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Comparative Analysis of Ethanolic Extracts from Banana *(Musa paradisiaca)* Exocarps as Potential Sources of Antimicrobial Properties

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Abstract

The banana *(Musa paradisiaca)* exocarps have been a substantial source for maintaining human health. Banana peel extracts for antimicrobial properties can be of great significance in therapeutic treatments. This study aimed to evaluate the antimicrobial activity of banana exocarps among the selected pathogens. The collected data on antimicrobial assay were presented in means and the standard error of the mean was properly calculated for the zones of inhibition measured for the experiment. Among the test microorganisms, only the Gram-positive bacteria were sensitive to the ethanolic extracts of Lacatan *(Musa acuminata* C.*)* and Cardaba *(Musa acuminata balbisiana)* with the diameter zone of inhibition ranging from 15.30±3.72mm to 15.35±2.13 mm. The ethanolic extract of two varieties of banana exocarps showed various inhibitory effects against several microbial isolates. Highest inhibitory effect against *S. aureus* with 15 mm inhibition zone, followed by *E. coli* with no effect. The ethanol extracts of banana exocarps could be considered a good antimicrobial agent against both Gram-positive and negative bacteria to restore the synthetic medicines in the treatment of diseases caused by these microorganisms. The study suggested that the local tribes or ordinary people could explicitly continue utilizing this banana plant as a source of treatment.

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Introduction

The banana plants *(Musa paradisiaca)* are fast-growing herbaceous perennials arising from underground rhizomes. According to Villaverde *et al.,* 2013), banana plants are of extraordinary nutritional value, containing Vitamin C and a high-grade protein, which incorporates three basic amino acids. Banana plants *(Musa paradisiaca)* and banana exocarps *(Musa sapientum)* these two of the same genus *Musa* are grown worldwide and popularly consumed as ripe fruit or used for any culinary purposes. Aside from that, all parts of the banana plants *(Musa paradisiaca)* have medicinal applications. Otherwise, the ripe banana is very useful in acidity, while green bananas are also a good source of pectin or an extract (Antorcha, 2016).

Phytochemical compounds are those kinds of compounds that certainly endure in various sorts of plant treatment (Aquino *et al.,* 2016). Evenly, it is worth repeating that the advancement of the current medication derived from applying scientific and logical principles to herbalism and right up until the present time, plant inferred compounds provide the skeleton for constructing particles with the ability to cure numerous diseases and ailment complication (Ehiowemwenguan *et al.,* 2014). Furthermore, the phytochemicals are well-known to occur in several parts of plants with their diversity and explicit functions which include the provisions of strength to plants, and the attraction of various insects or microorganisms for pollination and feeding. Also, it is for the defense against predators, and provision of color, while few are simply waste products (Onyema *et al.,* 2015).

There are two selected varieties of banana *(Musa paradisiaca)* exocarps as potential sources of antimicrobial properties of the lacatan and cardaba. The lacatan banana *(Musa acuminata* C.), also known as Masak Hijau, is one of the most popular and very well-known dessert banana cultivars in the Philippines. Banana Lacatan (*Musa acuminata* C.), a *Musa* hybrid or frequently called "the best-tasting banana", has a firm texture with a sweet taste and delicious aroma when ripe (Do *et al.,* 2014). Nonetheless, it grows to a height of 5 to 9' tall and fruits within 8 to 12 months after planting. This is an ideal banana for gardeners in southern zones who wish to grow bananas in their edible landscape (Logees, 2021). Cardaba (*Musa acuminata balbisiana*), also known as Saba, Sweet plantain, compact banana, and papaya banana. The Cardaba (Saba) banana is one of the triploid hybrids (ABB) banana cultivars originating from the Philippines.

In this study, the researchers came up to study how the banana exocarp from ripe ones can produce ethanolic extracts as a potential source of antimicrobial properties. There are new sources of antimicrobials that are widely developed and are used as a major source of treatment against certain diseases and antimicrobial products that can be beneficial for humans, animals, and even plants. However, some of these products are being commercialized for human consumption and some are causing detrimental effects due to prolonged use. Aside from that, there are many plant products that are studied for their antimicrobial properties, but information regarding the two varieties of banana *(Musa paradisiaca)* family has not yet been thoroughly examined. Therefore, the study aimed to compare the antimicrobial properties present in the two chosen varieties of banana *(Musa paradisiaca)* family that can be useful for future studies. The researchers really want to determine the chemical composition of the banana *(Musa paradisiaca)* family accurately. Researchers utilized phytochemical analysis and antimicrobial activity tests in order to come up with the results and to analyze the ethanolic extracts that were extracted from the samples.

This study tries to scrutinize the ethanolic extracts from banana exocarps as potential sources of antimicrobial properties. This study showed the important use of banana exocarps *(Musa sapientum)* by conducting phytochemical screening and antimicrobial assay. Specifically, the researchers sought to answer the following questions: What are the secondary metabolites that are present in the two varieties of banana *(Musa paradisiaca)* family and what secondary metabolite in the exocarps of two varieties of banana *(Musa paradisiaca)* has antimicrobial properties?

Materials and methods

Research design

The study utilized the experimental method of research. This design was chosen to meet the objectives of the study, namely, to assess the phytochemicals and potential antimicrobial properties of ethanolic extracts from the exocarp of two varieties of banana *(Musa paradisiaca)* family.

Research locale

This study was conducted in the local market located in Prosperidad, Agusan del Sur, CARAGA Region, Philippines. The Prosperidad public market is one of the big and most popular markets which is situated in Agusan del Sur. The market is well-known for selling numerous dry goods, vegetables and fruits, including different varieties of bananas. The ethanolic extraction of exocarps of two varieties of banana was conducted at the Laboratory of the Department of Biology, Caraga State University-Main Campus. Furthermore, the researchers conducted the phytochemical analysis and antimicrobial assay at Caraga State University-Main Campus, Ampayon, Butuan City, Agusan del Norte.

Research Samples

The extraction and phytochemical screening of the exocarps of Banana *(Musa paradisiaca)* family was conducted at the laboratory of Caraga State University-Main Campus, Butuan City. The other procedural activity was conducted as well at the laboratory of Caraga State University-Main Campus, Ampayon, Butuan City Agusan del Norte, namely, Antimicrobial Assay. It is explicit and equipped with the necessary materials needed in order to conduct the required processes for this study.

Ethical consideration

As this study deals with an experimental microorganism or known as selected pathogens, specifically *Staphylococcus aureus* and *Escherichia coli*, this concludes that there are no laws or ethics violated in this study; hence, the researchers guarantee that there were no other animals or humans harmed except for the experimental microorganisms used in this study. The researchers only utilized the availability of the two varieties of Banana *(Musa paradisiaca)* family, namely: Lacatan *(Musa acuminata* C.*)* and Cardaba *(Musa acuminata balbisiana)*. There were no ethical violations caused in conducting the experiments. The researchers also present proper consent in using the laboratory of Caraga State University-Main Campus, Ampayon, Butuan City, as means of achieving the research objectives.

Procedures of the study

This study required different laboratory experiments; hence the researchers performed phytochemical screening and antimicrobial assay to attain the objectives of the study.

The exocarps of the two varieties of Banana *(Musa paradisiaca)* family were collected from the public market of Prosperidad, Agusan del Sur, CARAGA Region, Philippines. The banana exocarps were washed in running tap water and were air-dried for seven days; the air-dried exocarp was then minced and crushed. After that, it was conducted at the Department of Biology for the extraction and concentration proper. When the ethanolic extract was prepared and executed with some procedural activities, phytochemical screening was performed. Phytochemical screening is used to identify the phytochemicals found in plant materials. Ethanolic extracts of exocarps from two varieties of banana *(Musa paradisiaca)* were tested for antimicrobial properties using an antimicrobial assay.

The zone of inhibition was measured to determine the level of responsiveness of the microorganisms to the treatment, which is an ethanolic extract from the exocarps of two Banana varieties *(Musa paradisiaca)*.

Extraction of the two varieties of Banana (Musa paradisiaca) family.

The exocarps of the two varieties of banana *(Musa paradisiaca)* family were extracted in the laboratory of the Department of Biology, Caraga State University-Main Campus. On the separated 2 sample glass container, 100 grams of each crushed material should mix with 250mL of 80% ethanol and the samples should macerate for three days. Afterward, the samples were filtered and the liquid sample obtained underwent an evaporation process using a rotary evaporator to acquire the crude extract and 50 grams of collected crude extract was added to 10mL distilled water to produce a stock solution of 5 mg/ml.

Qualitative phytochemical screening

Phytochemical analysis of the two varieties of Banana exocarps has been carried out according to standard protocols. Additionally, the extracts of Banana exocarps were performed to determine the presence of alkaloids, flavonoids, saponins, steroids, and tannins using the method described (Phytochemical Screening adapted from Guevara, 2005).

Screening for alkaloids

An equivalent of 4 grams of the extract (4mL) was evaporated into syrupy consistency through a steam bath. Then, 1 mL of 2M HCl was added and heated for 5 minutes with constant stirring. When cool, 0.1 gram of NaCl was explicitly mixed and filtered. The residue was washed with enough 2M HCl to bring filtrate to 1 mL. Two to three drops of Mayer's reagent were added. The white to cream precipitate indicates the positive presence of alkaloids.

Screening for flavonoids

A 1 gram of the extract (1 mL) was added with 5 mL of 80% ethanol. The solution was plainly divided into two parts. The first part served as control while the other part of the solution was mixed with 0.5 mL concentrated HCL (12M). The solutions were properly warmed for 15 minutes in a water bath. The appearance of strong red or violet color indicates a positive result.

Screening for saponins

An equivalent of 1mL of the extract was diluted with 10 mL distilled water and shaken vigorously for 2 minutes. A stable, persistent froth indicated the presence of saponins.

Screening for steroids

An equivalent of 1 gram of the extract (1mL) from the stock solutions was added with 1 mL Ferric chloride ($FeCl_3$) reagent. Also, 1 mL concentrated sulfuric acid was plainly added slowly at the side of the test tube. Wherein the two layers formed, aqueous and sulfuric acid in the upper and lower portion. The appearance of reddish-brown to purple in the interface of the two layers indicates the positive presence of steroids.

Screening for tannins

A 1mL solution of extract was added to distilled water in a test tube. Then, 10% ferric chloride solution was added to the mixed solution. The appearance of blue or green color signifies the positive presence of tannin. However, a blue or black indicates the presence of hydrolysable tannins, while a brownish to green may indicate the presence of condensed tannins.

Antimicrobial assay

The methodology for antimicrobial analysis of the extracts was adapted from the work of Guevara (2005). An equivalent of 1 gram of the extracts (1mL) was clearly taken from the sample stocks and evaporated to incipient dryness through a steam bath at less than 50^0 C. Furthermore, a sterile cotton applicator was properly dipped into a potato-glucose broth medium and the screening of the test microorganisms was straightened out into their respective sterile culture medium (nutrient Agar for the bacteria).

The sterile paper discs (6 mm in diameter) were impregnated with the two varieties of Banana *(Musa paradisiaca)* exocarps, ethanol (negative control), penicillin (commercial antimicrobial or positive control) was placed on the test-microorganism seeded plates in triplicate. The diameter (mm) of the zone of inhibition was taken after 24 hours of incubation at 37^0 C of bacteria, respectively.

Susceptibility test

The antibacterial susceptibility test was performed using the standard process of disk diffusion assay. The medium to be utilized by the researchers is the Muller-Hinton Agar (MHA).

Preparation of agar medium

Muller-Hinton Agar (MHA) from the dehydrated medium was equipped as specified in the direction of the manufacturer. In order for the medium to disseminate completely, it was heated until it boiled. While in the heat exposure, it was frequently uptight. Afterward, it was decontaminated for about 15 minutes in the autoclave at 121°C. After it underwent sterilization, the equipped medium' pH level was checked and the researchers made sure to be between 7.2 and 7.4 at room temperature. It was cooled at 40-50°C. The Petri dish was dried at 30 to 37°C in an incubator with caps partly distant for 30 minutes before it was placed in an autoclave for decontamination. The agar medium was dispensed into a glass Petri dish at a uniform depth of 4 mm.

Inoculation of plate

An uncontaminated cotton swab was saturated with the created standardized bacterial suspension. The extra inoculum was diminished by gently packing the cotton swab in contrast to the wall of the tube overhead the fluid. The cotton swab containing the inoculum was streaked suitably on the agar plate. In order to scrub the inoculum similarly on the plate, the researchers revolved it at 60 degrees. This system was done twice to ensure that there was an even dispersion of inoculum to the agar medium. The layer of the agar medium was dried up for three to five minutes to allow assimilation of extra dampness.

Preparation of disk

Whitman filter paper was utilized in preparing around a 6 mm in diameter disk which was set in hot air for disinfection. Subsequent to being cleaned, the disk was hampered with various concentrations of a sweeping range of antibiotic penicillin (positive control) and the readied ethanolic extracts (treatment) of two varieties of Banana *(Musa paradisiaca)* were held under refrigeration for 24 hours.

Preparation of antibiotic disk

A few drops of penicillin were accurately gauged and added in sterile distilled water to give appropriate dilution of 50, 100, and 200 mg/ml. The stock was aliquot in 5 ml volumes and was frozen at - 20°C.

The function of the disk to inoculated agar plates: antimicrobial disks

A recently prepared disk was disseminated on the surface of the inoculated agar plate. Each disk was compelled sturdily to set assurance that there was complete contact of the disk with the agar surface.

A maximum of six plates were situated in the petri dish. The disk was set on the medium at approximately 24 mm distance from each other and was placed in incubation at 5°C for an hour to permit dispersion, and it was transferred to the incubator for 24 hours at 37°C. The plates were switched and set in the incubator customary at 37°C for 24 hours. A zone of inhibition was observed after 24 hours by the researchers.

Reading and measuring the zone of inhibition

The zone of inhibition is the point where there is no growth development evident to the naked eyes. The appearance of individual colonies and an irresolute zone inside the zone of inhibition were recorded. However, the indistinct portion was disregarded while evaluating the zone of inhibition due to measuring only the zone of normal growth. A Caliper (0.5 mm) was wrought in measuring the zone of inhibition and was rounded at the nearest mm.

Statistical Analysis

The inhibition zone diameter was differentiated to test isolates treated with the positive control (penicillin). Thus, it was the standard reference. On the off chance that the zone of inhibition (ZoI) detected is greater than or equivalent to the standard reference, the microorganism is viewed as profoundly responsive to the treatment. However, if the observed zone of inhibition (ZoI) is lesser than the standard reference, the microorganism was considered to be resistant. The collected data on antimicrobial assay were presented in means and the standard error of the mean was properly calculated for the zones of inhibition measured for the experiment. These means were statistically compared based on the range introduced by Guevara (2005).

Rejection of criteria

The disk having these outcomes will be rejected. To start with, the disk has less secluded settlements or those with less blended development on the plate. Second, the disk has neighboring and covering zones. In conclusion, the disk has circularly twisted zones.

Results and discussion

This section comprises the presentation, analysis and interpretation of the findings resulting from this study. The analysis and interpretation of the data were based on the results of the experimental procedure conducted by the researchers, which deals with the statement of the problem and hypothesis of the study.

Table 1. The secondary metabolites of the two varieties of Banana *(Musa paradisiaca)* family.

Compound	Spotting phase	Result
Cardaba *(Musa acuminata balbisiana)*		
Alkaloids	presence of white to cream colored precipitate	+
Flavonoids	appearance of a strong red color	+
Saponins	foam layer on the top of the mixture	+
Steroids	appearance of a reddish brown to purple	+
Tannins	blue-black solution indicates the presence of hydrolysable tannins	+
Lacatan *(Musa acuminata C.)*		
Alkaloids	presence of white to cream colored precipitate	+
Flavonoids	appearance of a strong red color	+
Saponins	foam layer on the top of the mixture	+
Steroids	appearance of a reddish brown to purple	+
Tannins	blue-black solution indicates the presence of hydrolysable tannins	+

Legend: +, presence; -, not detected.

Secondary metabolites that are present in the two varieties of the Banana (Musa paradisiaca) family

The phytochemical result showed ethanol to be a better solvent for the extraction of the secondary metabolites in banana exocarps which include: alkaloids, saponins, flavonoids, steroids, and tannins. The different phytochemical constituents and spotting phases present in the peels of banana *(Musa paradisiaca)* exocarps are shown in Table 1. It was properly observed that the five screened secondary metabolites compounds were present in the two banana varieties. Various studies have been done to assess and evaluate the phytochemical compositions and antibacterial activities of different parts of diverse plant species. The main purpose of utilizing these plants for the treatment of microbial diseases and infections as possible alternatives to synthetic drugs to which several infectious bacteria have developed resistance. Accordingly, the findings indicated that the tannins are present; however, the flavonoids are not detected in the crude extract of *Musa sapientum* L., it was likely considered that the antibacterial activity of the banana peel is something related to tannins and not to flavonoids compound (Lino *et al.,* 2013). Table 1 shows the secondary metabolites of the two varieties of banana *(Musa paradisiaca)* family, namely, Lacatan *(Musa acuminata* C.*)* and Cardaba *(Musa acuminata balbisiana)*. These two varieties of banana exocarps contained alkaloids, flavonoids, saponins, steroids, and tannins. The antimicrobial properties of plant species extracts have been attributed to the presence of secondary metabolites which are flavonoids and alkaloids (Enyiukwu and Awurum, 2013). Additionally, phytochemicals with bitter taste, such as the two main secondary metabolites, the alkaloids and flavonoids, have been found to possess bacterial properties. In relation, various plant species and the parts of the plant, such as the exocarps of banana, have an ability to prevent the growth of bacteria and are caused by the existence of compounds that have a role as antibacterial or the presence of secondary metabolites which are, the flavonoids, saponins, steroids, alkaloids, and tannins (Meutia, 2017).

According to Ehiowemwenguan *et al.*, (2014), banana exocarp extracts were prepared using isopropyl alcohol, which is an organic solvent. They studied the antimicrobial activities of an organic extract and aqueous extract of banana peel. Thus, the organic extract from the sample had the least MIC value compared to the aqueous extract. Furthermore, the proponents in the same study also carried out a phytochemical analysis of both extracts of banana exocarps containing glycosides, alkaloids, flavonoids, saponins and tannins. In contrast, the aqueous extract from the sample contains only glycosides and alkaloids.

The phytochemical analysis result of the two varieties of banana exocarps (*Musa acuminata balbisiana* and *Musa acuminata* C.*)* has these secondary metabolite compounds, namely; alkaloids, flavonoids, saponins, steroids, and tannins. Thus, the high antibacterial activity in the ethanolic extracts of the two varieties of banana *(Musa paradisiaca)* family might be due to the presence of the high number of alkaloids, tannins and flavonoids that possesses a similar procedure. In the same manner, these phytochemicals are mainly the basis for plant medicinal properties because of the high antibacterial activity of banana exocarp against human pathogenic microorganisms and the starting point of materials for the production of new medicinal drugs today (Ighodaro, 2012).

Table 2. Antimicrobial activity of ethanol crude extracts of the two varieties of Banana *(Musa paradisiaca))* family against selected pathogens.

	Zone of inhibition (mm)	
	Gram (+) Bacteria	Gram (-) Bacteria
Extracts	*Staphylococcus aureus*	*Escherichia coli*
Lacatan (Musa acuminata C.)		
Ethanol	15.35±2.13	9.52±1.62
Cardaba (Musa acuminata balbisiana)		
Ethanol	15.30±3.72	8.61±1.95
Control		
80% Ethanol	8.14±1.09	10.15±1.79
Penicillin	9.31±0.29	16.69±1.82

Values that are presented as mean ± S.E. of triplicate experiment of the pathogens, the Diameter of inhibition zone including diameter of discs 6mm; <10mm = inactive; 10-13mm = partially active; 14-19mm = active; > 19mm = very active (Guevara, 2005).

Secondary metabolite in the exocarps of two varieties of Banana (Musa paradisiaca) antimicrobial property

In the present study, the researchers focused on determining the antimicrobial properties and secondary metabolites of the ethanolic extract of banana exocarps against standard strains of Gram-negative bacteria *(Escherichia coli)* and Gram-positive bacteria *(Staphylococcus aureus)* in both samples. Additionally, the researchers carried out a well serial broth dilution method to detect the antibacterial activity of ethanolic extract from the two varieties of banana exocarps. Based on the results of this study, it is evident that the presence of secondary metabolites in both samples (*Musa acuminata balbisiana* and *Musa acuminata* C.*)* has been responsible for antimicrobial activities (Fig. 2.).

The secondary metabolites found from the two varieties of banana *(Musa paradisiaca)* exocarps are alkaloids, flavonoids, saponins, steroids, and tannins. Rodrigues *et al.* (2011) also mentioned that flavonoids are the largest group of polyphenolic plant secondary metabolites. Also, different subclasses of flavonoids have existed in banana fruits. Herein, the flavonoids of different banana varieties share some characteristics (Tsamo *et al.,* 2015).

The banana plants *(Musa paradisiaca)* have great parts, which include roots, pseudostems, leaves, flowers, stems, and fruits that have long been utilized in local tribes as traditional medicine. Several countries used this plant species (America, Asia, Oceania, India, and Africa) (Tsamo *et al.,* 2015).

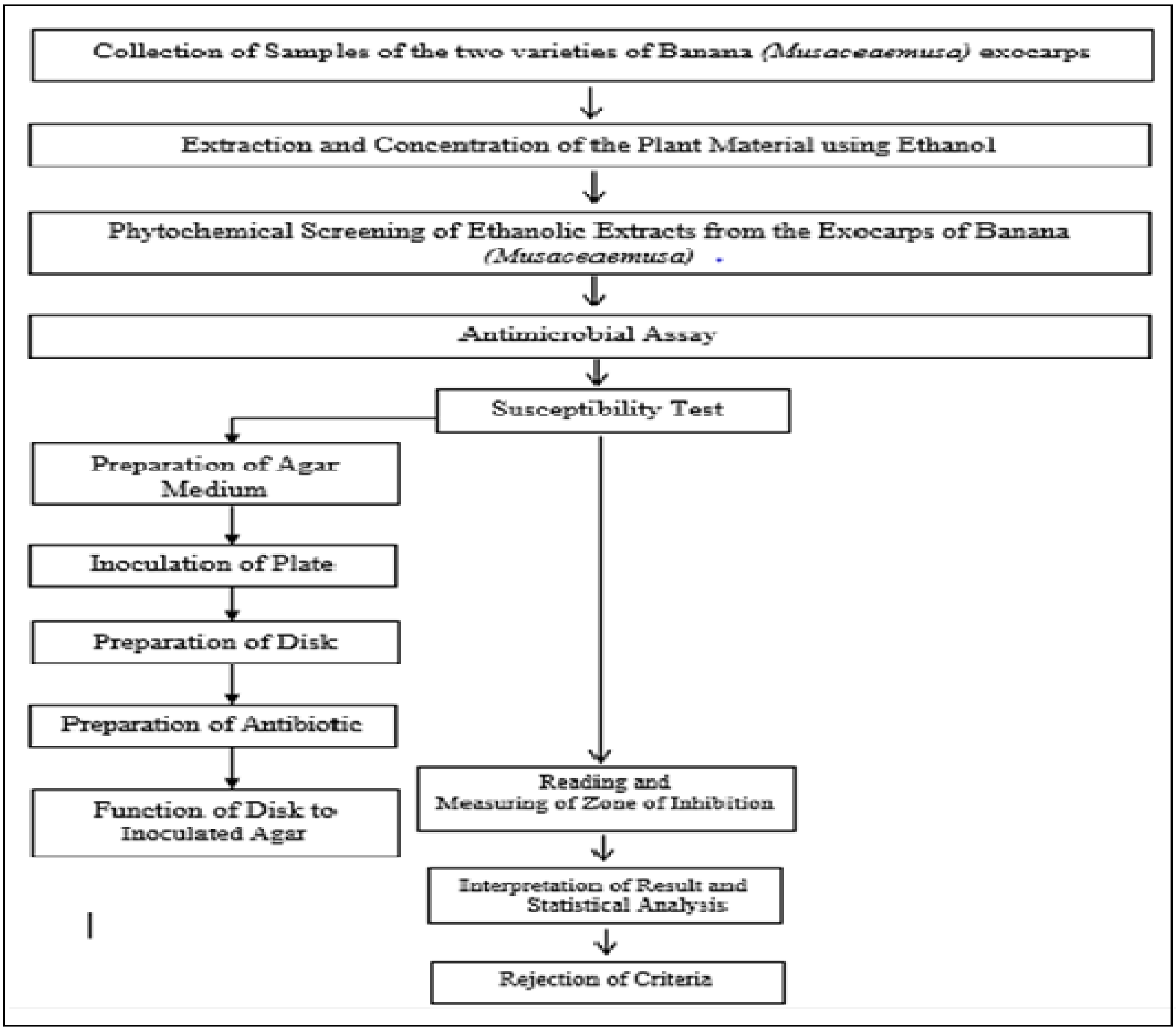

Fig. 1. Flow Diagram of Ethanolic Extracts of Exocarps of two (2) varieties of Banana *(Musa paradisiaca)* and the Determination of Phytochemicals and its Antimicrobial Property.

Rattanavichi and Cheng (2014) reported that there was antibacterial activity of the ethanol extracts and hot-water extracts of *M. acuminata* C. exocarps against pathogens. It was highlighted in their study that there are different extraction methods that can possibly use to test or screen the effectiveness against Gram-positive bacteria. Gram-positive bacteria are multi-resistant microorganisms that assuredly cause infections and might lead to a significant health problem for the public (Edenta *et al.,* 2014).

The findings suggest that banana exocarps from the two banana varieties *(Musa acuminata balbisiana and Musa acuminata* C.*)* have antibacterial properties against *Staphylococcus aureus*. This study enlightens a new line of approach and avenue for further research of different varieties of banana exocarps against different periodontal pathogens. Therefore, the findings provide the premise of antibiotics for the therapy of bacterial infections. However, the high genetic variability of microorganisms enables them to rapidly evade the action of antibiotics by promoting and developing antibiotic resistance. Hence, there has been a continuing search for new and more potent antibiotics. The inhibitory effect of ethanolic banana extracts on Gram-positive bacteria in the study was agreed with different studies. Ighodaro (2012) described that aqueous and ethanol extract of *Musa paradisiaca* gave an antimicrobial effect against *Staphylococcus aureus, Escherichia coli,* and *Proteus mirabilis* more than antifungal. Thus, banana exocarp can be applied directly to burn or boil for a good healing effect (Zainab *et al.,* 2013).

That means the banana peel extracts not only inhibit the non-spore-forming microorganism but have significant inhibitory effects at pH values as high as 7.5 (Zainab *et al*., 2013).

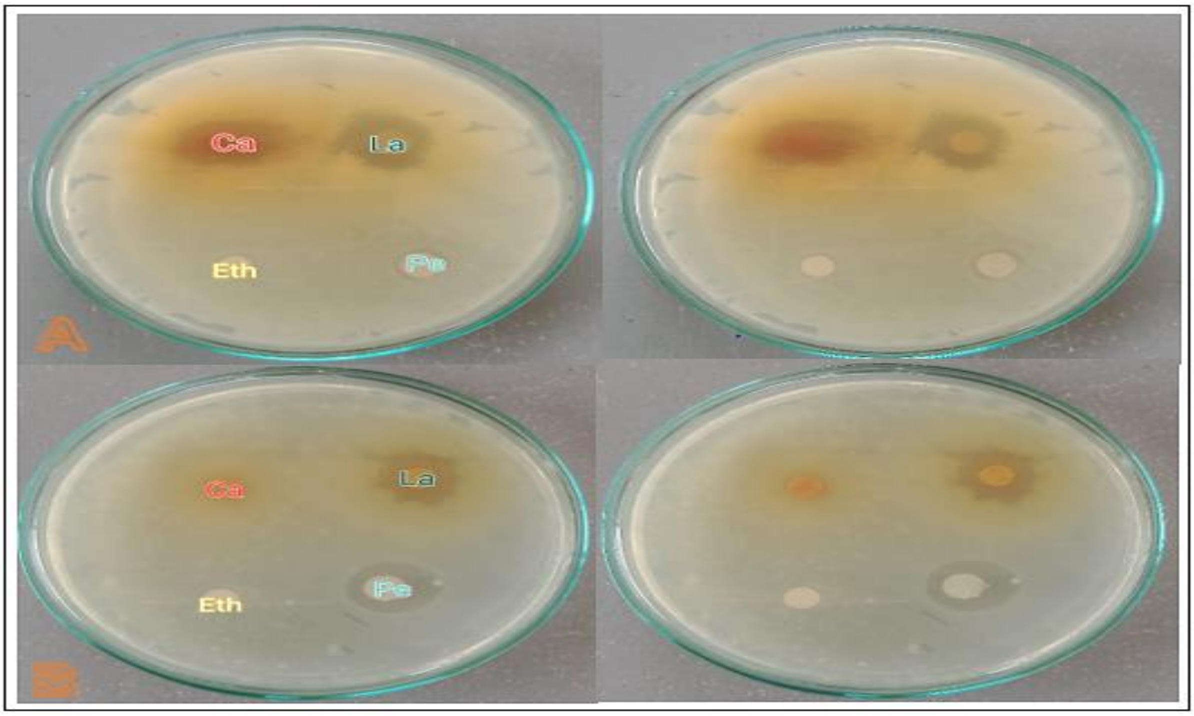

Fig. 2. Antimicrobial activity of ethanolic extracts of two varieties of Banana exocarps against selected pathogens, namely, *Staphylococcus aureus* and *Escherichia coli* (A) *S. aureus* (B) *E. coli*; Ca – Cardaba *(Musa acuminata balbisiana),* La – Lacatan *(Musa acuminata* C.*)*, Eth – ethanol (-, negative control), Pe – Penicillin (+, positive control).

Table 2 presents the antimicrobial activity of ethanol crude extracts of the two varieties of banana *(Musa paradisiaca)* family against selected pathogens. The ethanolic extracts of Lacatan *(Musa acuminata* C.*)* and Cardaba *(Musa acuminata balbisiana)* exhibited the highest activities against the selected pathogen, namely, *Staphylococcus aureus*. The ethanolic extracts of the banana varieties were explicitly prepared and applied to Gram-positive bacteria *(Staphylococcus aureus*), whereas the Gram-negative bacteria *(Escherichia coli)* used the disc diffusion method and based on the standard procedure. Furthermore, the antibacterial substance within the two varieties of banana seemed to be most prominent and the inhibitory activity was observed for Gram-positive bacteria *(S. aureus)*. This might be attributed to the fact that the cell wall in Gram-negative bacteria synthesizes a thin single peptidoglycan layer covered by an outer membrane, whereas the Gram-positive bacteria produce a thick multi-layer peptidoglycan. As shown in the table, Lacatan *(Musa acuminata* C.*)* has an equivalent of 15.35±2.13 *(S. aureus),* while Cardaba *(Musa acuminata balbisiana)* also exhibited an active zone of inhibition 15.30±3.72. Based on the findings, the 80% ethanol as a negative (-) control presented an individual mean based on the selected pathogens, *Staphylococcus aureus* (8.14±1.09) and *Escherichia coli* (10.15±1.79). In the same manner, the penicillin (+) control has an active zone of inhibition, as shown in Table 2; the *S. aureus* obtained 15.35±2.13 and 15.30±3.72 of the two samples compared to other pathogens. All the tested banana varieties were plainly found to contain antimicrobials, as demonstrated by inhibition of selected pathogens.

The result in Figure 3 showed an inhibitory effect against Gram-negative bacteria with inhibition zone ranging from 8 to 16 mm, with high susceptibility of *E. coli* underneath the two banana varieties, cardaba *(Musa acuminata balbisiana)* and lacatan *(Musa acuminata* C.*)*. Thus, this high activity could be due to the presence of secondary metabolites in the ethanol extract that could inhibit broad range bacteria. The isolation of bioactive compounds is essential in order to attain pure and effective antibacterial agents which efficiently inhibit the growth of different ranges of microorganisms.

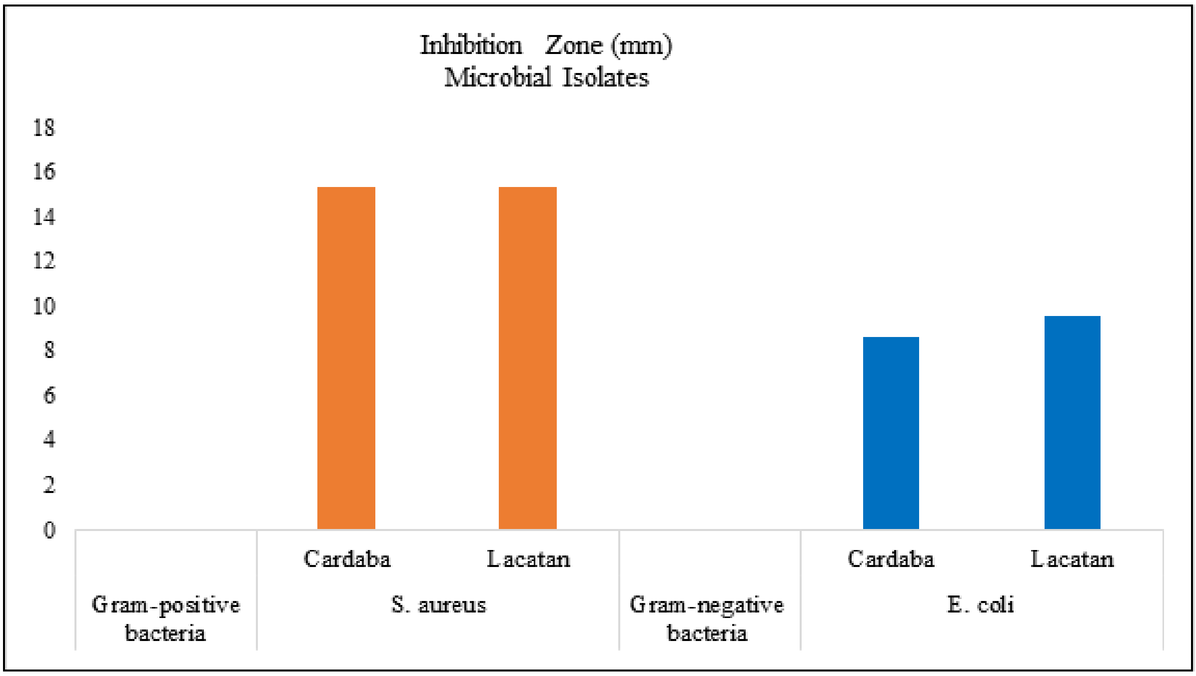

Fig. 3. Inhibition zone (mm) of microbial isolates by ethanolic extract of two banana varieties *(Musa acuminata balbisiana and Musa acuminata C.).*

This study's findings are greatly consistent with those of Zuvairea *et al.*, (2014); they precisely determined the standard antibiotics and antibacterial used, tetracycline, chloramphenicol and nystatin showed a zone of inhibition ranging from 8 to 35 mm against all test microorganisms while the negative controls did not plainly show any antimicrobial activity on the screening process. In the same study, the researchers evaluated the discovery of new types of antibiotic treatment-like substances that could serve as selective and has a low-cost source of natural antibacterial agents and might also help to conserve the environment (Berame *et al.,* 2017). Furthermore, Ismail *et al.,* (2018) stated that microorganisms vary widely in their susceptibility to antibacterial agents. In the same manner, the plant species and gram type of the tested bacterial strain might certainly influence the potential antibacterial effect and, later, the size difference of the inhibition zone (Norfaradhiah and Rapeah, 2017). In this study, the two varieties of Banana *(Musa paradisiaca)* exocarps could be utilized as a treatment for wound infections and other types of skin diseases locally. The ethanol extracts were found to be effective against several pathogens used in this study, which certainly highlights the potential extremity of herbal drugs and their possible use as local medicine.

Conclusion

This study concludes that the two banana exocarp varieties contained alkaloids, flavonoids, saponins, steroids, and tannins. The presence of secondary metabolites such as flavonoids and alkaloids has been linked to the antimicrobial properties of plant extracts. Furthermore, phytochemicals with a bitter taste, such as the two main secondary metabolites, alkaloids and flavonoids, have been discovered to have antibacterial properties. The presence of secondary metabolites in both samples is responsible for antimicrobial activity and had the highest antibacterial activity against the selected pathogen, *Staphylococcus aureus*. The results indicate that there was a presence of secondary metabolites in the exocarps of two varieties of Banana *(Musa paradisiaca)*, such as the alkaloids, flavonoids, saponins, steroids, and tannins. Thus, the antimicrobial properties of Lacatan *(Musa acuminata* C.*)* and Cardaba *(Musa acuminata balbisiana)* ethanolic extracts have been attributed to the presence of secondary metabolites. The findings of the study suggested that banana exocarps from the two banana varieties have antibacterial properties against Staphylococcus aureus. This provides the premise of antibiotics for the therapy of bacterial infections which certainly highlights the potential extremity of herbal drugs and their possible use in the local pharmacy. Further, the ethanol extracts were found to be effective against several pathogens used in this study, highlighting the potential extremeness of herbal drugs and their potential use as local medicine. Lastly, the study suggested that the local tribes or ordinary people could explicitly continue utilizing this banana plant as a source of treatment.

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