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Proximate Composition and Nutritional Evaluation of Raw *Musa sapientum* Peel

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ABSTRACT

Raw Banana peel (*Musa sapientum*), obtained as by-product of banana processing, contains sufficient amounts of nutritive and phytochemical constituents that have positive effects in human nutrition. The raw banana peel exhibits a slightly acidic range, with a pH of 5.0±0.2, Moisture 10.70±0.15%. The bulk density or a related measure of how tightly the material packs, the value is 8.99±0.31g/mL, Ash is 5.74±0.03 %, swelling and solubility is 5.11±0.10 g/100g. The value is 4.27±0.53g/g expressed as water absorption of the raw banana peel sample. Proximate analysis revealed 4.04±0.09g/100gof total protein, 2.29±0.14% of total fat, 1.036±0.04 g/100g of total dietary fiber, 1.6±0.14 g/100g of starch, and 52.32±0.32 g/100g of total carbohydrate. The DPPH (2,2-diphenyl-1-picrylhydrazyl) assay, with a range of 76.03±0.10% inhibition, the Total Flavonoids Content (TFC) is reported as 1.70±0.01 mg RE/100g, and the Total Phenolics Content (TPC) is significantly higher at 159.00±1.00mg GAE/100g. Furthermore, the sample contains a notable amount of Ascorbic acid (Vitamin C) at 0.040±0.00 mg/100g, and the Ferric Reducing Antioxidant Power (FRAP) assay result of 4.02±0.25mg AA/g. This work aims to determine the proximate composition of banana peels, with a view to their valorization for the development of value-added food products. The obtained results show that the nutritional parameters of banana peel provide values that vary depending on the origin of the fruit. The analyzed banana peels have considerable nutritional value and could be effectively integrated into a diverse range of value-added food products.

Keywords: Banana peel, Nutritional constituents, Functional food, Antioxidant potential

INTRODUCTION

Global fruit production and composition have experienced a remarkable increase worldwide because of taste and health benefits due to the presence of nutrients such as minerals, vitamins, fiber and other bioactive compounds needed by the human body for a healthy life. However, the increase in the consumption of these fruits indicates an increase in the volume of waste generated, especially peels. Food waste is the major problem worldwide, therefore the study of peel of fruit can reveal important natural sources of nutrients and country economic indexes. Banana (*Musa sapientum, Musaceae family)* is one of the most widely consumed fruit in the world, being an important source of nutrients, including carbohydrates, fiber, vitamins (especially vitamin B6 and -vitamin C), minerals (especially potassium), and various bioactive compounds such as phenols, carotenoids (Bennette and Sailu, 2022). These fruits are widely known for their high nutritional value, containing dietary fiber, pectin, high levels of minerals (potassium, phosphorus), phenolic compounds (tannins, anthocyanin), vitamins (A, B, C, E), beta- carotene and phytosterol (Huang *et al.*, 2024). Global banana production is reported in the range of 10 million of tone annually, with a recent FAO based dataset showing a large global output of

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bananas. Raw Banana peel has gained considerable attention in food science and technology due to its potential as a low cost, sustainable raw material for the development of value-added food products. Raw Banana peel, which constitutes nearly 30-40% of the total fruit weight, is rich fiber, resistant starch, polyphenols, flavonoids, carotenoids, essential minerals, and bioactive compounds exhibiting antioxidant and antimicrobial properties. Banana peel, the outer shell of the banana fruit, is a by-product of household consumption and banana processing (Hikal *et al.*, 2022), and is rich in nutrients (fiber, protein, crude fat, lipids, pectin, essential amino acids, polyunsaturated fatty acids, and micronutrients) (Kusumasari *et al.,* 2024), and bioactive compounds that provide many health benefits. Even though its nutritional content and bioactive compounds vary depending on the banana variety, environmental conditions, extraction methods, and evaluation methods (Ansari *et al.,* 2023), the amount of ash, protein, crude fiber, and digestible starch in banana peel flour was reported to be significantly higher than that of pulp, which makes the banana peel flour more effective as a functional additive (Kusumasari *et al.*, 2024). In addition to its excellent nutritional value, banana peels have a variety of health benefits. Bananas vary in color, size, and firmness but are usually elongated and curved, with soft, starchy flesh and skin that can be green, yellow, red, purple, or brown, depending on the variety. The nutritional content of bananas varies widely in concentration, depending on the banana variety, soil conditions, climate, cultivation, and stage of fruit development and storage conditions (Huang *et al.*, 2024). India stands as the world's largest banana producer contributing around 33-33.6 million tons per year, making it the dominant player in global supply. Within India, the state of Odisha produces approximately 5.1 lakh tones of banana the year 2023-2024. Having increased from 4.8 lakh tones in previous years. In Odisha's horticulture profile banana accounts for about 6.5% of the fruit cultivation area and nearly 19% of the state's total fruit production. However, 40% of this production in waste mainly peels. Peels are a waste material of various fruits and vegetables. Therefore, it is possible to obtain banana peel sufficiently and the application depends on its chemical composition. In addition, peels can present higher nutrient contents. According to Morais *et al.* (2015) and Moo- Huchin *et al.*, peels are highly perishable, mainly due to the large amount of water in their composition. Moreover, they have a wide range of vitamins and minerals present in both pulps and peels.

The objective of present research has shown that banana peel has a rich nutritional content with the aim of exploiting the potential value of those peels. It can be converted into many useful products such as functional food ingredients, natural food Preservatives and therapeutic agents in clinical nutrition. This review examines the proximate analysis, antioxidant properties and functional food applications of raw banana peel to highlight its potential as value added ingredient in the food and pharmaceutical industries.

METHODOLOGY

Raw material collection and processing:

Raw Banana was collected after the matured fruit of the plant that was harvested from a local farm of Burla,

Fig. 1 : (a) Collected fresh Banana, (b) Peeling and Cleaning, (c) Dried peel at 60°C in hot air oven, and (d) Banana Peel Powder

Sambalpur, and it was taken to Sambalpur University for further preparation and analysis. It was then was cut and peel was separated from the pulp and then place some times in room temperature and then dried in hot air oven at 60°C for over 3 days and then grounded into porous form, while the fresh banana peel was grounded by an electric grinder, and stored in airtight containers for further analysis (Fig. 1).

Physical Analysis of banan apeel:

Determination of pH:

For determination of pH (hydrogen ion concentration) in banana peel. A digital pH meter was used. The slurry or its supernatant is then used for testing. After calibrating the pH meter with standard Buffers and rinsing the electrode, the probe is immersed in the sample and gently stirred until the Reading stabilizes. The pH value is recorded, the measurement may be repeated for accuracy, and the Electrode is rinsed and stored properly affect (Chikezie and Akuwudike, 2013).

***Determination of Moisture (%)**:*

Moisture content in the powder banana peel was determined using hot air oven. Approximately 5 g of sample was weighed into a pre-weighed moisture dish. The dish was placed in a hot air oven maintained at 105°C for 4 hours. It was removed, cooled in desiccators, and reweighed. The heating, cooling, and reweighing cycle was continued until a constant weight was obtained (Akpabio and Akpakpan, 2012).

Moisture content was calculated:

$$\text{Moisture (\%)} = \frac{W_1 - W_2}{W_1} \times 100. \quad \text{.....(1)}$$

where, W_1= initial weight of sample g, W_2= final weight after drying g.

Determination of Ash Content (%):

Ash content was determined using a muffle furnace following (Ekwe *et al.,* 2020). About 3 g of sample powder was weighed in a previously ignited, cooled, and tared crucible. The sample was first charred over a low flame until smoking ceased. The crucible was then placed in a muffle furnace at 550°C for 5–6 hours until a light grey ash was obtained. The crucible was removed, cooled in a desiccator, and weighed (Pyar and Peh, 2018). Ash content was calculated as:

$$\text{Total Ash Content (\%)} = \frac{W_1 - W_2}{W} \times 100 \text{....(2)}$$

Determination of Bulk Density (g/mL):

Bulk density was measured according to the method. A measuring cylinder was weighed, and a known weight (W) of banana peel (*musa* spp) powder was gently poured into it. The cylinder was tapped lightly to ensure uniform settling without compacting the sample (Khalequzzaman *et al.*, 2009). Bulk density was calculated using:

$$\text{Bulk Density (g/mL)} = \frac{\text{Mass (M)}}{\text{Final Trapped Volume } (Vf)} \text{...(3)}$$

Water Absorption Capacity (WAC) (g water/ g sample):

Water absorption capacity was determined using the method of. One gram of banana peel powder was placed in a 15 mL centrifuge tube and mixed with 10 mL of distilled water. The mixture was allowed to stand for 30 min on a shaking incubator and then centrifuged at 2200 rpm for 15 minutes. The supernatant was discarded, and the weight of the hydrated residue was recorded (Asif-Ul-Alam *et al*., 2014), water absorption capacity was calculated as:

$$WAC = W_1 - (W_2 - W_3) \quad \text{..(4)}$$

and Water Absorption Capacity was expressed as grams of water absorbed per gram of dry powder. * W_1= W wet residue, W_2= W test tube, W_3= W sample, W water absorption capacity.

Determination of Swelling Power and Solubility (g/g):

Swelling power and solubility were determined. One gram of banana peel powder was suspended in 10 mL distilled water and heated at 90°C for 30 minutes with intermittent stirring. The mixture was then centrifuged at 3000 rpm for 20 minutes. The supernatant was carefully decanted (Otegbayo *et al.*, 2010).

Swelling power (g/g) was calculated from the weight of the swollen sediment:

$$\text{Swelling Power (g/g)} = \frac{\text{Weight of swollen sediment}}{\text{Dry wet of sample}} \text{.....(5)}$$

Solubility was calculated using the dried residue from the supernatant:

$$\text{Solution (\%)} = \frac{\text{Wet of dissolved solid}}{\text{Dry wet of sample}} \text{x100} \quad \text{.....(6)}$$

Proximate Composition of Banana Peel:

Proximate analysis of banana peel involves standard methods for determining moisture content (hot air oven drying at 105°C to constant weight), total protein (Lowry method),total fat (Soxhlet extraction with petroleum ether), total ash content (muffle furnace incineration at 550°C for 4-6 hours), total fiber (acid-alcohol digestion), and carbohydrates (by difference calculation).

Determination of Total Carbohydrate Content (g/100g):

Carbohydrate content of banana peel was determined using the Anthrone method as described by (Anhwange *et al.,* 2008). Approximately 100 mg of finely powdered sample was hydrolyzed with 5 mL of 2.5N HCl by heating for 3 hours in a boiling water bath. After cooling, the hydrolysate was neutralized using sodium carbonate. A suitable aliquot was taken, and 4ml of freshly prepared Anthrone reagent was added. The mixture was heated for 8 minutes in a boiling water bath until a green-blue color developed. Absorbance was measured at 620 nm using a UV-Visible spectrophotometer. Carbohydrate concentration was calculated using a standard glucose calibration curve and expressed as g/100 g of dry sample.

Determination of Total protein content (g/100g):

Protein estimation was performed using the Lowry method (Hassan *et al.,* 2019). One gram of dried sample powder was extracted with alkaline copper reagent, followed by addition of Folin–Ciocalteu phenol reagent. The reaction mixture was allowed to stand for 30 minutes for color development. The absorbance was recorded at 750 nm. A standard curve was prepared using bovine serum albumin (BSA), and protein content was calculated and expressed as g/100 g on a dry weight basis.

Determination of Total Fat (%):

Fat content was determined using the Soxhlet extraction method. About 3–5 g of sample powder was placed in a thimble and extracted using petroleum ether (boiling point 60–80°C) for 6 hours. After extraction, the solvent was evaporated, and the flask was dried in an oven at 105°C until a constant weight was achieved. The increase in flask weight represented the total fat content (Ekwe *et al.,* 2020). The percentage of fat was calculated using:

$$\text{Fat (\%)} = \frac{W_3 - W_2}{W_1} \text{ x 100} \quad \text{.....(7)}$$

[W_1- Weight of sample, W_2- Weight of empty petriplate, W_3- Weight of petriplate with fat]

Amino Acid Content (mg/100g):

Total amino acid content was estimated after hydrolyzing the sample according to standard procedures. About 100 mg of sample powder was hydrolyzed with 6 N HCl in sealed tubes at 110°C for 24 hours. After cooling, the hydrolysate was neutralized and filtered, an aliquot was reacted with ninhydrin reagent, and the mixture was heated at 100°C for 15 minutes to develop a purple color. Absorbance was recorded at 570 nm using a UV–Visible spectrophotometer. Total amino acid content was determined using a leucine standard curve and expressed as mg amino acids per g of sample (Zulfiqar and Javed, 2025).

Determination of Total Dietary Fiber (%):

Dietary fiber content was estimated using the acid–alcohol digestion method. Approximately 1 g of sample was taken then added NaOH. The mixture was centrifuged for 30 min at 25 °Cat 450 rpm. Then neutralized with HCl and again centrifuged at 6500 rpm for 15 min. The residue was washed in 80% ethanol 2-3 times again centrifuged at 5000 rpm at 20°c for 10 min, the residue dried at 50°C overnight onto petriplate (Zhang *et al.,* 2019).

$$\text{Yield (\%)} = \frac{W_t}{W_i} \text{ x 100} \quad \text{.....(8)}$$

Starch estimation (g/100g):

Banana peel is ground to a fine powder, sieved (60-mesh), and soaked in 0.3% NaOH (1:4–1:5 w/v). At 4° C to dissolve proteins. The mixture is blended into a slurry, filtered through muslin cloth, and the residue is washed to recover starch. The filtrate is centrifuged at about 3000 rpm for 10 minutes, forming a white starch pellet beneath a darker protein layer, which is removed. The starch sediment Is repeatedly washed and recentrifuged until the supernatant is clear, then the slurry is neutralized to pH 5-6. The starch is drained, dried at 40–45 °C, reground if needed, and stored airtight (Otegbayo *et al.,* 2010).

Antioxidant Activity Assay:

Total Phenolics Content TPC (mg GAE/100g dm):

The total phenolics content in banana peel was

measured by Folin-Ciocalteu's phenol colorimetric method based on the oxidation-reduction reaction according to the procedure described by Gajula *et al*. (2009). A calibration curve was constructed by taking gallic acid as standard The solution of banana peel extracts was mixed with the FCR reagent and sodium carbonate solution. Mix gently and allows to the content was incubated in dark place for 30 min. at room temperature to allow complete color development. Then measure the absorption at 765nm (Rebello *et al.,* 2014).

Total Flavonoids Content TFC (mg RE/100g dm):

The total flavonoid content in banana peel was estimated by aluminum chloride colorimetric assay according to the procedure described by Gajula *et al.* (2009), Transfer sample into test tube add distilled water to each tube to standardized the reaction volume. Then add $NaNO_2$ solution. Mix immediately the mixture was incubated for 15 min. After 5 min the addition of $AlCl_3$ solution. The mixture was incubated for 6 min at room temperature during this period the flavonoid form a coordination complex with aluminum resulting in a yellow color. The sodium hydroxide and purified water was added to the incubated solution and the absorbance was measured at 510 nm with the help of spectrophotometer. The standard curve was to determine Total flavonoid content (Rahman and Kar, 2019). Results are expressed as Rutin Equivalents (RE) based on a standard curve.

Evaluation of 2,2-diphenyl-1-picrylhydrazyl (DPPH) radical scavenging assay (% Inhibition)*:*

The DPPH radicle scavenging activity of prepare sample. The sample are diluted to a test tube. add DPPH of solution the mixture was shaken well and incubate for 30 min in the dark place. The absorbance was recorded at 517 nm. The degree of discoloration of the DPPH solution indicates the scavenging potential of the banana peel extract (Akram *et al.,* 2020).

Calculation of the DPPH radical scavenging activity (%) Using the formula

$$\% \text{ Inhibition} = \frac{AoAs}{Ao} \times 100 \qquad \text{.....(9)}$$

where: A0 = absorbance of control, As = absorbance of sample

Ferric Reducing Antioxidant Power Assay (mg AA/ 100g dm) (FRAP Test)

A fine powder and extract of antioxidant compounds using an appropriate Solvent such as methanol, ethanol, or water, following a consistent extraction method—e.g., Stirring, sonication, solvent ratio, and duration—to ensure reproducibility. The mixture is then Filtered or centrifuged to obtain a clear supernatant, which may be diluted if the antioxidant activity is too high. The FRAP working reagent is freshly prepared daily and kept at 37°C in the dark, Consisting of a 10:1:1 (v/v/v) mixture of 300 mm acetate buffer (pH 3.6), 10 mM TPTZ in 40 mM HCl, and 20 mM $FeCl_3$. For the assay, a measured volume of the urad dal extract is combined with the pre-warmed FRAP reagent and incubated at 37°C for 4–10 minutes, during which a blue color Develops in the presence of antioxidants, and the absorbance is recorded at approximately 593 nm using a spectrophotometer with a reagent blank for baseline correction.

Ascorbic acid/ vitamin C (mg/100g dm):

Vitamin C in banana peel powder is measured and titrating it against a known ascorbic acid solution until a stable pale-pink endpoint Appears, and the dye volume (V_1) is recorded. For the sample, about 5 g of raw banana peel is extracted with 3% metaphosphoric acid, filtered, and the extract is made up to a fixed volume. A measured Portion of this extract is then titrated with the Standardized DCPIP until the same endpoint is Reached, recording the dye volume (V_1). The titration is repeated to obtain an accurate average (Said and Radzi, 2016).

Ascorbic acid content (mg/100g) ==

$$\frac{\text{Concentration of} \times V_2 \times \text{Total volume of extract}}{V_1 \times \text{Volume of sample used for titration} \times \text{Weight of sample}} \times 100$$

.....(10)

Antinutrient Analysis of raw banana peel:

Assessment of antinutritional factors in Banana peel (*Musa sapientum*) was carried out to determine the presence of compounds that may interfere with nutrient absorption or exert physiological effects. All analyses were performed on dried, finely powdered banana peel samples using standard colorimetric and titrimetric procedures.

Determination of Oxalates:

Oxalate content was estimated using the titrimetric method. Approximately 1g of sample powder was digested with 10 mL of 2N HCl at 90°C, filtered, and made up to 100 mL with distilled water. An aliquot of the extract was precipitated with calcium chloride to form

calcium oxalate crystals, which were dissolved in hot sulfuric acid and titrated against standardized 0.05N $KMnO_4$ (Oyeyinka and Afolayan, 2019).

$$\text{Oxalate (mg/100 g)} = \frac{\text{Titration value} * \text{Normality of } KMNO_4 * 45}{\text{Weight of sample}} \quad \text{…….....(11)}$$

Determination of Phytates:

Phytate content was measured using the Wade reagent colorimetric assay. One gram of sample was extracted with 2% HCl for 3 hours and centrifuged. The supernatant was reacted with Wade reagent (iron (III)–sulfosalicylic acid complex), and absorbance was measured at 500 nm. Phytate concentration was calculated using a sodium phytate standard curve and expressed in mg/100 g (Anhwange *et al.*, 2008).

Determination of Saponins:

Saponin content was quantified using the vanillin–sulfuric acid colorimetric method. Sample powder (0.5 g) was extracted with aqueous ethanol (80%), evaporated, and the residue reacted with vanillin reagent. Absorbance was measured at 544nm Saponins concentration was determined using a diosgenin standard curve (Aslam *et al.*, 2018).

Saponins (mg/100 g) = Concentration from standard curve * dilution factor .....(12)

Determination of Alkaloid:

Total alkaloid content was assessed using the gravimetric method. Two grams of sample powder was extracted with 10% acetic acid in ethanol for 4 hours. The filtrate was concentrated and treated with ammonium hydroxide to precipitate alkaloids, which were filtered, dried to constant weight, and expressed as percentage alkaloids (Kumar *et al.,* 2019).

$$\text{Alkaloids (\%)} = \frac{\text{Weight of alkaloids precipitate}}{\text{Weight of sample}} \text{ x } 100 \quad \text{…….....(13)}$$

Determination of Tannins:

Tannins were determined according to the method. One milliliter of the sample extract was mixed with 3.5 mL of distilled water and 0.5 mL of 0.1 M $FeCl_3$ in 0.1 N HCl. The absorbance was read at 660 nm after 10 minutes of incubation. Tannins content was quantified using a tannic acid standard curve and expressed as mg tannic acid equivalents (TAE) per gram of dry sample (Onyenweaku and Kesas, 2024).

Minerals Test (Sodium and potassium content):

Minerals were quantified using wet digestion followed by flame photometry. Approximately 0.5 g of banana peel powder was digested with concentrated HNO_3 and $HClO_4$, and the final volume was made up to 50 ml. The digested extract was analyzed using a flame photometer calibrated with standard Na and K solutions (0–20 ppm). Results were expressed as mg/100 g dry weight (Musa and Akpomie, 2022).

Determination of the Calorific Value using Bomb Calorimeter:

The calorific value of banana peel powder was determined using a bomb calorimeter. About 1.0 g of the dried sample was accurately weighed, palletized, and placed in the crucible of the bomb calorimeter. A nichrome ignition wire was connected to the electrodes and brought in contact with the sample. The bomb was sealed and filled with pure oxygen at a pressure of 25–30 atm, then immersed in a calorimeter bucket containing a known volume of water. The initial temperature was recorded, and the sample was ignited electrically. The heat released during complete combustion caused a rise in water temperature, which was measured until a constant maximum temperature was reached. The calorific value was calculated using the observed temperature rise and the calorimeter constant and expressed as kcal/g or kcal/100 g of sample

$$\text{Calcorific value (kcal/g)} = \frac{\text{Energy equivalent of calorimeter x } \Delta T}{\text{Sample mass (g)}} \quad \text{……. (14)}$$

Statistical analysis:

Statistical analysis was performed on triplicate readings, and results were expressed as mean ± standard deviation. Data were analyzed using MS-Excel to determine significant differences among samples. p-value <0.05 was considered statistically significant.

RESULTS AND DISCUSSION

The present study evaluated the nutritional composition, phytochemical content, antinutritional

factors. The results obtained are discussed in relation to previous scientific findings to understand the nutritional and nutraceutical significance of banana peel.

Proximate analysis:

Proximate analysis provides valuable information about the nutritional composition and helps to assess the quality of the sample, providing information about the content of water, protein, lipids, ash, fiber and carbohydrates. (Saeed *et al.,* 2024; Pyar and Peh, 2018). The proximate composition of banana peels, which includes moisture, ash, protein, fat, fiber, and carbohydrates are present in Table 1. The experimental results obtained show that the analyzed considerable nutritional value that depends on the location and nature of the analyzed nutritional parameter: 4.04 ± 0.09g/100g of total protein, 2.29±0.14% fats, 1.03±0.04 g/10gt 50g dietary fibre, 1.6±0.14 g/100g of starch, and 52.32±0.32 g/100g of total carbohydrate and 0.60±0.09g/100g of total amino acid present. This can also be confirmed by numerous studies reporting that the proximal composition and nutritional properties of banana peels vary between different banana varieties (Ansari *et al.,* 2023), and even between the same varieties from different cultivation areas (Sahoo and Lenka, 2024). The moisture content of the analyzed indicates that the examined banana peels could be used in food processing, as well as in cosmetics, medicine, the textile industry, paper manufacturing, bio-absorbents, biofuel production, and the agricultural sector (Bhavani *et al.,* 2023).

Physical analysis Result:

The acidity or alkalinity of the sample. The banana peel exhibits a slightly acidic range, with a pH of 5.0±0.2, Moisture (%): The percentage of water content in the sample. It ranges from 10.70±0.15%. The bulk density or a related measure of how tightly the material packs. The value is 0.55g/mL, Ash is 5.74±0.03% where similar observation was made by (Emaga *et al.*, 2007) who reported that the ash content of banana peels varied from 6.4 to 12.8%, swelling and solubility is (5.11±0.10 g/g), bulk density was 8.99±0.31 g/ml (Table 2). The value is 4.27±0.53g/g expressed as water absorption of the banana peel sample, which is a crucial parameter in food science related to microbial growth and stability. The percentage of non-combustible inorganic mineral content remaining after the sample is incinerated. The parameters shown (pH, Moisture, Bulk density, Water absorption/ activity) are determined using standard, well-established analytical methods that have been developed and refined over many decades by organizations. They publish the Official Methods of Analysis, which are the globally recognized procedures for chemical and physical testing of agricultural and food products.

Antioxidant activity:

The antioxidant properties of the raw banana peel sample are comprehensively evaluated using several standard assays and compound quantifications, providing a clear profile of its potential health benefits. The DPPH (2,2-diphenyl-1-picrylhydrazyl) assay, with a range 76.03± 0.10% Inhibition (likely an IC50 value or similar measure where a lower value indicates stronger activity), is a common method to assess the sample's ability to scavenge free radicals through hydrogen atom transfer. The total content of key antioxidant compounds is also quantified. The Total Flavonoid Content (TFC) is reported as 1.70±0.01mgRE/100g, and the Total Phenolics Content

Table 1 : Proximate composition analysis of raw banana peel powder

Sample name	Total Carbohydrate (g/100g)	Total Protein (g/100g)	Total Fat Content (%)	Amino acid (g/100g)	Total Dietary Fiber (g/100g)	Starch (g/100g)
Raw Banana peel	52.32±0.32	4.04 ± 0.09	2.29±0.14	0.60±0.09	1.03±0.04	1.6±0.14

Table 2 : Physical properties of raw banana peel powder

Sample name	pH	Moisture (%)	Ash (%)	Bulk density (g/mL)	Water absorption (g/g)	Swelling and solubility (g/g)
Banana peel	5.0±0.2	10.70±0.15	5.74±0.03	8.99±0.31	4.27±0.53	5.11±0.10

Table 3 : Antioxidant Activity and Phenolic Content of Raw Banana Peel

Parameter	TPC (mg GAE/100g)	TFC (mg RE/100 g)	DPPH (% inhibition)	FRAP (mg AA/100g dm)	Ascorbic acid (mg/100g)
Raw Banana Peel	55.53±0.49	1.70±0.01	76.03± 0.10	4.02± 0.25	0.040±0.00

(TPC) is significantly higher at 55±0.49mg GAE/100g (milligrams of Gallic Acid Equivalent), Total phenolics contents were found significantly higher than the stated results of Rebello *et al.* (2014), who estimated 29 mg GAE/g total phenolics content in the banana peel. The variation of TPC in banana peels might be influenced by variety, growth environment, harvesting time, sample preparation, and methods of determination (Islam *et al*., 2020). Phenolics compounds and flavonoids are major contributors to the antioxidant activity of plant materials, acting as potent radical scavengers. Furthermore, the sample contains a notable amount of Ascorbic acid (Vitamin C) at 0.040±0.00mg/100g (grams), which is a well-known, direct antioxidant. Finally, the FRAP (Ferric Reducing Antioxidant Power) assay result of 4.02± 0.25mg AA/100 gindicates the sample's reducing capacity—its ability to donate electrons to reduce ferric iron (Fe^{3+}) to ferrous iron (Fe^{2+}). This provides a different mechanistic view of its overall antioxidant strength, complementing the DPPH free-radical scavenging results and confirming that the banana peel is a rich source of various natural antioxidants (Table 3).

Antinutrient composition of Banana peel:

The antinutrients in this study were found in minimal amounts, which tolerate limits as stipulated by the European Food Safety Authority (Aniemeka and Ndubuisi 2017). Antinutrients such as tannins that slightly higher values in raw banana peel powder, this could be arisen from environmental influences, genetic factors and difference in methodology, phytates (moderate -high), oxalates and saponins (moderate), alkaloids (low) were present, most were detected at moderate to low levels, suggesting that appropriate processing could enhance its usability (Fig. 2 and Table 4).

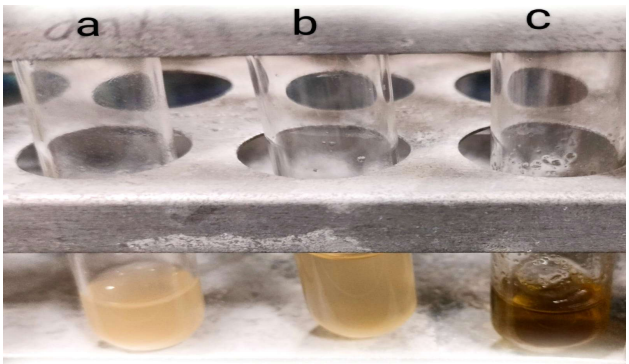

Fig. 2 : (a) Presence of Oxalates, (b) Tannins 1, (c) Tannins 2

Table 4 : Antinutrient Composition of Raw Banana Peel

Antinutrient	Presence	Level
Tannins	Present	High
Phytates	Present	Moderate- high
Alkaloids	Present	Low
Oxalate	Present	Moderate
Saponins	Present	Moderate

Minerals Content:

The sodium content of raw banana peel reported in literature is about 70.00mg/100g dry matter in contrast, the present study initially yielded a very low value 0.001± 0.00mg/100g, state that Na content appears sustainability lower than values reported 70.00mg/100g. Similarly, literature potassium content of raw banana peel is approximately 220.00mg/100g, where the raw dataset in this study contained an evidently erroneous entry 1987.139± 4.36 mg/100g. Literature values for K in peel are around 220.00mg/100g (Hassan *et al.*, 2019).

Calorific Value:

The calculated 5.75 kcal/100g is higher than the 3.80-4.00 kcal/100g range implied by several peer-reviewed proximate analysis of dried raw banana peel. Reported only proximate generally fall around 3.80-4.00 kcal/100g for dried peel, depending on fat and carbohydrate content (Hassan *et al.*, 2019).

Conclusion:

The present study of Banana peel (*Musa sapientum*), highlights the nutritional, physicochemical, antioxidant, and antinutrient potential of raw banana peel, emphasizing its value as a functional bioresource. Proximate analysis showed that banana peel is rich in carbohydrates 52.32±0.32 g/100g, dietary fiber 81.03±0.04 g/100g, with appreciable amounts of protein 4.04±0.09 g/100g, fat 2.29±0.14% and 1.6±0.14 g/100g of starch. These findings confirm that banana peel possesses significant nutritional value and should not be regarded merely as an agricultural waste. Physical analysis revealed favorable properties for industrial utilization, including a slightly acidic pH range 5.0±0.2, low moisture content 10.70±0.15%, Ash content 5.74±0.03%, Water absorption was 4.27±0.53g/g, swelling and solubility is 5.11±0.10g/g, and suitable bulk density 8.99±0.31g/mL. These parameters suggest good storage stability, reduced microbial susceptibility, and functional suitability for food and related applications. The

antioxidant evaluation demonstrated strong bioactive potential. Total phenolic content observed in banana peel powder was 55.53 ± 0.49 mg GAE/100g. High amount of total phenolic content leads to improved radical scavenging ability 76.03± 0.10% inhibition% determined by DPPH (2,2-diphenyl-1-picrylhydrazyl), indicated effective free radical neutralization. Total flavonoid content TFC1.70±0.01 mg RE/100g, significant Ascorbic acid level 0.040 ±0.00mg/100g and a FRAP value of 4.02±0.25 mg AA/100g collectively confirm the strong antioxidant and reducing capacity of banana peel. Although antinutrients such as tannins(high), phytates (moderate -high), oxalates and saponins(high), alkaloids (low) were present, most were detected at moderate to low levels, suggesting that appropriate processing could enhance its usability. Minerals analysis revealed in the present study initially yielded a very low value 0.001± 0.00mg/100g, and high potassium 1987.139± 4.36 mg/ 100g, suggesting potential benefits for dietary supplements. Overall, banana peel shows strong potential for application in functional foods, nutraceuticals, and sustainable waste valorization.

Conflict of Interest:

The authors declares that there is no conflict of interest related to the present research work.

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