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Utilization of Banana Peel Waste for Sustainable Production of Fortified Yogurt

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ABSTRACT

The present study investigated the utilization of banana peel waste for the sustainable production of fortified yogurt. Banana peel powder was incorporated into yogurt at three different levels T_1 (5 g), T_2 (8 g), and T_3 (10 g) along with a control T_0, and evaluated for sensory characteristics and proximate composition. Sensory evaluation was conducted by a panel of ten semi-trained members using a 9-point hedonic scale. All sensory parameters taste, texture, appearance, flavor, color, and overall acceptability showed statistically significant differences (F = S at 5% level of significance) among treatments. T_2 emerged as the most acceptable formulation with an overall acceptability score of 8.4, followed by T_1 (7.9) and T_3 (7.7). Proximate analysis revealed that the enriched yogurt contained moisture (72.21 ± 0.24%), ash (1.53 ± 0.05%), protein (5.06 ± 0.08 g), dietary fiber (1.33 ± 0.11 g), fat (4.87 ± 0.05 g), carbohydrate (14.9 ± 0.40 g), and energy (125 ± 1 kcal per 100 g), reflecting a nutritionally superior profile over conventional plain yogurt. The findings confirm that banana peel typically discarded as agro-industrial waste can be effectively valorized as a functional ingredient in yogurt fortification, supporting the goals of sustainable food production, waste reduction, and development of health-promoting dairy products.

Keywords Banana peel, Fortified yogurt, Sensory evaluation, Proximate composition, Waste valorization, Functional food, Sustainable production.

INTRODUCTION

The global food industry generates enormous quantities of agricultural and agro-industrial by-products each year, posing significant environmental, economic, and sustainability challenges. According to the latest data from the Food and Agriculture Organization (FAO) of the United Nations, food wastes account for 1.03 billion tons globally each year, with approximately 30% of all fruits and vegetables produced being wasted at various stages of the food supply chain (Taha *et al.* 2024). Among these, banana (*Musa* spp.) processing generates one of the most abundant fruit wastes worldwide. Banana peels

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account for approximately one-third of the fruit's total weight and are routinely discarded as waste in the food industry (Wani and Dhanya 2025). In 2023, global banana production reached an estimated 19.3 million tons, driven largely by leading producers in Asia, Latin America, and Africa (Wani and Dhanya 2025), meaning that millions of tons of peel are discarded annually. A total of 200 tonnes of banana peel waste are generated daily, with peels typically disposed of at municipal landfills, contributing to pressing environmental concerns (Ahmad *et al.* 2026).

Despite being regarded as waste, banana peels harbor an impressive array of nutritionally and pharmaceutically valuable constituents. Banana peel is a rich source of many bioactive compounds including carotenoids, biogenic amines, polyphenols, phytosterols, and antioxidants, as well as minerals such as iron, calcium, sodium, phosphorus, and magnesium, along with good levels of dietary fiber (Bhavani *et al.* 2023). More specifically, banana peel contains both phenolic antioxidants including flavanones, catecholamines, flavonols, and tocopherols and non-phenolic antioxidants such as carotenes, ascorbic acid, and cyanidin (Bishnoi *et al.* 2023). Bioactive substances discovered in banana peels include flavonoids, tannins, alkaloids, glycosides, anthocyanins, and terpenoids that exhibit a range of biological and pharmacological effects, including antimicrobial, antihypertensive, and antidiabetic activities (Bishnoi *et al.* 2023). Banana peels are also noted for their high total phenolics content, prebiotic potential, and beneficial effects on colon health (Khamsaw *et al.* 2024). These attributes make banana peel waste a particularly promising candidate for valorization within a circular bioeconomy framework. The concept of valorizing fruit peel waste into functional food ingredients has gained remarkable momentum in recent years. The utilization of agricultural by-products in functional food production has gained significant attention, with banana peel flour increasingly recognized as a food fortification ingredient enriched with antioxidants and dietary fiber (Yasin *et al.* 2025). Given its diverse bioactive properties, banana peel waste is now being explored within the framework of a circular economy to promote waste recycling and reduce environmental impact (Bishnoi *et al.* 2023). This valorization framework adopts circular economy principles, demonstrating a green, scalable approach to transform fruit peel waste into health-promoting functional ingredients aligned with sustainable food production (Nitisuk *et al.* 2025).

Yogurt, as one of the world's most widely consumed fermented dairy products, presents an ideal matrix for functional fortification. Yogurt is a nutrition-dense food, providing a good source of calcium, phosphorus, potassium, vitamins A, B2 and B12, along with high biological value proteins and essential fatty acids (Hadjimbei *et al*. 2022). There is accumulating evidence that yogurt and fermented milk consumption is associated with a number of health advantages, including the prevention of osteoporosis, diabetes, and cardiovascular diseases, as well as the promotion of gut health and immune system modulation (Hadjimbei *et al.* 2022). The global yogurt market, estimated at 182.56 billion dollars in 2023, is expected to grow to 212.08 billion dollars by 2031 (Taha *et al*. 2024), reflecting robust consumer demand for dairy-based health products. In response to modern consumer demands for innovation and sustainability, yoghurt fortification has gained popularity, with added nutrients such as vitamins, probiotics, antioxidants, and bioactive peptides intended to address nutritional deficiencies and improve immune function (Hazarika *et al.* 2026).

The fortification of yogurt with banana peel-derived ingredients represents a convergence of sustainability goals and functional food innovation. Fortified yoghurt with banana peel extract has been reported to possess higher total phenolic content (TPC), as well as strong antioxidant and anti-diabetic effects (Wani and Dhanya 2025). Studies have successfully demonstrated the bioactive efficacy of banana peel waste extract-fortified yogurt, with significantly higher radical scavenging activity and α-glucosidase inhibitory activity (Kabir *et al.* 2021). Furthermore, the addition of banana peel fiber to synbiotic yogurt has been shown to increase viscosity, improve the survival of probiotic bacteria, enhance consistency, and improve sensory properties including color, flavor, and overall acceptability (Wani and Dhanya 2025).

Despite these promising findings, there remains a paucity of systematic research comprehensively evaluating the physico-chemical, rheological, microbiological, and sensory characteristics of yogurt fortified with banana peel across varying concentrations and preparation methods. Food waste contains valuable compounds such as polyphenols, dietary fibers, and proteins that can be recovered and utilized in functional food systems, yet existing literature often lacks an integrated view connecting specific food waste types with suitable extraction technologies and their potential applications (Mia *et al.* 2025).

Therefore, the present study aims to investigate the utilization of banana peel waste as a sustainable, value-added ingredient for the production of fortified yogurt, evaluating its effects on nutritional quality, bioactive properties, textural attributes, and consumer acceptability. The findings of this research are expected to contribute to the broader goals of zero-waste food processing, circular economy practices, and the development of health-promoting dairy products.

MATERIALS AND METHODS

The present study outlines a method for preparing fortified yogurt enriched with banana peel powder, aiming to enhance their nutritional and functional properties. This research was conducted at the Department of Food and Nutrition, College of Community Science, A.N.D.U.A.T., Kumarganj, Ayodhya.

Preparation of banana peel powder

Fresh Banana peels were collected and thoroughly cleaned to remove dirt and impurities. The cleaned peels were then dried using two methods: In a regulated hot air oven (Plate- 1A) and by sun drying. After drying (Plate- 1B), the peels were grind into a fine powder (Plate- 1C), sieved to ensure uniform particle size, and stored in airtight containers for use in the study.

Preparation of yogurt

After pasteurization, standardized milk was cooled the fermentation temperature. Powdered banana peel was added at preset amounts and well blended (Plate- 1D). Fresh culture, was added and mixed throurly. In order to enable appropriate curd formation, the samples were kept in a incubator between 37–40 0°C temperature for over-night. The yogurt was chilled and refrigerated for further examination once the fermentation process was completed (Plate- 1E). The ingredients used for the preparation products were give in Table 1.

Flowchart of preparation process of banana powder-enriched probiotic yogurt:

Collection of banana fruit peels
↓
Washing of banana fruit peels
↓
Drying of washed banana fruit peels
↓
Grinding of dried banana fruit peels
↓
Preparation of banana peel powder
↓
Milk standardization
↓
Addition of banana peel powder to standardized milk
↓
Probiotic inoculation
↓
Fermentation
↓
Cooling and storage
↓
Functional yogurt production

Sensory characteristics

The sensory characteristics of products were judged by the panel of ten semi-trained member from the department of Food and Nutrition, College of Community Science, A.N.D.U.A.T., Kumarganj, Ayodhya. The panelists were asked to evaluate the product for

Table 1. Composition of yogurt prepared by Using Banana peel Powder.

Ingredient (g)	T_0	T_1	T_2	T_3
Milk (ml)	80	75	72	70
Milk powder (g)	5	5	5	5
Banana Peel powder (g)	----	5	8	10
Sugar (g)	10	10	10	10
Curd (g)	5	5	5	5
Total	100	100	100	100

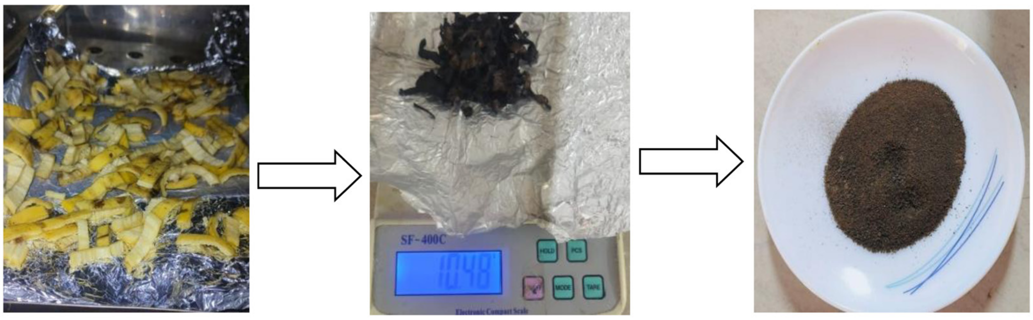

Plate- 1A: (Drying of Banana Peels in Hot Air Oven), Plate- 1B: (Dried Peels of Banana), Plate- 1C: (Peel Powder of Banana).

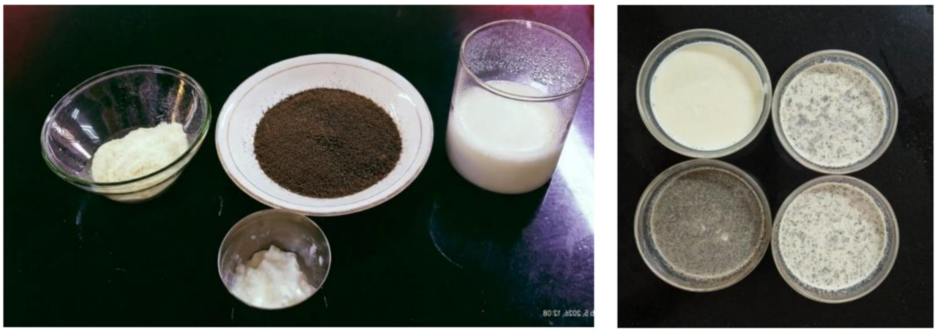

Plate- 1D: Ingredient for preparation of yogurt, Plate- 1E: Functional yogurt.

different sensory attributes namely color, flavor/taste, Body/texture, appearance, and overall acceptability. Nine-point Hedonic scale and score Card method were used for evaluation of sensory characteristics of different products (Ahmad *et al.* 2026).

Analysis of nutritional composition

Moisture

Moisture content was determined gravimetrically by drying samples at 105 ± 2°C for 24 h in a hot air oven until constant weight, following AOAC (2005) method.

Ash

Ash content was determined by incinerating samples in a muffle furnace at 550 ± 5°C for 5–6 h until constant weight, following AOAC (2005) method.

Protein estimation

Crude protein was estimated by the Kjeldahl method following AOAC (2019), where nitrogen content obtained after digestion, distillation, and titration was multiplied by 6.25.

Crude fiber estimation

Crude fiber was determined using the Weende method, involving sequential acid and alkali digestion, followed by drying, ashing, and weighing of the residue (Woldemariam 2025).

Fat estimation

Fat content was analyzed by the Soxhlet extraction method, where fat were extracted using petroleum ether and quantified gravimetrically (Min and Ellefson 2010).

Carbohydrate estimation

Total carbohydrate content was calculated by difference as described by Kochhar *et al.* (2006) :

$$\text{Carbohydrate (\%)} = 100 - (\text{Protein} + \text{Fat} + \text{Fiber} + \text{Ash} + \text{Moisture})$$

Energy value

Energy value was calculated using the At water factors (Sánchez-Peña *et al.* 2017) :

Energy (kcal) = (4 × Protein) + (9 × Fat) + (4 × Carbohydrate)

Statistical analysis

The statistical tools used for analysis of sensory quality and nutrient composition will be mean± SD. For analysis of collected information, suitable and appropriate statistical techniques would be applied interpretation would be drawn according to the results.

RESULTS AND DISCUSSION

Sensory evaluation

The sensory evaluation of banana peel-fortified yogurt was carried out across four treatments (T_0–T_3) on a 9-point hedonic scale, covering taste, texture, appearance, flavor, color, and overall acceptability. All parameters showed statistically significant differences (F = S at 5% level of significance), confirming that the incorporation of banana peel powder meaningfully influenced consumer perception across all sensory attributes.

Taste

Taste scored highest in T_0 (8.9 ± 0.05), followed by T_2 (8.1 ± 0.11), T_1 (8.0 ± 0.23), and T_3 (7.5 ± 0.45), with a CD value of 0.48. The progressive decline in taste scores with increasing banana peel concentration can be attributed to the presence of tannins and polyphenols in banana peel, which impart astringent and bitter notes at higher levels. Emaga *et al.* (2008) documented similar bioactive phenolic compounds in banana peel that negatively influence flavor perception when incorporated into food matrices at elevated concentrations.

Flavor

Flavor followed an identical declining trend T_0 (8.9 ± 0.11) > T_2 (8.1 ± 0.41) > T_1 (7.9 ± 0.23) > T_3 (7.6 ± 0.75), with a narrow CD of 0.50, indicating statistically clear differences between treatments. The off-flavor development in higher-concentration treatments is consistent with findings by Sah *et al.* (2016), who reported that fruit by-product polyphenols can cause perceptible flavor deviations in fermented dairy products even at moderate inclusion levels.

Texture

Texture was highest in T_0 (8.4 ± 0.98), with T_1 and T_3 both scoring 7.9 and T_2 at 8.1 (CD = 1.30). The notably high standard deviation in T_0 reflects inter-panellist subjectivity in evaluating the plain yogurt base. The influence of banana peel on texture is attributable to its dietary fiber and pectin content, which interact with the yogurt protein network. Ramasubramanian *et al*. (2012) reported that the water-binding capacity of fruit peel pectins can either reinforce or disrupt the gel matrix depending on the level of incorporation, which explains the moderate yet acceptable texture scores observed in T_1 and T_2.

Appearance and color

Appearance scores decreased from T_0 (8.6 ± 0.57) through T_1 and T_2 (both 8.1) to T_3 (7.8 ± 0.92), with a CD of 1.05. Similarly, color declined from T_0 (8.9 ± 0.11) to T_3 (7.8 ± 0.69), with a CD of 0.73. These reductions are linked to the browning pigmentation of banana peel powder, which results from enzymatic browning during processing and the presence of carotenoids and chlorophylls that darken the yogurt matrix. Mahajan *et al.* (2020) reported comparable reductions in visual and color acceptability scores in yogurt fortified with fruit peel powders, attributing them to Maillard reaction products and oxidized polyphenols that impart a brownish tint.

Overall acceptability

Overall acceptability presented in Table 2 a particularly noteworthy trend: T_0 scored highest (8.8 ± 0.05), but T_2 (8.4 ± 0.45) ranked above T_1 (7.9 ± 0.23), with T_3 scoring the lowest (7.7 ± 0.15) at a CD of 0.51. This non-linear pattern where T_2 outperforms T_1 despite T_2 representing a higher fortification level, suggests that a moderate concentration of banana peel powder strikes an optimal balance between functional

Table 2. Sensory Evaluation.

Sensory Evaluation	T_0	T_1	T_2	T_3	CD (5%)	SEM	F Value
Taste	8.9±0.05	8.0±0.23	8.1±0.11	7.5±0.45	0.48	0.15	S
Texture	8.4±0.98	7.9±0.23	8.1±0.55	7.9±0.69	1.30	0.40	S
Appearance	8.6±0.57	8.1±0.20	8.1±0.1	7.8±0.92	1.05	0.32	S
Flavor	8.9±0.11	7.9±0.23	8.1±0.41	7.6±0.75	0.50	0.15	S
Color	8.9±0.11	8.2±0.11	8.1±0.3	7.8±0.69	0.73	0.22	S
Overall acceptability	8.8±0.05	7.9±0.23	8.4±0.45	7.7±0.15	0.51	0.16	S

(S = Significant, CD= Critical Difference).

enrichment and sensory quality. This finding is in agreement with Akhter *et al.* (2021), who observed a similar intermediate treatment optimum in yogurt fortified with agri-waste-derived ingredients, concluding that consumer acceptability is not strictly inversely proportional to fortification level but follows a threshold effect. The relatively low standard error values across all treatments (S.EM range: 0.15–0.40) further confirm the consistency and reliability of panelist responses.

Taken together, these results indicate that while the control yogurt (T_0) consistently achieved the highest individual attribute scores, T_2 represents the most promising formulation for practical application, delivering meaningful bioactive fortification from banana peel waste while maintaining overall sensory acceptability above 8.0 on the hedonic scale. These findings support the broader agenda of sustainable food production through valorisation of agricultural by-products, as banana peel, typically discarded as waste, demonstrates clear potential as a functional ingredient in fermented dairy products.

Nutrient composition

The proximate nutritional composition of banana peel-enriched yogurt is presented in the Table 3. The moisture content was 72.21 ± 0.24%, which is within the standard range for fermented dairy products as reported by Chandan and Kilara (2013). Ash content was recorded at 1.53 ± 0.05%, reflecting the mineral-rich nature of banana peel, consistent with findings of Someya *et al.* (2002), who documented high ash fractions in banana peel compared to pulp.

Table 3. Nutritional composition of yogurt.

Parameters	Nutritional value Enriched yogurt
Ash %	1.53±0.05
Moisture %	72.21±0.24
Protein (g)	5.06±0.08
Fiber (g)	1.33±0.11
Fat (g)	4.87±0.05
Carbohydrate (g)	14.9±0.40
Energy (kcal)	125±1

Protein content was 5.06 ± 0.08 g, slightly higher than conventional plain yogurt, which typically ranges between 3.5–4.5 g/100 g (Paul and Yewande, 2019). Dietary fiber was 1.33 ± 0.11 g, a notable improvement over standard yogurt, which contains negligible fiber ; this is attributed to the pectin, cellulose, and hemicellulose present in banana peel (Emaga *et al.* 2008). Fat content was 4.87 ± 0.05 g, consistent with full-fat yogurt formulations reported by Hassan *et al.* (2019). Carbohydrate content was the highest macronutrient at 14.9 ± 0.40 g, owing to the resistant starch and non-starch polysaccharides contributed by banana peel incorporation (Aurore *et al.* 2009). The energy value was 125 ± 1 kcal, which is moderate and comparable to commercially available fortified yogurt products (Chavan *et al.* 2018).

CONCLUSION

The present study confirmed that banana peel waste can be successfully utilized as a functional ingredient for the production of fortified yogurt. Among all treatments, T_2 emerged as the most acceptable formulation, achieving an overall acceptability score of 8.4 on the 9-point hedonic scale, with statistically significant differences observed across all sensory parameters at the 5% level of significance. Proximate analysis revealed that the enriched yogurt possessed a nutritionally superior profile, with enhanced protein

(5.06 ± 0.08 g), dietary fiber (1.33 ± 0.11 g), and ash content (1.53 ± 0.05%) at a moderate energy value of 125 ± 1 kcal per 100 g, indicating its potential as a functional dairy product. Overall, the findings suggest that banana peel, typically discarded as agro-industrial waste can be effectively valorized as a cost-effective, nutrient-dense ingredient in yogurt fortification, supporting the goals of sustainable food production and waste reduction. Further studies on shelf life, microbial safety, and bioactive retention during storage are recommended.

REFERENCES

Ahmad, R., Dupas de Matos, A., Hort, J., Day, L., & Dalziel, J. E. (2026). Influence of sugar composition in yoghurt on sweet receptor activation and sensory sweetness perception. *Food Chemistry*, 508, 148351. https://doi.org/10.1016/j.foodchem.2026.148351

Akhter, M. J., Al-Amin, M., Hossain, M. A., & Kamal, M. M. (2024). Enriching wheat bread with banana peel powder: Impact on nutritional attributes, bioactive compounds, and antioxidant activity. *International Journal of Food Science*, 2024 (1), 2662967. https://doi.org/10.1155/2024/2662967

Aurore, G., Parfait, B., & Fahrasmane, L. (2009). Bananas, raw materials for making processed food products. *Trends in Food Science and Technology*, 20 (2), 78—91.

Bhavani, M., Morya, S., Saxena, D., & Awuchi, C. G. (2023). Bioactive, antioxidant, industrial, and nutraceutical applications of banana peel. *International Journal of Food Properties*, 26 (1), 1277—1289. https://doi.org/10.1080/10942912.2023.2209701

Bishnoi, S., Sharma, S., & Agrawal, H. (2023). Exploration of the potential application of banana peel for its effective valorization: A review. *Indian Journal of Microbiology*, 63 (4), 398—409. https://doi.org/10.1007/s12088-023-01100-w

Chandan, R. C., & Kilara, A. (2013). Manufacturing yogurt and fermented milks (2nd edn.). Wiley-Blackwell.

Chavan, M., Gaikwad, S., Kumar, P., & Bhatt, D. (2018). Nutritional evaluation of value-added yogurt enriched with plant-based functional ingredients. *Journal of Food Science and Technology*, 55 (4), 1482—1489.

Emaga, T. H., Robert, C., Ronkart, S. N., Wathelet, B., & Paquot, M. (2008). Dietary fiber components and pectin chemical features of peels during ripening in banana and plantain varieties. *Bioresource Technology*, 99 (10), 4346—4354. https://doi.org/10.1016/j.biortech.2007.08.030

Hadjimbei, E., Botsaris, G., & Chrysostomou, S. (2022). Beneficial effects of yoghurts and probiotic fermented milks and their functional food potential. *Foods*, 11 (17), 2691. https://doi.org/10.3390/foods11172691

Hassan, F. A. M., Abd El-Gawad, M. A. M., & Enab, A. K. (2019). Physico-chemical and sensory properties of yogurt fortified with fruit peel extracts. *International Journal of Dairy Technology*, 72 (1), 56—63.

Hazarika, U., Saikia, P., Choudhury, M., & Das, M. (2026). Unlocking the potential of banana peel waste – A multi-faceted review emphasizing its nutrient profile, extraction strategies, and prospective utility within the context of circular waste bioeconomy. *Food Chemistry Advances*. https://doi.org/10.1016/S277250222600017X https://doi.org/10.1080/10942912.2023.2209701

Kabir, M. R., Hasan, M. M., Islam, M. R., Haque, A. R., & Hasan, S. M. K. (2021). Formulation of yogurt with banana peel extracts to enhance storability and bioactive properties. *Journal of Food Processing and Preservation*, 45 (3), e15191. https://doi.org/10.1111/jfpp.15191

Khamsaw, P., Sommano, S. R., Wongkaew, M., Willats, W. G. T., Bakshani, C. R., Sirilun, S., & Sunanta, P. (2024). Banana peel (Musa ABB cv Nam Wa Mali-Ong) as a source of value-adding components and the functional properties of its bioactive ingredients. *Plants*, 13 (5), 593. https://doi.org/10.3390/plants13050593

Kochhar, A., Nagi, M., & Sachdeva, R. (2006). Proximate composition, available carbohydrates, dietary fiber and anti nutritional factors of selected traditional medicinal plants. *Journal of Human Ecology*, 19 (3), 195—199. https://doi.org/10.1080/09709274.2006.11905878

Mahajan, P., Bera, M. B., Panesar, P. S., & Chauhan, A. (2020). Development and quality evaluation of banana peel fortified value-added products. *Journal of Pharmacognosy and Phytochemistry*, 9 (3), 1524—1528.

Mia, M. S., Ahmed, M. M., & Zzaman, W. (2025). Valorization of food waste into functional ingredients supports a sustainable strategy for the food industry. *Discover Food*, 5, 275. https://doi.org/10.1007/s44187-025-00584-3

Min, D. B., & Ellefson, W. C. (2010). Fat analysis. In S. S. Nielsen (Edn.), *Food Analysis* (4th edn., pp, 117—132).

Nitisuk, P., Wanyo, P., Chamsai, T., & Charoenjit, K. (2025). Sustainable valorization of tropical fruit peels for sustainable production of natural antioxidants and functional food ingredients. *Sustainable Food Technology*, 3 (4), 1189—1202. https://doi.org/10.1039/d4fb00371c

Paul, A., & Yewande, I. (2019). Proximate composition of fortified dairy products using fruit by-products. *African Journal of Food Science*, 13 (8), 188—195.

Ramasubramanian, L., Restuccia, C., & Devahastin, S. (2012). Physical and textural properties of natural banana peel fiber fortified yogurt. *International Journal of Dairy Technology*, 65 (2), 178—184.

Sah, B. N. P., Vasiljevic, T., McKechnie, S., & Donkor, O.N. (2016). Effect of probiotics on antioxidant and antimutagenic activities of crude peptide extract from yogurt. *Food Chemistry*, 156, 264—270.

Someya, S., Yoshiki, Y., & Okubo, K. (2002). Antioxidant compounds from bananas (*Musa cavendish*). *Food Chemistry*, 79 (3), 351—354.

Sánchez-Peña, M. J., Márquez-Sandoval, F., Ramírez-Anguiano, A. C., Velasco-Ramírez, S. F., Macedo-Ojeda, G., & González-Ortiz, L. J. (2017). Calculating the metabolizable energy of macronutrients: A critical review of At water's results. *Nutrition Reviews*, 75 (1), 37—48. https://doi.org/10.1093/nutrit/nuw044

Taha, S. H., Elshaghabee, F. M. F., & Ameen, M. A. (2024). Quality attributes and antioxidant activity of stirred yoghurt fortified with some nano-fruit waste powders. *Discover Food*, 4 (1). https://doi.org/10.1007/s44187-024-00179-4

Wani, K. M., & Dhanya, M. (2025). Unlocking the potential of banana peel bioactives: Extraction methods, benefits, and industrial applications. *Discover Food*, 5 (1). https://doi.org/10.1007/s44187-025-00276-y

Woldemariam, G. A. (2025). Estimation of crude fiber content of a feed from its ADF value where there is no laboratory service. *Online Journal of Animal and Feed Research*, 15 (2), 79—88. https://doi.org/10.51227/ojafr.2025.10

Yasin, M., Gangan, S., & Panchal, S. K. (2025). Banana peels: A genuine waste or a wonderful opportunity ? *Applied Sciences*, 15 (6), 3195. https://doi.org/10.3390/app15063195