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Proximate composition of *Musa balbisiana* cv. Bhimkal pseudostem, an indigenous banana cultivar of Assam

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Abstract
Banana pseudostem, which is often discarded as agricultural waste, possesses significant potential as a sustainable food resource. The tender central core is a nutrient-rich ingredient of traditional Assamese cuisine, popularly known as '*Kol Posola'*. It is prepared by cooking young and tender, banana pseudostem particularly of *Musa balbisiana* cv. Bhimkal, a highly seeded indigenous banana cultivar of Assam. Based on this concept, the present investigation was carried out in the Food Analysis and Experimental Laboratory, Department of Horticulture, College of Agriculture, Assam Agricultural University. Pseudostems of *Musa balbisiana* cv. Bhimkal were harvested at 120 days after planting and the proximate composition was analyzed to explore its nutritional and industrial potential. The results showed a high moisture content of 95.62%, with a neutral pH of 7.11 and a low titratable acidity of 0.04%. The carbohydrate content was found to be 52.44%, indicating a significant energy source, while crude fiber was 27.28%, making the pseudostem a valuable material for fibre-rich applications such as fibre rich food supplements and bio-industrial products. Crude protein content was measured at 3.26%, and ash content was 8.36%, suggesting it a good source of minerals. The pseudostem also contained 1.35° Brix of total soluble solids and 7.74 mg of vitamin C per 100 g, indicating modest antioxidant potential. However, the crude fat content of 0.87% in pseudostem reflects that it is a potential low-fat dietary component. These findings highlight, the pseudostem as a promising by-product with potential applications in fibre production, biofuel, and as a supplementary source of carbohydrates and minerals. Further studies are needed to explore the bioactive compounds, potential industrial and nutritional applications of this underutilized agricultural by-product.

Keywords: Banana pseudostem, biochemical composition, Bhimkal, by-product, nutrient-rich, sustainable food

Introduction
Banana (*Musa* spp.*)*, a robust perennial herb belonging to the family Musaceae, is one of the most well-known and useful plants in the world. This crop is widely cultivated in more than 130 countries of tropical and subtropical regions (Mohapatra *et al.,* 2010) [10]. It is mostly confined to the regions between 30°N and 30°S of the equator, while hot tropical regions of South-East Asia is believed as the center of origin of Banana (Spiden, 1926) [17]. The Assam-Myanmar-Thailand is considered as the main center of diversity. Hence, it is a leading crop in north-eastern states of India, particularly Assam. Banana is the second largest produced fruit, contributing about 16% of world's total fruit production (Varma *et al.,* 2019; Mydhili *et al.*, 2022) [21, 11].

This plant is also known for their wide range of applications in the food industry as it holds great potential beyond the commonly consumed fruit. However, a large portion of banana plants often goes underutilized, generating significant amount of waste (Li *et al.,* 2010) [9]. One such underutilized part is the pseudostem, despite being rich in fibre, antioxidants and essential nutrients. As a result, the use of banana pseudostem in food and industrial products has gained attention in recent years, driven by efforts to reduce waste and create sustainable value from agricultural by-products.

The banana pseudostem, which consists of tightly packed leaf sheaths (Elanthikkal *et al.*, 2010) [7], is a fibrous structure that plays an important role in the plant's growth. The central core of the pseudostem is the most tender and nutritious part, which is primarily composed of water, total dietary fibre and carbohydrates (Saravanan *et al.*, 2011) [16]. The fibres are rich in cellulose, hemicellulose and lignin. Additionally, the pseudostem contains a significant amount of starch, proteins, vitamin C, ash, bioactive compounds and essential micronutrients like potassium, iron (Saravanan *et al.*, 2011) [16]. On the other hand, fresh banana pseudostem has a comparatively low fat content, making it a low-fat component of the diet (Ramu *et al.*, 2017; Buvaneshwari *et al.*, 2021; Kendole *et al.*, 2022) [13, 5, 8].

In addition, it is having enormous medicinal properties like antiulcerogenic, antilithic, hypolipidemic, antioxidant, dissolving kidney stone, gall bladder stone, treating diarrhoea, dysentery, diabetes (Desai *et al.*, 2016) [6]. Therefore, the pseudostem is consumed as food in many parts of India (Tiroutchelvame *et al.*, 2019) [20] and has been a part of various traditional cuisines since immemorial times. Among these, one very popular dish of ethnic Assamese cuisine is '*Kol Posola'*. It is prepared by cooking young and tender, 4 months (120 days) old banana pseudostem (central core) particularly of *Musa balbisiana* cv. Bhimkal (BB genome), a highly seeded indigenous banana cultivar of Assam, having its pseudostem marked with no or very little black / brown blotches (Borborah *et al.*, 2016) [4]. Moreover, due to the state's favourable climatic condition, banana pseudostems are readily available all-round the year.

This study aims to assess the proximate composition of *Musa balbisiana* cv Bhimkal pseudostem and investigate how these nutritional compositions may affect its potential uses in food and industrial sectors. The results of this study could contribute to the diversification of banana plant utilization and promote the sustainable management of agricultural by-products.

Materials and Methods

The Banana Pseudostems (*Musa balbisiana* cv. Bhimkal) were procured from the Experimental Farm, Department of Horticulture, Assam Agricultural University, Jorhat, Assam. The pseudostems were harvested at 120 days after planting, in the morning hours and were immediately transported to the laboratory after packing them in polyethylene bags. The raw material was received gently, with no bruising on the surface.

Proximate analysis

Total Soluble Solids (TSS)

The Total soluble solids of the pseudostem samples was determined by Milwaukee MA871 digital refractometer. A drop of the sample was added to the Refractometer at room temperature and the result was expressed as °Brix.

Moisture content

The moisture content of the sample was estimated using the AND MX-50 digital moisture analyser (A & D Company Ltd., Tokyo, Japan) and values were expressed in %.

pH

The pH of the pseudostem sample was directly measured by a digital pH meter (Mettler-Toledo India Pvt. Ltd, Mumbai) coupled with a combined electrode.

Titratable Acidity

A 2-gram sample was combined with 30 ml of distilled water and 20 ml of methanol, then placed in a water bath for 15 minutes. Afterward, the mixture was filtered through cotton. A 4 ml portion of the filtrate, along with 5 ml of distilled water, was transferred into a conical flask, and two drops of phenolphthalein indicator were added. The solution was titrated with 0.1N NaOH until the endpoint was reached, indicated by the appearance of a pink color. The results were expressed as the percentage of lactic acid (Adelekan and Oyewole, 2010) [1].

Ash content

Using the standard procedure of AOAC (2000) [2], ash content of the sample was determined. One gram powdered sample was weighed in a previously dried and weighed silica crucible. The sample was then charred to remove all organic matter and the crucible containing the charred sample was incinerated in a muffle furnace at 600±2 °C for 6 hours until the ash become greyish white or white in colour. The crucible was cooled in a desiccator and its weight was recorded and the result was expressed in %.

$$\text{Ash Content (\%)} = \frac{\text{weight of crucible after ignition (g)} - \text{weight of crucible (g)}}{\text{Weight of sample (g)}} \times 100$$

Carbohydrate Content

Carbohydrate content was estimated by anthrone method as compiled by Thimmaiah (2004) [19]. 0.5 g of sample was taken in a test tube and made up the volume up to 50ml with distilled water. 100 µl of aliquot was taken from there and made up the volume up to 1ml with distilled water. 4ml of anthrone reagent was added to the tubes and heated for 8 minutes in boiling water bath. The tubes were cooled rapidly and the absorbance was read at 630 nm using UV-VIS Spectrophotometer (Varian Cary 50 Scan) against a blank. A standard curve was plotted using different concentrations of glucose (0-1000 µg/ml) on X-axis and absorbance on Y-axis. From the graph, total carbohydrate content of the pseudostem samples was calculated in %.

Crude Protein

The protein content of the sample was determined using Lowry's method. A 0.5 g sample was mixed with a solvent and centrifuged. The supernatant (0.2 ml) was transferred to test tubes, and 5 ml of Lowry's reagent was added. After incubating for 10 minutes, 0.5 ml of Folin-Ciocalteu reagent was added, and the mixture was incubated for an additional 30 minutes. The developed blue color was measured at 660 nm, and the protein content in the sample was calculated and expressed in %.

Vitamin C (Ascorbic Acid)

Vitamin C content was estimated using the method suggested by Ruck (1963). 0.5 g of dried sample sample was mixed with 4% oxalic acid and made up to up to a volume of 100ml and centrifuged. The supernatant part (5 ml) was added with 10ml of 4% oxalic acid and titrated against the dye until a pale pink color appeared.

Crude fibre

Crude fiber content was determined by extracting a 2 g sample using ether. The 2 g of dried sample was boiled with

200 ml of sulfuric acid for 30 minutes, with the addition of bumping chips. The mixture was then filtered through muslin cloth and washed with boiling water until all acidic traces were removed. Next, the sample was boiled with 200 ml of sodium hydroxide solution for 30 minutes, followed by filtration through muslin cloth again. The filtered solution was washed with 25 ml of boiling 1.25% H_2SO_4, three 50 ml portions of water, and 25 ml of alcohol. The residue (W_1) was then removed and dried for 2 hours at 130±2 °C. After cooling in a desiccator (W_2), the dried residue was ignited for 30 minutes at 600±15°C. Once cooled in a desiccator, the residue was reweighed (W3). The loss in weight was calculated as (W_2-W_1)-(W_3-W_1) (AOAC 2000) [2].

$$\text{Crude fibre (\%)} = \frac{(W_2 - W_1) - (W_3 - W_1)\,(g)}{\text{Weight of sample (g)}} \times 100$$

Crude Fat

The crude fat content was determined by the method as compiled by Thimmaiah (2004) [19], where ether was continuously distilled, condensed and then allowed to pass through the sample to extract ether-soluble materials. The residual crude fat was dried, weighed, and the percentage of oil was estimated after the ether was distilled and collected in another container.

Results and Discussion

Chemical Composition

Table 1. showed the chemical composition of the freshly harvested banana pseudostem of *Musa Balbisiana* cv. Bhimkal.

Table 1: Chemical composition of banana pseudostem of *Musa Balbisiana* cv. Bhimkal

Chemical Composition	Mean ± SD
TSS (ºBx)	1.35±0.044
Moisture (%)	95.62±0.072
pH	7.11±0.015
Titratable Acidity (%)	0.04±0.001
Crude Fibre (%)	27.28±0.044
Crude Protein (%)	3.26±0.081
Crude Fat (%)	0.87±0.006
Ash (%)	8.36±0.031
Carbohydrate (%)	52.44±0.010
Vitamin C (mg/100 g)	7.74±0.035

*SD= Standard Deviation

Moisture content

Water is a crucial component of food ingredients, due to its potential to influence food's appearance, freshness, texture, durability, and flavour (Supriadi *et al.*, 2004; Santosa *et al.*, 2016) [18, 15]. The moisture content has a significant impact on the nutritional density and storage life of fresh commodities (Pavani and Aduri, 2018) [12]. The moisture content of the *Musa balbisiana* cv. Bhimkal pseudostem was notably high at 95.62%. This aligns with typical values found in banana pseudostems, which are composed mostly of water due to their soft, fibrous nature. High moisture content suggests that the pseudostem is perishable and must be processed promptly to avoid microbial spoilage. The moisture level also indicates that drying or dehydration may be necessary for preserving the material for industrial use or as a nutritious. Buvaneshwari *et al.* (2021) [5] reported that moisture content in pseudostem of two varieties Ottuvazhai (syn Mupaddai) (V1) and vayalvazhai (V2) as 91.20% and 91.60% respectively.

pH and Titratable Acidity

The pH depends on the total quantity of acids as well as the strength of the acids present (Schmidl and Labuza, 2000) [22]. In fresh-cut fruits, lower pH is preferred because it is better against microbial growth. The pH of the *Musa balbisiana* cv. Bhimkal pseudostem was measured at 7.11, which indicates a neutral to slightly alkaline nature. This pH level suggests that the pseudostem does not exhibit significant acidity or alkalinity, making it a potentially suitable substrate for various industrial and nutritional applications. Similarly, pH value (7.1) of banana pseudostem of Grand Nine variety was reported by Mydhili *et al.* (2022) [11].

The titratable acidity was found to be 0.04%, which is relatively low, further supporting the neutral pH and indicating that the pseudostem is not highly acidic. Such a mild acidity could make it more versatile in processing for different purposes, including food products or fermentation processes. Ho *et al.* (2012) [23] reported a similar value of titratable Acidity (0.4%) in banana pseudostem flour of *Musa acuminata* X *balbisiana* cv. Awak.

Total Soluble Solids (TSS)

Several compounds found in fruits and their juices which are soluble in water including sugars, acids, vitamin C and some pectins constitute Total Soluble Solids (Bhatt *et al.*, 2011) [24], which is measured in Degree Brix (ºBx). The total soluble solids (TSS) content of the Bhimkal pseudostem was found to be 1.35° Brix. This low TSS value indicates that the pseudostem is not rich in dissolved sugars or soluble compounds, which is typical for fibrous plant materials like banana pseudostems. While the TSS value is not high, it suggests that the pseudostem is not overly sweet and may be more suitable for non-sugar or low-sugar based food applications. Tiroutchelvame *et al.* (2019) [20] in their study reported that banana pseudostem of Poovan variety had TSS of 1.2 ºBx. Whereas, Mydhili *et al.* (2022) [11] observed the highest value of TSS in the variety Karpooravalli (3.0 ºBx) and lowest value in Ney Poovan (0.6 ºBx).

Carbohydrate Content

Total carbohydrate content in banana pseudostem have low glycaemic index (GI) (Aparicio-Saguilan *et al.*, 2007) [25]. The carbohydrate content of the pseudostem of Bhimkal cultivar was found to be 52.44%, which is notably high. This value reflects the significant starch and sugar content in the pseudostem, especially considering the fact that carbohydrates typically accumulate in plant tissues as they mature. The high carbohydrate content suggests that the pseudostem has potential as a source of energy or even as a raw material for the production of bioethanol and other carbohydrate-based industrial products. Additionally, the carbohydrate-rich nature of the pseudostem could make it useful in various food applications, such as flour or fiber supplements. Aziz *et al.* (2011) [26] revealed that the carbohydrate content in pseudostem flour was 57.58 g/100 g. Whereas, Ramu *et al.* (2017) [13] found that the carbohydrate content in the pseudostem of *Musa* sp. cv. Nanjangud rasa bale was 46.58 g/100 g.

Crude Fibre Content

The banana pseudostem is rich in crude fibre, which is an indigestible cell wall component of plant materials and plays an important role in human health (Sokchea *et al.*, 2018) [28]. The crude fibre content of the pseudostem was determined to be 27.28%, which is relatively high. This high fibre content is characteristic of the fibrous structure of the pseudostem and highlights its potential for use in fibre-rich products. The presence of fibre makes the pseudostem suitable for applications in dietary supplements, animal feed, or even as a raw material for paper and biodegradable products. The high fibre content also suggests that the pseudostem could be beneficial for improving digestive health if used in food products, as fibre is essential for gastrointestinal health. As reported by Sokchea *et al.* (2018) [28], the crude fibre content of fresh-cut banana pseudostem varies from 20% to 40%.

Protein Content

The protein content of the *Musa balbisiana* cv. Bhimkal pseudostem was found to be 3.26%. While this is a relatively low protein content compared to other plant materials, it still indicates that the pseudostem contains a modest amount of protein. This could be valuable as a supplemental protein source in the development of sustainable food sources. The protein content may vary depending on the maturity stage and environmental factors, but it is clear that the pseudostem can contribute to the overall protein intake in certain applications. As reported by Mydhili *et al.* (2022) [11], the highest protein content of pseudostem was observed in the variety Monthan (5.0%) whereas lowest was observed in the variety Poovan (2.2%).

Ash Content

Banana pseudostem is a potential source of minerals and thus rich in ash content (%) (Cordeiro *et al.*, 2004) [27]. The ash content represents the amount of inorganic residue present in a sample after destruction of organic matter. High ash content indicates the higher amount of minerals present in the sample (Mydhili *et al.*, 2022) [11]. The ash content of the pseudostem was measured at 8.36%. Ash content represents the mineral content of the sample, and this value suggests that the pseudostem contains a moderate amount of minerals. The presence of minerals such as potassium, calcium, and magnesium could contribute to the nutritional value of the pseudostem, making it potentially useful in dietary supplements or as a source of essential minerals in various food or feed applications. Further analysis of the specific mineral composition would provide a more detailed understanding of the pseudostem's nutritional profile. Ho *et al.* (2012) [23] studied the proximate composition of the prepared banana pseudostem flour. They observed that the banana pseudostem dried at 60 ºC for overnight contained 6.75% ash.

Vitamin C Content

The vitamin C content of the *Musa balbisiana* cv Bhimkal pseudostem was measured at 7.74 mg/100 g. While this is a modest amount, it is still a notable source of vitamin C compared to other non-fruit plant materials. Vitamin C is an essential antioxidant that plays a critical role in immune function and the maintenance of connective tissue. The pseudostem's vitamin C content suggests that it could provide some health benefits when incorporated into food or functional foods. Mydhili *et al.* (2022) [11] showed the highest vitamin C content in the variety Karpooravalli (9.5 mg/100 g) and lowest in Ney Poovan (3.4 mg/100 g).

Fat Content

The Crude fat content of the *Musa balbisiana* cv. Bhimkal pseudostem was determined to be 0.87%. This low fat content suggests that the pseudostem can be considered a low-fat component of the diet. Given the increasing demand for low-fat dietary options, the pseudostem may offer a suitable alternative for use in formulations requiring minimal fat content, such as certain processed foods or animal feed. The low fat content also highlights that the pseudostem is not a significant source of dietary fats, which could make it more appealing for health-conscious consumers or in applications where fat reduction is a priority. Similarly, Buvaneshwari *et al.* (2021) [5] found the fat (%) content of the Ottuvazhai (synMupaddai) (V1) and vayalvazhai (V2) samples of banana pseudostem as 1.25% and 0.60%, respectively.

Conclusion

The proximate composition of *Musa balbisiana* cv. Bhimkal pseudostem reveals that it is a nutrient-rich, low-fat, fibrous material with a high carbohydrate and fiber content, moderate protein and ash levels, and a modest amount of vitamin C. The high carbohydrate and fiber content make the pseudostem a valuable component for use in bioindustrial applications, such as biofuel production, paper manufacturing, and as a source of dietary fiber. The relatively low protein and vitamin C levels suggest that the pseudostem's primary use would be in industrial applications or as a supplement in animal feed rather than as a direct food source. However, its nutritional composition could be optimized through further research, including studies on different maturity stages and environmental factors. The findings highlight the potential of *Musa balbisiana* cv. Bhimkal pseudostem as an underutilized resource with significant industrial and ecological value.

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