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Research Article

Utilization of Banana Peels: A Novel Approach Towards Food Security and Environmental Sustainability

Anushriya Sahoo and Chandrashree Lenka*

Department of Home Science, Rama Devi Women's University, Vidya Vihar, Bhubaneswar, Odisha, India

***Corresponding Author:** Chandrashree Lenka, Department of Home Science, Rama Devi Women's University, Vidya Vihar, Bhubaneswar, Odisha, India

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Abstract

Due to modernisation, urbanisation, and industrialisation, the globe is currently confronting four major challenges: food loss, food waste, food security, and environmental sustainability. Thus, environmental friendly agricultural by-products were gaining more and more attention now-a days. Bananas, one of the most widely consumed fruits in the world, greatly increase the amount of waste generated by food consumption. Banana peels are rich source of macro and micro nutrients, food fibre, phenols, flavonoids, antioxidants, antibacterial and antimicrobial agents. These bioactive substances may lower the risk of chronic illnesses such as diabetes, cancer, hypertension and cardiovascular diseases. Food products that are lack of phenolic and dietary fibre can improve their nutrient content by the incorporation of banana peel. With the help scientific techniques, such as fermentation and anaerobic digestion, researchers have effectively transformed banana peels into bio fuels like ethanol and biogas. The orphan peel of banana may also be used in agriculture as an organic fertiliser to improve soil quality and plant growth. Animal feed can also be prepared out of banana peels. The aim of the present endeavour is to create awareness among people about nutritional potential of banana peels and their utilization in achieving food security and environmental sustainability through a scientific approach.

Keywords: Banana Peels; Utilization; Bioactive Substances; Food Security; Environmental Sustainability

Introduction

Food loss, food waste, food security and environmental sustainability are most important challenges the world is facing today mostly due to modernization, urbanization and industrialization. The concern is also getting worsen due to consistent war in European countries. After declining throughout the early 21st century, food insecurity has become a growing problem, rising every year since 2014. Over 30 per cent of the world struggled with food insecurity in 2020. This situation shows no signs of improvement, with research from IEP's latest Ecological Threat Report (ETR) projecting that by 2050 the number of food-insecure people will increase by 43% to 3.4 billion.

In 2022, as per the Global Food Security Index of India ranked 68th out of the 113 major countries in terms of food security [13]. In 2023, the Global Hunger Index showed India ranked at 111th out of 125 countries. With a score of 28.7 in the 2023 Global Hunger Index, India has a level of hunger that accounts as serious [14] issue. According to United Nations, there are nearly 195 million undernourished people in India that make up a quarter of the world's undernourished population. In addition, roughly 43% of children in India are chronically undernourished [27]. Though the current nutritional standards meets 100% of daily food requirements, India lags far behind in terms of a quality protein intake at 20%. The Human Rights Measurement Initiative finds that India is operating at only 56.8% of its capacity based its economic power to ensure its citizens have adequate food security. 17% of food is lost between harvest and retail. Addressing this massive loss of food is fundamentally important to achieving the UN Sustainable Development Goals (SDGs). SDG 12 promotes 'sustainable consumption and production patterns' and the third target of this goal 'seeks to halve per capita global food waste at retail and consumer levels and reduce food loss along the entire supply chain by 2030' [20,18].

At this juncture it is imperative to restore the Indian culture, heritage and indigenous practices to prevent food loss and to bring

those practices to the lime light for a better green economy perspective in future. The ethnic foods or traditional cuisines are losing their identity and preparation of organic compost and organic farming are coming up as a new research avenue.

India is the second-largest producer of fruits, as well as vegetables, in the world. Globally, the production of fruits and vegetables is about 675 million metric tons annually and out of which 1.3 billion tons of waste is produced. As reported by Food and Agriculture Organization (FAO) India alone produces 103.03 million metric tons of fruits and 197.23 million tons of vegetables annually. But this constitutes about 40 to 50% of waste annually [31]. Therefore, this waste content should be used in such a way that the greatest possible benefits should be achieved and extracted without incurring any financial loss or posing any environmental risks. As a result, waste materials generated by these industries can be composted and land filled through aerobic or anaerobic treatment, biogas production, animal feed preparation and value-added food production.

India is the world's largest banana producer, accounting for 27% of global production. The banana (Musa sp.) is regarded as the India's second-most valuable fruit crop after citrus fruit and the most popular fruit due to it's variety, taste, nutritional quality, affordability, medicinal properties and availability throughout the year. The production and area of fruit crops in India are also dominated by the banana having strong export potential. It makes up 13% of the total area of production and produces 33% of the fruits. Maharashtra (3924.1 thousand tonnes) and Tamil Nadu (3543.8 thousand) produce the most fruits. Compared to the national average of production i.e. 30.5 tonnes/ha, Maharashtra in India has the highest productivity at 65.70 metric tons/ha [41]. In terms of global trade, bananas come in at number five after cereals, sugar, coffee and cocoa. China, Brazil, Ecuador, India and Ecuador together produce half of all bananas worldwide. The annual production of banana peels is almost 36 million tons, and its existing endpoint is connected to negative environmental impact and economic loss [15].

Due to their high perishability and seasonality, processing waste from fruits and vegetables presents a challenge to both the processing industry and organisations responsible for monitoring pollution. Utilizing its high-value components, such as the dietary fibre fraction, which has a lot of potential for use in the manufacture of functional foods, can help solve this problem. Dietary fibre with antioxidant properties is a concept that is becoming more significant in this regard. As a natural source of antioxidants and nutritional fibre, peels of many different fruits are currently receiving attention.

Banana peel has gained popularity as a very good source of dietary fibre and antioxidants on the basis of these arguments. The peel and the pulp are the two main sections of the banana fruit. The peel, the secondary product of bananas, contributes about 40% of the total weight of the fruit. With the increase production of the fruit, the waste of their peel is also increased. According to Ahmed., *et al*. [1], banana peels, which are about one-third of the fruit weight, are mostly thrown away as waste instead of being used for further utilization. A total of 200 tonnes of banana peel waste are generated daily. The peels are typically disposed of at municipal landfills, contributing to current environmental issues. Natural bioactive compounds are also found in banana peels, such as polyphenols, carotenoids, and dietary fibre which plays a pivotal role in preventing cardiovascular disease, cancer, and other degenerative diseases. Because of its various bioactive compounds, banana peel has demonstrated its excellent uses in a variety of food products, including bakery, culinary, and meat products, in terms of nutritional quality. [46].

With this back drop, the present research is designed to explore the inner potential of banana peels in food and agriculture sector in attaining sustainable development goals and mitigating environmental pollution.

Methodology

The information for the present research was collected from the secondary sources such as books, journals and internet. Necessary data were compiled and presented below. This review shades some lights on the agricultural prospects, nutritional aspects as well as possible interventions of Banana Peels on health benefits.

Result and Discussion

Nutritional quality

Findings of various researchers on nutritional quality of banana peels delineates interesting results. It was reported that the green banana peels has less fibre content than dessert banana peels, and as they ripen, their lignin concentration rises from 7 to 15% dry matter. Therefore, the nutritional value of banana peels vary depending on the cultivar and maturation stage. Plantain peels contain 40% are starch which turn into sugars as the plantains ripe. While ripe banana peels can contain up to 30% free sugars.

Table 1 presents the proximate composition of banana peels found out by different researchers. It was observed that banana peels were good source of moisture, ash, protein, fat, crude fibre and carbohydrate. The moisture content of these banana peels was in the range of 6.70 to 81g/100g. The ash level was varying between 0.70 to 12.45g/100g. Dibanda., *et al*. was reported the highest ash content. Different research findings showed the protein content of banana peel was ranging between 0.90 to 10.44g/100g where as fat content was found to be in between 0.89 to 8.40g/100g. The fibre content was reported by several researchers in their study such as Anhwang., *et al*. [4], Romelle., *et al*. [34], Tsado., *et al*. [38], Mozeda

Nutrients	Dry Sample (%)				Wet Sample (%)
	Anhwang., *et al.* (2009)	Dibanda., *et al.* (2016)	Tsado., *et al.* (2021)	Mozeda Khatun., *et al.* (2021)	Hassan., *et al.* (2018)
Moisture (in g/100g)	6.70 ± 02.22	-	9.83 ± 0.03	81	62.33 ± 0.14
Ash (in g/100g)	8.50 ± 1.525	12.45 ± 0.38	9.56 ± 0.06	0.70	9.60 ± 0.02
Protein (in g/100g)	0.90 ± 0.25	10.44 ± 0.38	3.23 ± 0.05	4.77	1.95 ± 0.14
Fat (in g/100g)	1.70 ± 0.10	8.40 ± 1.15	0.89 ± 0.04	1.7	5.93 ± 0.13
Crude Fiber (in g/100g)	31.70 ± 0.25	11.8 ± 0.06	12.67 ± 0.08	11.95	8.31 ± 0.18
Carbohydrate (in g/100g)	59 ± 0.36	43.40 ± 0.55	63.82 ± 0.32	9.4	11.82 ± 2.17

Table 1: Proximate composition of Banana Peels.

Khatun., *et al*. [22] and Pyar., *et al*. [32], which varied from 8.31 to 31.70g/100g. The carbohydrate content of the banana peels were ranging from 9.4 to 63.82g/100g as reported by the researchers.

Some researchers were worked on the banana peel powder and the table 2 is showing the results of their findings. The moisture content of banana peel powder ranging between 6.36 to 11.6g/100g, which was comparatively lesser than that of moisture content of banana peels as stated by several researchers. Ash content was varying from 4.4 to 22.10g/100g, which showed higher value than the value reported for banana peels. Similarly the value of protein, fat, fibre and carbohydrate was ranging from 6.83-10.04g/100g, 4.01-5.97g/100g, 11.09-66.8g/100g and 54.01-67.25g/100 g respectively.

Nutrients	Filiz Yangilar (2015)	Mozeda Khatun., *et al*. (2021)	Garsa Ali (2022)	Asima Safi (2022)	Imran Pasha (2022)
Moisture (in g/100g)	11.6	**11.2**	7.53 ± 0.03	8.9 ± 0.03	6.36 ± 0.65
Ash (in g/100g)	4.4 ± 0.2	18.87	9.53 ± 0.05	-	22.10 ± 3.01
Protein (in g/100g)	-	10.04	6.83 ± 0.02	-	8.82 ± 0.64
Fat (in g/100g)	-	5.97	4.01 ± 0.03	-	4.52 ± 0.59
Crude Fiber (in g/100g)	66.8 ± 1.3	11.09	12.38 ± 0.92	52.5 ± 0.15	11.20 ± 1.73
Carbohydrate (in g/100g)	-	54.01	67.25 ± 4.36	-	-

Table 2: Proximate Value of Banana Peel Powder.

Emaga., *et al.* investigated the chemical makeup of six types of banana and plantain fruit peels. According to their findings, chemical components were not consistently impacted by the types. However, when fruits matured, their soluble sugar concentration increased while their starch level decreased. The rise in the amount of soluble sugar could be explained by the breakdown of starch by endogenous enzymes. They suggested that endogenous enzymes were responsible for the breakdown of starch, which could account for the rise in the amount of soluble sugar. They identified notable levels of leucine, valine, phenylalanine, and threonine, among other amino acids [42].

The nutritional composition of banana peel powder was observed to very impressive as its values were at par with the nutrient composition of cereals and cereal products. So further research in this direction need to be conducted for better utilisation of banana peels to treat not only celiac diseases and other health complication related to cereal products but also to achieve food security by replacing cereal flours with banana peel flour as a future food.

Table 3 showed the varied ranges of different micronutrients present in banana peel powder. Interestingly the banana peels which were considered as the pollutants for the environment were having the excellent nutritional potential to be considered as one in mainstream of foods. The several studies showed that banana peel powder are a rich source of potassium, sodium, calcium, iron, magnesium and phosphorus. Also it contains a sizable amount of copper, zinc and manganese in it which can be proved itself very good for maintenance of bone health, heart health, nerve health and blood health as well.

The biochemical properties of banana peel

Fatty acid content

The chemical makeup of fruit peels is the primary factor that determines their suitability for use in nutritional supplementation. Like its pulp equivalent, banana peel is rich in organic matter (lipids, fibre, carbohydrates, and protein) and a major source of numerous bioactive substances. Banana peels are a good source

Nutrients	Anhwang., *et al.* (2009) mg/100g	Filiz Yangilar (2015) mg/kg	Dibanda., *et al.* (2016) mg/100g	Kumar., *et al.* (2019) (in ppm)	Garsa Ali (2022) mg/100g	Imran Pasha (2022) mg/100g
Potassium	78.10 ± 6.58	1492.54	-	618.4 ± 25.74mg/100g	110.24 ± 6.04	7124 ± 3.7
Calcium	19.20 ± 0.00	729.18	19.86 ± 0.24	220 ± 08.32	80.27 ± 10.16	332.6 ± 44.7
Sodium	24.30 ± 0.12	265.60	-	38.0 ± 2.91	96.43 ± 3.14	440.5 ± 59.2
Iron	0.61 ± 0.22	42.06	15.15 ± 0.36	12.4 ± 0.32	42.75 ± 0.11	216.3 ± 188.1
Manganese	76.20 ± 0	-	9.05 ± 0.34	-	85.25 ± 4.23	54.3 ± 7
Zinc	-	-	1.72 ± 0.17	2.8 ± 0.06	37.11 ± 1.03	2.0 ± 0.1
Phosphorus	-	918.0	-	-	217.92 ± 0	647.3 ± 47.2
Manganese	-	101.40	-	536 ± 30.37	5.29 ± 0.15	-
Copper	-	-	-	-	0.60 ± 0.07	-

Table 3: Mineral Content of Banana Peel Powder.

of polyunsaturated fatty acids such as linoleic acid (Omega-6) and α-linolenic acid (Omega-3), which make up about 40% of total fatty acids. Studies using a linoleic acid-enriched diet have demonstrated a reduction in liver fat and a slightly improved metabolic condition without any indications of inflammation [23]. Meanwhile, α-linolenic acid has been shown in clinical investigations to have an anti-inflammatory effect on obesity [10]. Banana peels have a high PUFA content, including omega-3 and omega-6 linoleic and α-linolenic acids.

Conversely, there has been a lot of interest in learning more about the antihyperglycemic effect of banana fruit as a result of recent research on the fruit's potential as an antidiabetic. About 20% of the pulp's starch is hydrolysed, which helps sucrose, glucose, and fructose accumulate throughout maturation to make the pulp sweeter and more pleasant. In contrast, just around 3% of starch is found in unripe peels, which may contribute to the low sugar content of the inner peel even after ripening, rendering it tasteless [8,15].

Antioxidant content of banana peels

When compared to other fruits, banana peels contain a higher concentration of phenolics, which are significant secondary metabolites. Banana peels contain a variety of phenolic chemicals, including epicatechin, gallic acid, tannins, and anthocyanins [38]. Furthermore, banana peels have five times more gallocatechin than pulp, which suggests that they are rich in antioxidant chemicals. The peel of ripe bananas (Musa acuminata Colla AAA) also includes catecholamines and anthocyanins (cyanidin and delphinidin). However, sterols and triterpenes like β-sitosterol, stigmasterol, campesterol, cycloalkanol, cycloartenol, and 24-methylenecycloartanol have been found in banana peels, along with carotenoids like β-carotene, α-carotene, and different xanthophylls that range from 300 to 400 µg lutein equivalent/100 [42].

Antimicrobial substance present in banana peel

According to a prior study, banana peels have antibacterial qualities that can effectively combat *Salmonella enteritis, Escherichia coli, Bacillus subtilis, Staphylococcus aureus, and Bacillus cereus* [24]. According to research by Dahham., *et al.* [6], the banana peel extract made from hexane solvent had the maximum toxicity towards the human colon cancer cell line HCT-116, showing 64.02% cell suppression of cell proliferation. The aqueous methanol extract of Nendran banana peel has shown to have a significant cytotoxic effect against MCF-7 breast cell lines by Durgadevi., *et al.* [9] in a different investigation. It was also found out that the crude extract from banana peels could also be utilised to create gold nanoparticles that were cytotoxic to human lungs cancer cells and prevented the formation of bio films by the Gram-positive bacteria *Enterococcus faecalis*.

Pharmacological activity

Bioactive substances found in banana peels include flavonoids, tannins, alkaloids, glycosides, anthocyanins, and terpenoids. These compounds have been shown to have a variety of biological and pharmacological effects, including antibacterial, antihypertensive, antidiabetic, and anti-inflammatory properties [30].

Application of banana peels in several industries

Banana peels' application in the culinary sector

Both ripe and unripe banana peels have been used in earlier studies to enhance the nutritional value and physicochemical characteristics of various food products (e.g. bread, noodles, jelly and meat products). Furthermore, compared to pulp, banana peels contain far more ash, protein, fat, crude fibre, and dietary fibre. This has allowed banana peels to be used to make foods with a variety of amazing capabilities [26].The phytochemical and antioxidant effectiveness of food formulations may be enhanced by incorporation of banana peels.

Use of banana peels in first aid

Some practitioners of folk medicine propose the following remedies in light of banana peels' antibacterial, antioxidant, and anti-inflammatory characteristics. To relieve itching, the peel is applied

on insect bite, poison ivy rash, or sunburn. One frozen banana peel applied to the forehead and another to the back of the neck will help alleviate headache pain. Applying a banana peel for fifteen minutes to a skin splinter to aid in its removal.

Banana peels for teeth whitening

Natural healing practitioners believe that rubbing a banana peel on teeth is beneficial for gums and teeth. Banana peels have demonstrated antibacterial activity against *A. actinomycetemcomitans* and P. *gingivalis*. These bacteria contribute to periodontal diseases, such as gingivitis and periodontitis.

Use of banana peels for healthy hair

Banana peel is recommended as an element in hair masks by proponents of natural health and cosmetic goods. It is said to give hair a shiner, softer texture. They bolster that argument, for example, by highlighting the antioxidants found in banana peel. It is suggested that these antioxidants keep hair strong and healthy by counteracting free radicals.

Use of banana peels for skin care

Proponents of using banana peels for skin care advise to do the following: applying a banana peel to face to brighten it and minimise wrinkles; covering closed eyes to reduce puffiness; moisturising skin with a banana peel; rubbing the peel on acne scars to make them disappear; treating psoriasis for moisturising and relieving itching; and removing warts by taping a piece of ripe banana peel over the affected area and leaving it there for the night.

Use of banana peels for health benefits

Studies on stages of banana and banana peels provide various health advantages. More evidence suggests that riper, blackened bananas assist white blood cells fight off illness and infection, whereas under ripe, green bananas may be more useful in addressing stomach problems.

Gastrointestinal health

Banana peels high in fibre helps ease diarrhoea and constipation by balancing the digestive tract and improving gut health. This is a benefit of banana peels that may be especially significant for those who have irritable bowel syndrome or Crohn's disease.

Reduced risk of cancer

Banana peels are a rich source of antioxidants, carotenoids, and polyphenols that combat free radicals in body that cause cancer. Consuming more banana peels-particularly the green, unripe ones-can raise antioxidant levels and lower the chance of developing cancer, however more research in this direction is required for its better utilization.

Improved vision

Maintaining healthy and strong eyes can be aided by vitamin A. Banana peels and bananas themselves are great sources of this vitamin-A and carotene.

Relieving depression

In addition to providing B6 from banana peels, bananas' high tryptophan content can help reduce symptoms of depression and other mood disorders. As tryptophan degrades, serotonin is produced, which elevates mood. As banana peels are rich in vitamin B6, intake of value-added products rich in banana peel can help to sleep better, which ultimately improves mood [43].

Using banana peels as fertilisers

Farmers use fewer organic fertilisers because they are more expensive, despite the fact that they are more environmentally friendly and effective. Because of this, banana peels can be used to make an inexpensive, natural fertiliser. Peels from bananas, which are usually thrown away as garbage, are being gathered from houses and vendors, cleared of any unnecessary material, and sun-dried. The powdered alkaline banana peel is applied to the soil to increase pH, enhance morphology, and supply necessary nutrients. In comparison to chemical fertilisers and chicken manure, organic fertilisers produced by composting banana waste are thought to be more practical and reasonably priced [33]. The utilisation of solid-state fermentation to transform banana waste into a soil conditioner that stimulates growth and reuse it as fertiliser in banana farming has been shown to considerably lower planted sucker mortality, enhance plant biomass, and boost fruit yield. The bacteria *Azospirillum, Azotobacter*, and *phosphate-solubilizers* are effectively transported by banana waste, which has a positive influence on the soil's availability and the phosphorus content of the bananas' leaves [36]. Rich in nitrogen, phosphate, and potassium, banana peels have an impact on plant growth. Furthermore, recycling banana peels is a great way to control trash [39,41].

Biological substrate

Banana peels have been used as a bio-substrate because of their high cellulose content. The material is utilised in the synthesis of ethanol, laccase, xylanases, and organic acids. Banana peels have been used as a substrate for both the production of wine and the cultivation of edible mushrooms. Researchers have looked into the possibility of employing banana peels as a bio substrate for the production of bioethanol, a sustainable energy source. Bioethanol could be produced from the lignocellulose agricultural waste of banana peels [7]. Banana peels have also been investigated as a potential source of biomethane, a renewable energy source that can be produced by anaerobic digestion [3].

Using banana peels to make biodegradable plastic

Wastes that spontaneously disintegrate or breakdown are known as biodegradable wastes. Non-biodegradable materials are substances that affect the environment by taking a long time to break down and persist in the environment, causing environmental harm and pollution. Biodegradable plastics fall into two categories: those that break down anaerobically and aerobically. Biodegradable plastics might be composed of petroleum-based plastics, additive-based plastics, polymers produced from renewable basic materials, or bioplastics (PHA or PHB). Food packaging industries can effectively use leftover banana peels as a component of edible film. Since it lowers the chance of microbiological growth, the edible coating helps preserve food and increase its shelf life. Banana peels is thus managed less expensively while also yielding a byproduct useful to the food industry [46].

Conclusion

Banana peels which are found to be power house of various nutrients having enormous nutraceuticals and pharmaceuticals properties. They are not only rich source of carbohydrate, protein, fat and fibre but also a profound source of antioxidants, essential fatty acids with antimicrobial properties. Being a rich source of calcium, iron, potassium they can be utilized for betterment of bone health, blood health and heart health. Besides this they can be utilized as a vital source for maintenance of gut health due to high fibre content. Because of its bioactive components it can be utilized as fertilizer and also can help in synthesis of ethanol, xylanases, laccase and organic acids, substrate for both the production of wine and the cultivation of edible mushrooms, preparation of biodegradable plastics and also in preparation of bioethanol and biomethanol a source of renewable energy. Thus banana peels with those tremendous potential prove itself as an miraculous ingredient for food security and environmental sustainability rather than a waste. However further research in this area is required to unfurl the novel potentialities of banana peels and to bring this fact to lime light that banana peels are not waste/trash/garbage rather those are invisible potential resources for mankind for sustainable development.

Conflict of Interest

The authors declare that there is no conflict of interest regarding publication of this paper.

Bibliography

1. Ahmed Z., *et al*. "Use of Banana Peel as A By-Product to Increase the Nutritive Value of The Cake". *Journal of Food and Dairy Sciences Mansoura University* 12.4 (2021): 87-97.

2. Alshehry Garsa Ali. "Medicinal Applications of Banana Peel Flour Used as a Substitute for Computing Dietary Fiber for Wheat Flour in the Biscuit Industry". *Hindawi Applied Bionics and Biomechanics* (2021): 1-9.

3. Anal AK., *et al*. "Enhanced yield of phenolic extracts from banana peels (Musa acuminate a Colla AAA) and cinnamon barks (Cinnamomum varum) and their ant oxidative potentials in fish oil". *Journal of Food Science and Technology* 51 (2014): 2632-2639.

4. Anhwange BA., *et al*. "Chemical Composition of Musa Sapientum (Banana) Peels. EJEAFChe 8.6 (2009): 437-442.

5. AOAC. "Official Methods of Analysis, Association of Official Analytical Chemists 17th edition Washington DC (2000).

6. Dahham SS., *et al*. "Antioxidant activities and anticancer screening of extracts from banana fruit (Musa sapientum)". *Academic Journal of Cancer Research* 8.2 (2015): 28-34.

7. Danmaliki GI., *et al*. "Bioethanol production from banana peels". *IOSR Journal of Environmental Science, Ver. II* 10.6 (2016): 56-62.

8. Dris R and Jain SM. "Production practices and quality assessment of food crops". V-3. Quality handling and evaluation. London: Kluwer Academic Publication (2004).

9. Durgadevi PKS., *et al*. "Antioxidant potential and antitumour activities of Nendran banana peels in breast cancer cell line". *Indian Journal of Pharmaceutical Sciences* 81.3 (2019): 464-473.

10. Faintuch J., *et al*. "Systemic inflammation in morbidly obese subjects: Response to oral supplementation with alpha-linolenic acid". *Obesity surgery* 17.3 (2007): 341-347.

11. Feumba Dibanda Romelle., *et al*. "Chemical Composition of Some Selected Fruit Peels". *European Journal of Food Science and Technology* 4.4 (2016): 12-21.

12. Food Safety and Standards Authority of India. FSSAI Manual of Methods of Analysis of Foods - Cereal and Cereal Products -2nd edition. FDA Bhawan, Kotla Road, New Delhi-110002 (2023).

13. Global Food Security Index (GFSI)". The Economist (2023).

14. GLOBAL HUNGER INDEX 2023: INDIA. Global hunger index (2023).

15. Gopalakrishnan K., *et al.* "Utilization of banana peel waste and its application: A review". *The Pharma Innovation Journal* 12.5 (2023): 2544-2548.

16. Hana Mohd Zaini., *et al.* "Banana peels as a bioactive ingredient and its potential application in the food industry". *Journal of Functional Foods* (2022): 105054.

17. Health Benefits of Banana Peel. Written by WebMD Editorial Contributor (2022).

18. Human Rights Measurement Initiative-The first global initiative to track the human rights performance of countries" (2022).

19. India slips in Global Hunger Index, ranks 107 out of 121 nations". Al Jazeera.

20. India: Global Food Security Index" (2023).

21. Jabbour MY., *et al.* "Banana Peel Utilization: Practice and Perspective, Highlights from Lebanon". *International Journal of Clinical Studies and Medical Case Reports* 34.4 (2024): 1-4

22. Khatun Mozeda., *et al.* "Utilization of Banana Peel Flour in Biscuit Making as Wheat Flour Substitute". *European Journal of Agriculture and Food Sciences* 3.6 (2021): 32-35.

23. Marangoni F., *et al.* "Dietary linolenic acid and human health: Focus on cardiovascular and cardiometabolic effects". *Atherosclerosis* 292 (2020): 90-98.

24. Mokbel MS and Hashinaga F. "Antibacterial and antioxidant activities of banana (Musa, AAA cv. Cavendish) fruits peel". *American journal of Biochemistry and Biotechnology* 1.3 (2005): 125-131.

25. Mudambi RS and Rao MS. "Food Science. Chennai. New Age International (P) Publishers Ltd (1989).

26. Nasrin TAA., *et al.* "Physico-chemical characterization of culled plantain pulp starch, peel starch, and flour". *International Journal of Food Properties* 18 (1 (2015): 165-177.

27. Nutrition and Food Security - UN India". UN India (2018).

28. PS Kumar., *et al.* "Antioxidant Potential and Antitumour Activities of Nendran Banana Peels in Breast Cancer Cell Line". *Indian Journal of Pharmaceutical Sciences* 81.3 (2019): 464-473.

29. Pasha Imran., *et al.* "Probing nutritional and functional properties of salted noodles supplemented with ripen Banana peel powder". *Food Production, Processing and Nutrition* 4 (2022): 22.

30. Pereira A and Maraschin M. "Banana (*Musa spp*) from peel to pulp: Ethnopharmacology, source of bioactive compounds and its relevance for human health". *Journal of Ethnopharmacology* 160 (2015): 149-163.

31. Pooja J Gupta., *et al.* "Proximate Analysis of Vegetable and Fruit Waste Collected from the Kadi Vegetable Market, Gujarat". *Biosciences Biotechnology Research Asia* 20.2 (2023): 673-679.

32. Pyar Hassan Peh KK. "Chemical Compositions of Banana Peels (*Musa sapientum*) Fruits cultivated in Malaysia using proximate analysis". *Research Journal of Chemistry and Environment* 22 (2018).

33. Rebello LPG., *et al.* "Flour of banana (*Musa AAA*) peel as a source of antioxidant phenolic compounds". *Food Research International* 55 (2014): 397-403.

34. Romelle FD., *et al.* "Chemical Composition of Some Selected Fruit Peels". *European Journal of Food Science and Technology* 4.4 (2016): 12-21.

35. Saeed MK., *et al.* "Banana peels a contemptible source of dietary fiber and natural antioxidants". *ACTA Pharmaceutica Sciencia* 62.1 (2024): 89-103.

36. Santhos Kumar AU., *et al.* "Studies on mechanical properties and biodegradation of edible food wrapper from banana peel". *Asian Journal of Advanced Basic Sciences* 7.2 (2019): 01-04.

37. Shafi Asima., *et al.* "Effect of the Addition of Banana Peel Flour on the Shelf Life and Antioxidant Properties of Cookies". *ACS Food Science and Technology* 8 (2022): 1355-1363.

38. Sidhu JS and Zafar TA. "Bioactive compounds in banana fruits and their health benefits". *Food Quality and Safety* 2.4 (2018): 183-188.

39. Sultan NFK and Johari WLW. "The development of banana peel/corn starch bioplastic film: A preliminary study". *Bioremediation Science and Technology Research* 5.1 (2017): 12-17.

40. Tsado Amos Ndarubu., *et al.* "Proximate, Minerals, and Amino Acid Compositions of Banana and Plantain Peels". *BIOMED Natural and Applied Science* 01.01 (2021): 32-42.

41. Vanitha M., *et al.* "Quality changes in fish burger from Catla (*Catla catla*) during refrigerated storage". *Journal of Food Science and Technology* 52 (2015): 1766-1771.

42. Wafaa M Hikal., *et al.* "Banana Peels: A Waste Treasure for Human Being" (2022).

43. WebMD. "Health Benefits of Banana Peel".

44. Yangılar Filiz. "Effects of Green Banana Flour on the Physical, Chemical and Sensory Properties of Ice Cream". *Food Technology and Biotechnology* 53.3 (2015): 315-323.

45. Zhang P., *et al.* "Banana starch: production, physicochemical properties, and digestibility-a review". *Carbohydrate Polymers* 59 (2005): 443-458.

46. Zou F., *et al.* "The Valorization of Banana By-Products: Nutritional Composition, Bioactivities, Applications, and Future Development". *Foods* 11.20 (2022): 3170.