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Extraction and Physico-Chemical Characterization of Plantain (musa spp) Exudates

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ABSTRACT

In this study, exudate from plantain stem was extracted and physico-chemically characterized. Exudation from the trees was carried out by making an incision on the tree bark during harvesting. Both physical and chemical properties such as pH value, microbial stability, solubility in polar and non-polar solvents, cations, anions, phenols and tannins content were determined. Results obtained were pH value: 4.93; phenol contents: 20.684 mg/L; tannin content: 0.32%. It contains very low quantities of cations such as calcium, potassium, magnesium and sodium which are present at a composition of 0.80 mg/L, 0.18 mg/L, 0.13 mg/L and 0.64 mg/L respectively. They had aromatic smell which became pungent after a period of one week. It contains high quantities of some anions such as sulphate and chloride which are present at a composition of 261 mg/L and 320.35 mg/L respectively, concentrations far from the range of consumable products. Plantain exudates can be preserved using well known food preservatives. From the results, it was deduced that the exudates may serve as raw materials for pharmaceutical, steel and paint industries if the machinery for their collection and preservation are established.

Keywords: *Exudation, Phenol, Tannin, cations and anions*

INTRODUCTION

The importation of industrial materials especially chemical substances has been an economical loss in Nigeria. In Nigeria, over 70% of the population are engaged in Agricultural sectors due to lack of employment. This was one of the main causes of the development of chemical engineering, chemical technology and organic chemistry, which quickly became the basis for exudates and the precursor employed in their production [1]. Exudates are complex mixtures of organic compounds oozed by plants, often, but not always as a result of injury. These products are rich in carbon and hydrogen atoms and are also commonly called “sap” although the word “sap” is used to describe any fluid that travels inside plants. In contrast, the word “exudate” refers to any such material when it is oozed out of the plant [2]. These plant products have been collected since about 3000 BC, during the Egyptian civilization from Acacia and gum Arabic trees, native to North Africa and used as adhesive in hieroglyphic paints and in the embalming of Egyptian mummies [3, 4].

Today’s exudates are part of a major group of chemical products. Their importance has grown in almost every area of an economic growth and cultural values. Besides traditional products (such as leather goods and fibers), Nowadays, known exudates are employed as ingredients in medicines, cosmetics, perfumes, industrial and food products [5, 6]. In developing countries, plant exudates are used in traditional medicine, for example, a good percentage of the populations depend on medicines made from trees for their primary health-care needs [3, 4].

African banana (*Musa sapientum*), and plantain (*Musa paradisiaca*), grow abundantly in Nigeria especially in the rain forest region of the country. Mango is a rich source of vitamins A, C, and D. Its inner bark is light brown and bitter. Whitish latex exudes from cut twigs and a resin from cuts in the trunk and the bark is the source of a yellowish-brown dye used as silk [7]. Little or no study has yet been reported on banana and plantain exudates. Research gaps on priority species have been identified and they include resource conservation and availability, quality efficacy, husbandry, products diversification, markets and developmental gaps, among others [8].

Exudates of *Musa Spp* (Plantain) always leave strong and indelible stains on fabrics. Farmers can attest to this significant property of the plant species, therefore it is necessary to investigate the physical properties and chemical composition of the plantain exudates as a possible industrial material especially textile (dyestuff or mordant). Many plants exude sticky material as the result of damage or disease, and this viscous material often solidifies with time. Such materials have found religious, medicinal, and other practical and symbolic uses by humans [9]. The research into the study of physical and chemical constituents of plantain exudates after harvest is justified. It safe cost to locally discover new products from the agricultural Musa Spp waste which could be of industrial application rather than the frequent importation, creating employment opportunity in the process. The successful completion of this research will encourage and create a very cost effective and more efficient post-harvest use of plantain herb.

Over the years, exudates from musa spp stems has been untapped and a waste, of which could possibly serve as a good source of income and job opportunities in Nigeria. It is therefore pertinent that study on plantain exudates to evaluate its properties, preparatory to its projection as an excellent material in chemical industries in Nigeria. The objectives of this work therefore, are to conduct some instrumental characterization of exudates from Musa spp from Nigeria.

MATERIALS AND METHODS

Plantain stem used in this work was obtained from Afe Babalola University, Ado-Ekiti, (ABUAD Farm), Southwest Nigeria. All reagents and chemicals used were of analytical grade.

2.1 Extraction of Plantain Exudate (Exudation): Exudates were obtained from the stems of the trees by making incision on the barks with a sharp knife (Stanley, UK). The pointed end of the knife was

pushed tangentially into the stem so as to penetrate the bark and then pushed up to strip off a small length of the bark longitudinally from the wood. The incisions were left to bleed for 24 h before the half-dried gummy exudates were gently removed from the surface using a plastic spoon and stored in a wide mouth glass bottle until use. The colour was observed colourless. The exudates was then sieved by 212 micrometer of sieve mesh, and 310 ml was extracted and kept in a volumetric flask and labelled as A. 20 ml of the exudates was then separated in a beaker so as to observe any colour change.

2.2 Characterization of Exudates

2.2.1 pH value

The pH measurements of the freshly collected liquid exudates was carried out using a microprocessor pH meter (OAKLON Instruments UK, model ION 700). The mixture was allowed to stand for about one hour at room temperature before the pH and temperature were recorded. The procedure was repeated three times.

2.2.2 Microbial stability

One milliliter of fresh exudates from plantain was aseptically placed in a sterile test tube and dosed with 0.1 ml each of 1% w/v solution of the following preservatives in water: Benzoic acid, sodium benzoate, sorbic acid, potassium sorbate and methyl paraben. The microbial growth during a 24 h period was monitored by culturing the mixture on nutrient agar.

1.2.3 Solubility

Sample preparation for solubility tests: The raw exudates were dried in sunlight for 2 to 3 days and kept for tests. When needed, the dry exudate was powdered with mortar and pestle. 10 gram of freshly collected exudates from plant ain was aseptically placed in a sterile test tube. The microbial growth within a specified period was monitored by culturing the mixture on nutrient agar (NA) and potato dextrose agar (PDA).

Solubility in polar and non-polar solvent: 10 g of thoroughly mixed sample was dissolved in 30 ml of each of the polar and non-polar solvents: toluene, hexane, dimethyl ether, carbon-tetrachloride, cold/hot water. The solution was allowed to stand for 30 minutes and the solubility of the sample in the different solvents was determined qualitatively.

2.2.4 Determination of chemical constituents

Tests were carried out to determine the chemical compositions of the samples. These tests include test for cations and anions such as calcium, magnesium, sodium and potassium; phenols and tannin content; chlorides and sulphates.

Cations: These were determined using Perkins Elmer Atomic Absorption Spectrophotometer (AAS) (Model 290B, Perkin-Elmer Co. Ltd. USA) which was suitably calibrated. 1.0 g each, of the samples were weighed into a 250 ml conical flask. Thereafter, 5 ml at 60% per chloric acid and 10 ml of nitric acid were added and the sample heated in an electro-thermal heater till the solution became clear and produced white fumes. The sample was removed from heating, allowed to cool, diluted to 25 ml with distilled water and then sent for AAS analysis.

Anions:

(i) **Test for sulphates**

Sulphate was determined using UV Spectrophotometer (Model Spectrumlab 752s VTS) which was suitably calibrated. The formula used to obtain the concentration of sulphate is as follows:

$$Concentration\ of\ sulphate\ (mg/L) = (X \times 1000)/(ml\ of\ sample\ taken) \quad \text{----- (1)}$$

where X = mass of sulphate in mg

(ii) **Test for chlorides**

Standardization of silver nitrate- About 25 ml of 0.0141 N sodium chloride was taken in a conical flask and 2 ml of potassium chromate indicator was added. The solution was titrated against silver nitrate until a brick red precipitate of silver chromate appeared. The volume of silver nitrate consumed was noted down.

Determination of chlorides in the sample: About 25 ml of water sample was taken in a conical flask and 2 ml of potassium chromate indicator was added. The solution was titrated against standardized silver nitrate until a brick red colour precipitate of silver chromate started precipitating. The volume of the silver nitrate was noted down.

The formula used to obtain the concentration of chlorides is as follows:

$$Concentration\ of\ chlorides\ (mg/L) = ((ml * N)\ of\ AgNO\_(3) \times 35.5 \times 1000)/(ml\ of\ sample\ taken) \quad \text{---------(2)}$$

(iii)*Test for phenols*: 100 ml of the sample (sample A) was heated gently and filtered. 2.5 ml of the filtrate was then transferred into a 100 ml conical flask and 2.5 ml of distilled water added. The blank (sample B) was also prepared by measuring 2.5 ml of distilled water into another 100 ml conical flask. Thereafter, the sample (sample A) and blank (sample B) were treated the same way. 5 ml of 0.1 M NaOH was added, followed by 2.5 ml of iodine and 0.5 ml of concentrated HCl and the sample and blank titrated against sodium thiosulphate using starch as an indicator. The titre values of the blank and sample were noted and recorded.

(iv)*Test for tannins*:10 ml of the sample was weighed and transferred to a 250 ml conical flask. 100 ml of distilled water was added to the sample and boiled for 1 h. The solution obtained was diluted to 100 ml and filtered. 1.0 ml of the filtrate, 10 ml of freshly prepared 17 % sodium carbonate and 2.5 ml of Folin Denis reagent were placed in a test tube and allowed to stand for 20 min for colour development. Thereafter, the absorbance/optical density was read at 520 nm using the UV Spectrophotometer (Model Spectrumlab 752s VTS). Also, the standard tannic acid curve was prepared according to [10].

The formula used to obtain the percentage of tannin is as follows:

$$\%\ tannin = (T(mg) \times filtrate\ volume(ml))/(10 \times aliquot(ml) \times sampleweight(mg)) \times 100 \quad \text{---------- (3)}$$

where $T(mg)$ = mass of tannic acid obtained from the standard curve.

RESULTS AND DISCUSSION

pH Meter Readings

3.1 Table 1 shows the pH values of exudate

The colour change of the exudate as at the time of extraction was from colourless to brown after 1 hour due to oxidation when exposed to air. The exudates extracted from the plantain tree was found to have a pH of 5.5 at 24.6 °C, relatively strong acid, similar to 4.93 reported by David and Charles in 2012. Indication of its possible application as corrosion inhibitors for mild steel and

aluminium industries due to its high solubility in water and high molecular size [11].

Trial	pH Value	Temperature(°C)
1	5.49	24.7
2	5.51	24.2
3	5.50	25
Average	5.5	24.6

3.2 Microbial Stability and Observation

3.2.1 Nutrient agar (NA)

There was no visible growth of microorganisms after 24 hours

3.2.2 Potato dextrose agar (PDA)

There was no visible growth after 5-7 days. After 12 days, 21 moulds (total number of organisms) were found. The tests shows that the lesser the concentration, the lesser the microbial growth. Earlier reports test made by [10] did not cover growth of moulds.

3.3 Solubility in Polar and Non Polar Solvents

Table 2 and 3 shows the solubility result of exudate in polar and non-polar solvents respectively.

Table 2: Solubility in polar solvents

Solvent	**Solubility**
Cold water	Soluble
Warm water	Soluble
Dimethyl ether	Insoluble
Carbon tetrachloride	Sparingly soluble

Table 3: Solubility in non-polar solvents

Solvent	**Sample**
Hexane	Insoluble
Toluene	Insoluble

Solubility test carried out proved that the exudate sample is soluble in cold and warm water but sparingly soluble in CCl_4 and insoluble in hexane and toluene.

3.4 Determination of Cations; Readings and Observation

Figure 1 to 4 present the test for cations and its respective concentrations:

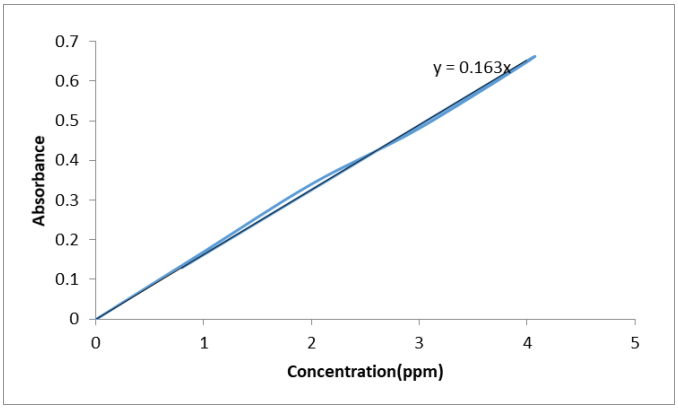

Figure 1: Absorbance against Concentration for calcium

Model calculation:

From the calibration graph,

$$Y = mX + c$$

Where,

Y = Absorbance of the sample

m = Slope of the straight line

X = Concentration of cations in mg/L or ppm

For calcium concentration; $0.13 = 0.163X + 0$

Therefore, $X = 0.80$ mg/L

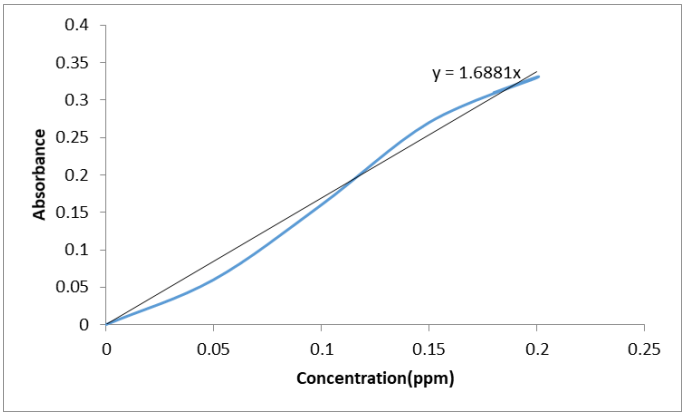

Figure 2: Absorbance against Concentration for potassium

For potassium conc., $0.31 = 1.6881X + 0$

Therefore, $X = 0.18$ mg/L

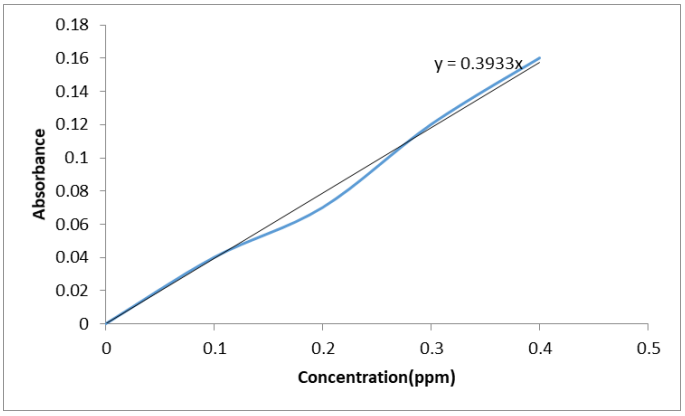

Figure 3: Absorbance against Concentration for magnesium

For magnesium concentration; $0.053 = 0.3933X + 0$

Therefore, $X = 0.13$ mg/L

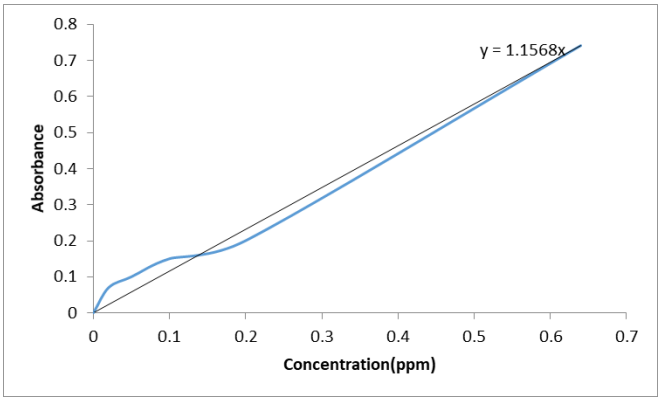

Figure 4: Absorbance against Concentration for sodium

For sodium concentration; $0.74 = 1.1568X + 0$

Therefore, $X = 0.64$ mg/L

3.5 Determination of Anions; Readings and Observation

3.5.1 Test for chlorides calculation

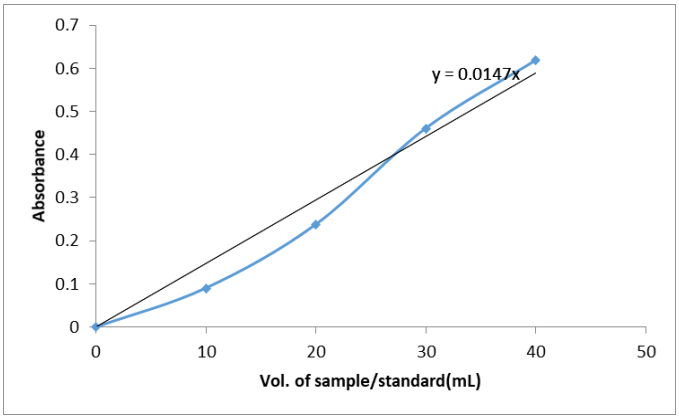

Figure 5: Absorbance against volume of sample/standard for sulphate

For sulphate concentration; $0.0767 = 0.0147X + 0$
Therefore, $X = 5.22$ mg
concentration of sulphate in mg/L = $(X \times 1000)/(ml\ of\ sample\ taken)$
= 5.22 × 1000/20 = 261 mg/L

3.5.2 Test for chlorides calculation

Chlorides, mg/L = $((ml * N)\ of\ AgNO\_(3) \times 35.5 \times 1000)/(ml\ of\ sample\ taken)$
= $(16.0 \times 0.0141 \times 35.5 \times 1000)/25.0$ = 320.35 mg/L

From the experimental results obtained for cations and anions, it was observed that exudates contains very low quantities of some useful cations such as calcium, potassium, magnesium and sodium which are present at a composition of 0.80 mg/L, 0.18 mg/L, 0.13 mg/L and 0.64 mg/L respectively, which concentrations not in the range of consumable products. They had aromatic smell which became pungent after a period of one week.

However, sulphate and chlorides are considered as secondary contaminants according to Environmental Protection Agency (EPA). It contains high quantities of some anions such as sulphate and chlorides which are present at a composition of 261 mg/L and 320.35 mg/L respectively, which concentrations not in the range of consumable products.

3.6 Test for Phenols

Table 4 contains results obtained from phenols test

Table 4: Functional chemical Properties

Parameter	Sample	Blank
Phenol (mg/ml)	9.7 mg/ml	13.00 mg/ml

Concentration of phenols was obtained as follows:
Phenol (mg/L) = (Blank titre – sample titre) × 1.567 × 4 × 1000
= 20684/1000 = 20.684 mg/l.

3.7 Test for Tannins

This section contains results obtained for test of tannins using UV spectrophotometer and graphical representation of absorbance against volume of sample/standard for tannins is shown in figure 6.

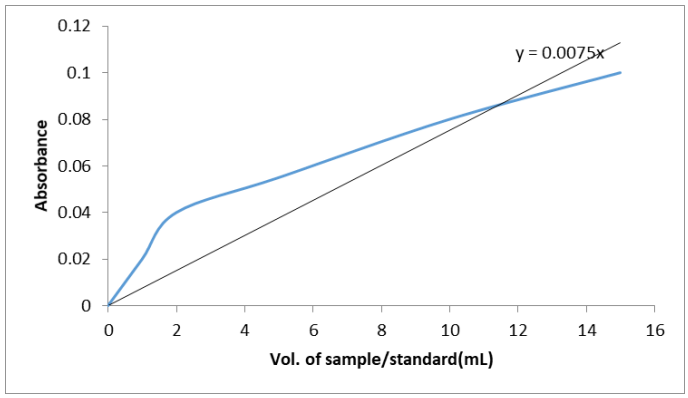

Figure 6: Absorbance against volume of sample/standard for tannins

For tannins conc., $0.03 = 0.0075X + 0$
Therefore, $X = 4$ mg
$\%\ tannin = (T(mg) \times filtrate\ volume(ml))/(10 \times aliquot(ml) \times sampleweight(mg))\ \times 100$
$= (4 \times 1.0)/(10 \times 12.5 \times 10)\ \times 100$ = 0.32 %

From the result obtained from phenols and tannins test, it was observed that the level of degradation was not very fast as a result of the presence of phenols and the amount of phenol determined was 20.684 mg/L. The amount of tannin present was determined to be 0.32 %, which is not up to the range required for tannin and dyeing industries. Therefore, as a result they could be used as antioxidants i.e. a substance that inhibits oxidation, especially one used to counteract the deterioration of stored food products.

CONCLUSION

This study present extraction and characterization of exudate from plantain stem. Exudation from the trees was carried out by making an incision on the tree bark during harvesting. Results obtained were pH value: 4.93; phenol contents: 20.684 mg/L; tannin content: 0.32%. It contains very low quantities of cations such as calcium, potassium, magnesium and sodium which are present at a composition of 0.80 mg/L, 0.18 mg/L, 0.13 mg/L and 0.64 mg/L respectively. They had aromatic smell which became pungent after a period of one week. It contains high quantities of some anions such as sulphate and chloride which are present at a composition of 261 mg/L and 320.35 mg/L respectively, concentrations far from the range of consumable products. Plantain exudates can be preserved using well known food preservatives. From the results, it was deduced that the exudates may serve as raw materials for pharmaceutical, steel and paint industries if the machinery for their collection and preservation are established.

Based on the analysis of results from this research work, the following conclusion can be made; the exudate obtained was acidic which can be used as corrosion inhibitors for mild steel and aluminium industries due to its high solubility in water and high molecular size. Microbial stability test shows that the lesser the concentration, the lesser the microbial growth. Exudate contains more concentration of anions than cations which are not in the range of consumable products. Exudate level of degradation was not very fast as a result of the presence of phenols which can be used as antioxidant. The amount of tannin presents is also not in the range required for usefulness in tannin and dye industries. From results, it was also deduced that the exudates may serve as raw materials for

pharmaceutical, steel and paint industries.

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