2SO_4$ all retained species were eluted and by using flame atomic absorption and ultraviolet visible spectroscopy technique total amount of chromium and Cr (IV) were analyzed. (Itelima *et al*., 2013). Partitioning behavior for the system at different temperature were used to describe by Langmuir and dubinin-redushkevich isotherms. By using banana peel kinetics and thermodynamics of Cr (VI) removal were also studied. (Memon *et al.,* 2008)

### *5.7.1. Bio-Ethanol production from banana peel*

Banana peels that are waste of fruit industry and present in abundance and are used to produce Bio-Ethanol. Peels were subjected to scarification and fermentation simultaneously for 7 days by using co-culture of Aspergillus Niger and Saccharomyces Cerevisea. (Itelima *et al*., 2013) Ethanol yield, reducing sugar concentration, cell dry weight and biomass yield were determined after 24 hours' interval. After 7 days of fermentation was banana peel had biomass yield of 1.60 OD. 0.20-0.82 mg/cm$^3$ and ethanol yield were about 7.45% v/v. fruit waste that contain fermented sugars such as banana should be used for alternative source of energy. (Itelima *et al*., 2013)

### *5.7.2. Bio methane production from banana peel*

Raw banana peel is also used for bio methane production. Physical treatment by grinding the peel into small pieces prior to anaerobic fermentation was used. Batch reactor was used under mesophilic conditions pH 7 and different concentration of total solids used. (Pisutpaisal *et al.,* 2014) Air and liquid samples were collected at 12 hours' interval for gas composition and volatile fatty acids analysis. At 7.5% concentration of TS maximum yield and production of bio methane were 439 Ml g$^{-1}$TVS and 5.31 Ml hr$^{-1}$. Size reduction of banana peel and fungal pretreatment might improve the methane yield from banana peel fermentation in future work. (Pisutpaisal *et al.,* 2014).

## 6. Conclusions

This assessment overlooks the effective use of banana peels, which are frequently discarded. The conversion of banana peel into numerous valuable applications in the food sector, for medicinal purposes, livestock feed, and the creation of bio ethane and bio methane was reviewed in this paper. The peel of a banana gives nutritious value to a variety of foods. The use of banana peels as a cheap and rich source of antioxidants, phenolic compounds, and minerals points to a future research direction of cost-effective and efficient nutrient recovery, usage, and enrichment.

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