Nutritional and Biological Analysis of Nutrient-dense Banana Sap Water

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Abstract— *The analysis of banana sap water (BSW) reveals its significant bioactive properties and potential applications in various fields, particularly in medicine and agriculture. Research indicates that banana sap is rich in antimicrobial compounds, making it a valuable resource for health-related applications. Additionally, its nutrient composition supports plant growth, suggesting its utility in agricultural practices. BSW shows antibacterial activity, and it is more active against Gram-negative bacteria. The absence of a zone of inhibition in the case of antifungal activity indicates, BSW does not show antifungal activity against Aspergillus niger and Aspergillus flavus. BSW contain a considerable amount of N, P, and K along with essential micronutrients like Ca, S, Mg, Mn, Fe, Zn, Cu, B, etc., which play a significant role in plant health and productivity. The nutritional and biological analysis revealed the presence of micronutrients and antibacterial qualities, which broadens its range of applications. The application of bio-enriched banana pseudostem sap as a liquid organic fertilizer (LOF) topically affects nutrient absorption, yield and quality of plants.*

Keywords— Banana sap water, antimicrobial, antifungal, nutritional analysis.

I. INTRODUCTION

Banana pseudostem sap contains essential macro and micronutrients, along with growth-promoting substances like cytokinin. It serves as a cost-effective organic fertilizer, enhancing crop growth and yield, particularly in cowpea cultivation [1]. Banana sap can be utilized as an organic bio-fertilizer, enhancing onion growth and reducing chemical fertilizer dependency, with increasing yield. The sap's nutrient content supports sustainable agricultural practices, making it a valuable resource in farming [2]. Foliar application of enriched banana pseudostem sap significantly improves nutrient uptake in crops like sweet corn and onions, leading to increased yields and quality [3]. Banana sap contains significant compounds such as apigenin glycosides, myricetin glycosides, and dopamine, which are linked to antioxidant and antimicrobial activities. High-performance liquid chromatography analysis has identified these compounds, indicating their potential health benefits [4]. In vitro studies show that unoxidized banana sap has strong antibacterial effects, with minimal inhibitory concentrations. The sap's antioxidant capacity is notable, with a DPPH radical scavenging activity demonstrating significant efficacy. Unoxidized banana sap demonstrates strong antibacterial effects, with minimal inhibitory concentrations against various bacteria and fungi. The sap exhibits notable radical scavenging activity, indicating its potential as an antioxidant. Extracts from banana sap have shown significant cytotoxicity against human breast cancer cells, with a proliferation inhibition rate [5].

LOF can be produced through anaerobic fermentation of banana peels and stems, often using effective microorganisms as bioactivators [6]. Training programs have been implemented to educate communities on producing these fertilizers, enhancing local agricultural practices [7]. Organic fertilizers with biopesticides, addressing both nutrient supply and pest management [8]. Fermented banana pseudostem sap enriched with various ingredients can effectively enhance marigold growth and yield attributes, serving as a sustainable alternative fertilizer [9]. Novel organic liquid fertilizer, along with the recommended dose of fertilizers improves the growth and yield parameters of vegetable crops. These organic formulations can be an effective tool towards the era of organic vegetable farming in the future tenure [10]. BPS can be considered as potential organic fertilizers for ‘Sewy’ date palms and were able to save 40% of chemical fertilizers [11]. Organic liquid manures are a superior substitute

for organic fertilizers and chemicals based on carriers. It could help the soil in a variety of ways [12]. Studies on rats showed improved wound healing when treated with banana sap, attributed to its saponins and flavonoids [13].

The nutritional and biological analysis of nutrient-dense BSW is essential for understanding its potential as a functional food ingredient and therapeutic agent. BSW, a natural byproduct of banana plants, contains high levels of essential nutrients, bioactive compounds, and phytochemicals that may enhance health. Evaluating its nutritional content helps pinpoint vital elements such as vitamins, minerals, antioxidants, and enzymes that benefit metabolic processes and overall health. Moreover, biological assessments, including antimicrobial and antifungal properties, shed light on BSW's possible role in preventing diseases and natural preservation. A thorough analysis of BSW can facilitate its application in nutraceuticals, promote sustainable agriculture, and support alternative medicine, ultimately increasing the value of banana production while minimizing agricultural waste. The present study focuses on the nutritional and biological analysis of BSW.

II. MATERIALS AND METHODS

BSW was extracted from banana pseudostem (*Musa acuminata*) collected from the fields of Ainpur, Jalgaon, Maharashtra, India. The antibacterial activity of BSW was evaluated using the disk diffusion assay against *Escherichia coli, Salmonella typhi (Gram –ve) & Bacillus subtillis, and Staphylococcus aureus (Gram +ve)* bacteria. 0.1 ml bacterial suspension was spread on a sterile nutrient agar plate. A sterile filter paper disk soaked in BSW was placed at the center of the plate. The plate was incubated for 24 hours at 37°C. On the next day, the plate was observed for the occurrence of zone of inhibition around the filter paper disk. The diameter of the zone of inhibition was measured in millimeters.

The antifungal activity of BSW was evaluated using the disk diffusion assay against *Aspergillus niger* and *Aspergillus flavus*. A sterile potato dextrose agar (PDA) plate was uniformly inoculated with a fungal spore suspension. A sterile filter paper disk was impregnated with BSW and placed at the center of the inoculated PDA plate. The plate was incubated at room temperature for 48 hours. After the incubation period, the plate was examined for the occurrence of zone of inhibition surrounding the filter paper disk. The diameter of the zone of inhibition was measured in millimeters.

III. RESULTS AND DISCUSSION

BSW sample was analyzed in the Bioscience Biotech laboratory, Central Govt. Approved AGMARK & ISO9001:2015 certified, Pune and antimicrobial activities were analyzed in department of Zoology, S.V.P Arts and Science College, Ainpur, Maharashtra, India. The results of analysis per 250 ml BSW sample are shown in Table 1.

Nitrogen is essential for vegetative growth and is often diagnosed through leaf analysis, which shows varying levels throughout the plant's life cycle. It plays a crucial role in energy transfer and photosynthesis, with its content fluctuating during different growth phases [14]. While the focus on N, P, and K is essential for optimizing banana production, it is also important to consider the balance of micronutrients and the potential for deficiencies, which can significantly impact plant health and yield [15]. The pH, electrical conductivity, and organic carbon content of banana sap water are critical parameters that influence its utility as a fertilizer and its effects on plant growth. The pH of banana sap water is essential for nutrient availability. A neutral to slightly acidic pH (around 6-7) is generally favorable for nutrient uptake in plants. Maintaining optimal pH levels can enhance the effectiveness of organic fertilizers, such as those derived from banana sap, which can stimulate plant growth and improve soil health. Electrical conductivity (EC) indicates the salinity of the sap water, which affects plant growth. Higher EC values can suggest a higher concentration of dissolved salts, which may be beneficial or detrimental depending on the plant's tolerance. Monitoring EC is crucial for ensuring that the sap water does not lead to salt stress in plants, which can hinder growth and yield. Organic carbon in banana sap water contributes to soil fertility and microbial activity. It serves as a food source for beneficial soil microorganisms, promoting a healthy soil ecosystem. The presence of organic carbon can enhance the soil's water retention capacity and nutrient-holding ability, which is vital for sustainable agricultural practices [16]. Ca ranges from 120-150 mg/L, essential for cell wall structure and stability. Mg, found at 30-40 mg/L, is vital for chlorophyll production. S, Concentration is approximately 45-55 mg/L, important for amino acid synthesis. Mn, Levels of 0.6-1.0 mg/L are noted, crucial for photosynthesis. Fe, Present at 4.0-6.0 mg/L, is necessary for electron transport in plants. Zn, found at 0.3-0.5 mg/L, is important for enzyme function. Cu, Concentration is around 0.03-0.05 mg/L, involved in photosynthesis and respiration. B, typically 0.3-0.5 mg/L, is essential for cell division and growth. The nitrogen concentration in banana sap water is typically

around 130-150 mg/L, a Phosphorus level in banana sap water range from 30-40 mg/L, Potassium is found in higher concentrations, approximately 300-360 mg/L [17].

The moisture content in banana sap water is significant for nutrient transport and overall plant hydration, although it is also important to consider that variations in nutrient levels can occur due to environmental factors and fertilization practices, which may influence the overall health and yield of banana crops. The study analyzed macro and micronutrients in banana root sap, finding significant concentrations of Ca and Mg, with Mn and Fe being predominant in fertilized and unfertilized plants, respectively [18]. The mineral composition of banana sap water, including elements such as S, Ca, Mg, Mn, Fe, Zn, Cu, B, and moisture content, is crucial for understanding the nutritional status of banana plants. Research indicates that these elements play significant roles in plant health and productivity.

3.1 Antibacterial activity of BSW:

Banana sap, particularly from the midrib and stem, contains various bioactive compounds such as saponins, flavonoids, and tannins, which contribute to its effectiveness against both bacteria and fungi. The antibacterial and antifungal activity of banana sap water has been extensively studied, revealing its potential as a natural antimicrobial agent. Banana midrib sap demonstrated significant antibacterial activity against Staphylococcus aureus [19]. Extracts from banana plants have shown efficacy against various bacteria, including Enterococcus faecalis and Escherichia coli, due to their rich phytochemical composition [20]. Banana tree sap is effective against Staphylococcus aureus bacteria. Phytochemical test confirms antibacterial properties of banana tree midrib sap. The antibacterial properties of banana tree midrib sap against Staphylococcus aureus, demonstrating its effectiveness at concentrations of 15%, 30%, and 60% [21]. The antimicrobial properties of various banana cultivars' corm, pseudostem, and leaves against selected human pathogens, including bacteria and Candida biofilm, using different solvent extracts. Some cultivars exhibited broad-spectrum activity, inhibiting all tested pathogens [22].

The antibacterial and antifungal properties of banana sap water have been extensively studied, revealing its potential as a natural antimicrobial agent. Research indicates that banana sap, particularly from the midrib and pseudostems, exhibits significant antibacterial activity against various pathogens, including Staphylococcus aureus and Escherichia coli, as well as antifungal effects against Candida albicans. The antibacterial activity of BSW is shown in Table 2.

The above result indicates that BSW shows antibacterial activity and it is more active against Gram-negative bacteria.

3.2 Antifungal activity of BSW:

Saponins extracted from the Amboina banana stem inhibited the growth of Candida albicans, with an average inhibition zone indicating its potential as an antifungal agent. The use of banana extracts may provide an alternative to conventional antifungal treatments [23]. Banana sap demonstrates antibacterial properties; its antifungal activity is less pronounced. Some studies indicate limited effectiveness against fungi like Aspergillus niger [24]. The antifungal activity of BSW is shown in Table 3. (-) indicates the absence of a zone of inhibition.

The above result indicates that BSW does not show antifungal activity against *Aspergillus niger and Aspergillus flavus.*

3.3 Preparation of LOF from BSW:

The use of banana pseudostem sap and turmeric extract as liquid organic fertilizers presents a promising avenue for sustainable agriculture. Research indicates that BSW enhances plant growth, yield, and quality across various crops, while turmeric extract is recognized for its potential bioactive properties. Turmeric, particularly its active compound curcumin, has demonstrated significant insecticidal and pest-repellent properties with significant mortality rates. Higher concentrations of turmeric extract correlate with increased mortality rates in pests [25]. A low-cost organic fertilizer has been developed using underutilized resources, including Palmyrah leaves, coconut leaves, and banana pseudostems, along with Spirulina and Azolla. This initiative aims to mitigate the harmful effects of inorganic fertilizers and contribute to the circular economy by transforming waste into valuable agricultural inputs [26]. Foliar sprays of banana pseudostem sap can enhance the productivity and quality of sweet corn in acidic soil [27]. Apart from the other applications of banana pseudostem [28, 29], BSW can be used as an efficient base in addition to various organic extracts for the preparation of LOF [30]. As BSW contains a considerable number of micronutrients along with antimicrobial properties, it can be effectively mixed with turmeric water extract to prepare LOF for various crops, as shown in fig. 1.

FIGURE 1: Bio-Enriched Lof

TABLE 1
NUTRITIONAL ANALYSIS OF BSW

Sr. No.	Parameters	Unit	Observed Value
1	pH	---	05.75
2	Electric conductivity	µS/cm	06.00
3	Organic Carbon	%	01.11
4	Nitrogen (N)	%	00.39
5	Phosphorus (P)	%	00.46
6	Potassium (K)	%	00.58
7	Sulphur (S)	mg	03.00
8	Calcium (Ca)	mg	05.20
9	Magnesium (Mg)	mg	07.80
10	Manganese (Mn)	mg	01.00
11	Iron (Fe)	mg	02.10
12	Zinc (Zn)	mg	01.08
13	Copper (Cu)	mg	01.50
14	Boron (B)	mg	00.20

TABLE 2
ANTIBACTERIAL ACTIVITY OF BSW

Bacterial Strain	Compound	
	BSW zone diameter (mm)	Positive Control (Azithromycin) zone diameter (mm)
E. coli.	17	34
S. typhi.	10	29
B.Subtilis.	6	23
S. aureus.	7	20

TABLE 3
ANTIFUNGAL ACTIVITY OF BSW

Bacterial Strain	Compound	
	BSW zone diameter (mm)	Positive control (Fluconazole) zone diameter (mm)
A. niger.	-	22
A. flavus.	-	18

IV. CONCLUSION

Based on the findings in the present study, BSW shows antibacterial activity and it is more active against Gram-negative bacteria but it does not show antifungal activity against *Aspergillus niger and Aspergillus flavus.* BSW contain a considerable amount of N, P, and K along with essential micronutrients like Ca, S, Mg, Mn, Fe, Zn, Cu, B, etc., which play a significant role in plant health and productivity. It can be concluded that the nutritional and biological analysis of nutrient-dense BSW is crucial for its use in a variety of applications.

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