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COMPARATIVE STUDY OF EFFECTIVENESS OF DIFFERENT BANANA PEELINGS HYDROGEL INCOPORATED WITH BANANA PEEL EXTRACT IN WOUND HEALING

BY

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A dissertation submitted to the Department of Chemistry in partial fulfillment of the requirements for the award of the degree of Bachelor of Science and education of Busitema University.

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DECLARATION

I declare that this research report does not contain material or information which has been accepted for the award of any other degree at any university and to the best of my knowledge and understanding, this report doesn’t contain any material previously published or written by another person, except where due reference is made in the text of the thesis.

APPROVAL

All the work in this report has been done under my supervision as the university supervisor

DEDICATION

Special thanks dedicated to the almighty God who has seen me through the entire studies right from Primary School to Degree level.

This research study report would not have been a success without my beloved mother CHEMTAI BETTY, all my siblings and my dear husband ADAR JAMES and all my friends especially my coursrmates of who have always encouraged me that I can make it.

Special recognition and thanks to my colleagues and very good friends with whom my academic moments were shared to reach this stage.

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ABSTRACT

Consumption of bananas is in great demand by the various groups in the world. They contain antioxidants, vitamins and minerals which are of great importance to our bodies but one part of banana that can be wasted is banana peel which pollute the environment when they decompose causing bad smell to the environment.

Nutrients and bioactive compounds in banana fruits are essential to lead to a healthy life. The consumptions of banana fruits have increased worldwide to acquire prevention from diseases for example ulcers inflammation. Banana peel wastes ate highly seasonal and perishable but considered as environmental nuisances and, in every year, considerable quantities of banana peels are equivalent to 40% of the actual weight of fresh banana and often generated as wastes.

Recently researchers gained huge attention on biomedical applications such as antimicrobial, antioxidant, anti-inflammatory, anti-cancer activity of banana peel to reduce the cost increase in healthcare industries. The current research seeks to find out the effectiveness of different banana peelings in wound healing

Key words banana peel, wound healing

CHAPTER 1: INTRODUCTION

1.1 BACKGROUND

Wounds are conditions that arise from damage to body tissues, it can be referred to as a break in the skin, which may result from physical, mechanical, or thermal damage, or develop as a result of the presence of an underlying medical or physiological condition for example, Pressure, ulcers, abrasions, grazes, knife wounds. Wounds are as a result of: Accidents and trauma such as falls, road accidents, or sports which can result into cuts, bruises, surgical procedures which involve incisions or punctures on the body leading to wounds, burns caused by heat, chemicals, or radiations can result into wounds, chronic conditions such as diabetes or peripheral vascular disease can also lead to the development of wounds (Murray, 1996)

When wounds are left untreated, it increases the risk of infections where bacteria and other pathogens can enter the wound causing local infection leading to severe complications like tetanus. Wounds that are not properly treated can result in excessive scaring which involves the formation of raised, discolored, or keloid scars. Untreated wounds can impair the normal functioning of the affected areas which can either restrict movement, cause pain, or lead to partial or complete loss of function (Dann, 1941). Systematic complications can occur as a result of untreated wounds causing complications such as sepsis or abscess formation.

Wound healing is a response to tissue damage that includes both molecular and cellular processes for tissue repair. It can be defined as the collective term for the physiological processes that repair and restore damaged skin tissue which involves a complex series of molecular, cellular, and chemical changes that result in inflammations, proliferation, granularity, remodeling, and re-epithelialization. (Harun Achmad, 2021) The wound therapies include antibacterial treatment, bioengineered dressings, compression therapy, offloading, vacuum-assisted wound closure, wound debridement, and hyperbaric oxygen treatment.

In many traditional settings, herbal extracts are used to treat wounds in the absence of conventional treatment. Herbal plants contain a number of secondary metabolites that help in the wound healing process. For instance, compounds such as flavonoids, saponins, tannins and

alkaloids derived from plants have been demonstrated to promote wound healing in a number of studies (Cite studies here). Bananas and particularly the peels have been used traditionally to stop bleeding and facilitate wound healing. There is a need to verify the traditional usage of banana peels in wound healing. In most cases, the extract is applied directly to the wound which causes drying of the wounds making it difficult to clean. Hydrogels have been investigated as carriers for wound healing compounds. Here talk briefly about hydrogels as carriers of bioactive molecules for wound healing.

This study evaluated the potential of peels of two banana species in wound healing. Particularly, the phytochemistry and antimicrobial properties of the extracts of the banana peels was evaluated. Further, an attempt was made to develop a hydrogel based formulation to administration of the banana peel extracts to wounds.

1.2 Statement of the Problem

Wounds are becoming serious challenge to the world health at large in that, according to world health organization it predicted 40% increase in global deaths owing to injury that is between 2002 and 2003 (organisation, 1977)and road traffic deaths as a result of poorly treated wounds to increase from 1.2 million in 2002 to 1.9 million in 2020 globally to become the third leading cause of daily loses In Uganda, annual mortality rate due to injuries is 217/1000000 (Temizel, 2021) and in Tororo district it has been reported to be 11% according to mortality statistic of Tororo main hospital 2023 (Testafalul, 2020)and this has been reported to be a serious challenge to the people in TORORO district especially those of low economic status. This is due to inability to afford medications for wounds, long distances to reach medical facilities, inadequate remedies available, cheap for wound healing in Manakor village Tororo district.

But over decades, there has been wide spread use of banana peelings of (Musa Peppas, 2019)acuminate and Musa asapietium) traditionally as anti-inflammatory, as an oxidant that helps in stopping bleeding in the process aiding wound healing in Tororo district Uganda. However, there is limited understanding of comparative effectiveness of different banana peelings that is either ripe or row and the type of banana that is effective in stopping bleeding and aiding wound healing processes. While anecdotal evidence suggests the potential benefits of banana peel, there is paucity of information about the properties and mechanism by which banana peel helps in wound healing. This knowledge gap hinders the development of evidence

based wound care strategies utilizing banana peelings as a natural remedy for affordable, available, quick and easy to apply remedy for wound healing.

With this miss concept this research therefore seeks to find out the type of banana peel that is effective in wound healing to help build up evidence-based knowledge on banana peel correlation with wound healing process.

1.3 RESEARCH QUESTIONS

What are the different components in banana peel extract responsible for wound healing?

Can banana peel extract be incorporated in a drug delivery system?

Which type of banana peel is effective in antimicrobial activity?

1.4 Objectives of study

1.4.1 General objectives

To determine the effectiveness of different banana peel extract in wound healing (ripe or row peel)

1.4.2 Specific objectives

1. To extract components responsible for wound healing in different banana peel
2. To qualitatively determine some of the phytochemicals present in banana peel extract.
3. To carry out the antimicrobial activity using the banana peel extract by disc diffusion method.
4. To develop hydrogel incorporated with the banana peel extract.

1.5 SCOPE OF STUDY

1.5.1 Geographical scope

This research covered Tororo district in eastern Uganda. The study area covered selected sub counties in Tororo district that is Kayoro and Osukuru Sub County in Tororo South County in Tororo district.

1.5.2 Content scope

Project was focused on identifying, determining and comparing effectiveness of different banana peel in wound healing.

The study also focused on the two varieties of banana that are mostly eaten in Tororo district and this include Musa sapientum (yellow banana.) and Musa acuminate (bogibogi)

1.5.3 Time scope

This research was done in the period of three months that's from February to April as specified according to the semester schedule

1.6 Significance of the study

The information obtained from this study of comparison of the effectiveness of different banana peel extracts (ripe and row, and banana type) of Musa sapient and *Musa acuminata* in wound healing can be used by the community, government or authorities and NGO like WHO to sensitize and create awareness for the development of evidence-based wound care strategies utilizing banana peelings as a natural remedy for affordable, available and quick wound healing remedy.

The research will also act as a footstep for researchers to establish the effectiveness of more local processing methods of getting banana peel extract.

The study provides baseline information for the effectiveness of different banana peels in wound healing process to reduce on throwing of banana peel as waste because it is a cheap, local and affordable remedy that can aid in wound healing process

1.7 JUSTIFICATION OF STUDY

There are health threats associated with wounds as result of leaving them untreated. These health threats include rotting of the affected part, unpleasant smell , head ache , fatigue, tetanus disease which can cause mental disorders, can also deform the affected body part and death for several cases in Tororo district , bananas are consumed as fruits there is little usage as a wound healing agent so there is need to raise awareness on use of banana peel as remedy for wounds and the research will provide a baseline and there is need to assess the effectiveness of different banana peel in wound healing process.

CHAPTER 2: LITERATURE REVIEW

2.1 wounds

Wound is damage of tissue or organs accompanied by distraction of the skin structure or mucous membrane, which plays an important role in preventing water loss and blocking the invasion of harmful substances and pathogenic microorganisms as significant interference between the body and it's surrounding. (Munro, 2017)

Wound healing is body's natural reaction to tissue injury involving a series of cellular events that generates resurfacing, reconstitution, and restoration of the tensile strength of injured skin.

2.2 **wound healing process**

Normal wound healing is a complex process consists of four highly integrated and overlapping phases: (Gonzalez, 2016)

Hemostasis: this occurs just after injury and it can last for two days. As soon as there is a wound on the body, the blood vessels in the wound area constrict to reduce the blood flow known as vasoconstriction. At the same time clotting factors are released at the wound site to coagulate with fibrin, resulting in thrombus which is more commonly known as blood clot. The clot acts a seal between the broken blood vessels to prevent blood loss. (Davies, 2016)

Inflammation: This involves phagocytic cells that release reactive oxygen species, lasting for up to seven days in acute wounds and longer in chronic wounds. (Sherwood, 2004)

During white blood cells and some enzymes enter the wound area to stave of infection by clearing bacteria and debris and preparing the wound bed for new tissue growth. The characteristics of the phase include inflammation or redness at the wound site, edema, heat and pain.

Proliferation: it deals with filling, covering of the wound's cells undergo apoptosis, wound healing processes to proliferation phase characterized by formation of granulation tissue, angiogenesis contraction of wounds and epithelialization process time for tissue regeneration depends on the production of collagen, fibroblast proteins and this phase can last for four days to three weeks or more.

Remodeling: The tissue gradually becomes stronger and more flexible; collagen production continues to build the tensile strength and elasticity of the skin buildup of collagen in the granulation tissue leads to scar tissue formation which is 20 weaker and less elastic than injured skin.

2.3 **Treatment of wounds**

Wound care is constantly evolving with the advances in medicine but wounds are still a significant health problem worldwide, often having severe complications.

There are two methods of convectional wound treatment that include absorbable and nonabsorbable sutures. Non absorbable sutures provide great tensile strength and body chemicals does not dissolve them during the natural healing process. (Heyer, 2013)

In recent years wound care professional revisited the ancients' healing methods by using traditional medicine in wound management. Traditional medicines which are more effective, nontoxic and cost-effective are gaining popularity throughout the world.

2.4 Medicinal plants used in wound healing

It has been discovered that herbal plants like turmeric, aloe vera, pot marigold and centella asiatica play a crucial role in wound healing process .

Musa acuminata (Musaceae) or Musa sapient is one of the most widely distributed and consumed fruit in the world. Considering the nutritional aspects, it is one of the world's leading food crops with a great source of minerals, vitamins, carbohydrates, flavonoids and phenolic compounds. (P.Anandhi, 2023)

All parts of banana plants have been used in traditional medicine to treat a variety of diseases. The fruit has been used in diarrhea, dysentery, intestinal lesions in ulcerative colitis, diabetes and as a dressing for burns. Banana leaves (ashes) are used in eczema, Flowers are used in dysentery and menorrhagia. Stem juice of fruited plant is used for treating diarrhea, dysentery, cholera, otalgia and hemoptysis

The peels of a variety of fruits have gained attention as a natural source of antioxidants and phytochemical content which are rich in compounds with free radical scavenging activity compounds. The banana fruit, peel and trunk from various species and sampling areas have been reported to be rich in essential minerals, mainly containing high concentrations of potassium.

Banana peel is an underutilized source of phenolic compounds is considered as a good source of antioxidants for foods and functional foods against cancer and heart disease. The research on banana (Musa acuminata) peel extract indicated that banana peel is potential source of bioactive compounds like flavonoids and polyphenols with wide range of medicinal properties in particular the high free radical scavenging activity. Antifungal and antibiotic principles are found in the peel and pulp of fully ripe bananas. (P.Anandhi, 2023)

The presence of flavonoids and tannins in natural products can affect wound healing. The flavonoids and tannins' role are to inhibit the formation of inflammatory mediators, so that the inflammation process goes through normally and it aids in acceleration of wound healing process. (Harun Achmad, 2021)

Generally, flavonoids and tannins are highly found in Saba banana peel. Therefore, it can be used as an accelerating agent in the wound regeneration process reported the wound healing activity of Saba banana peel extract (Musa paradisiaca) by creating incision wounds in male mice.

The study looked at how best banana peel extract can be incorporated with hydrogels to aid in wound healing

2.5.0 Hydrogels and wound healing

Hydrogel is a water-swollen, and cross-linked polymeric network produced by the simple reaction of one or more monomers. Another definition is that it is a polymeric material that

exhibits the ability to swell and retain a significant fraction of water within its structure, but will not dissolve in water. (Peppas, 2019)

Hydrogel wound dressing is composed of natural and synthetic polymers, which can absorb tissue fluid, improve the local microenvironment of wound, and promote wound healing.

The water holding capacity and permeability are the most important characteristic features of a hydrogel. The polar hydrophilic groups are the first to be hydrated upon contact with water which leads to the formation of primary bound water. As a result, the network swells and exposes the hydrophobic groups which are also capable of interacting with the water molecules.

This leads to the formation of hydrophobically-bound water, also called 'secondary bound water'. Primary and secondary bound water are often combined and called 'total bound water'. The network will absorb additional water, due to the osmotic driving force of the network chains towards infinite

2.5.1 Classification of hydrogels

The hydrogel products can be categorized on different bases as described below:

Classification according to polymeric composition

(a) Homopolymer hydrogels: polymer network which are derived from a single species of monomer, which is the basic structural unit comprising of any polymer network. Homopolymers may have cross linked skeletal structure dependent on the nature of the monomer and polymerization method. (Peppas, 2019)

b) Copolymeric hydrogels: These are consisted of two or more distinct monomer species with at least one hydrophilic component, assembled in a random, block or alternating configuration along the chain of the polymer network.

(c) Multipolymer hydrogels: These are also called as interpenetrating polymeric hydrogel (IPN), an important class of hydrogels, which is made of two independent cross-linked synthetic and/or natural polymer component, confined in a network form. In semi-IPN

hydrogel, one component is a crosslinked polymer and other component is a non-cross-linked polymer (Naficy, 2011)

2 Classification based on configuration and chemical composition which can be illustrated as follows: (a) Amorphous (non-crystalline). (b) Semi crystalline: A complex mixture of amorphous and crystalline phases. (c) Crystalline.

3 Classification based on type of cross-linking Hydrogels can be divided into two Chemically cross-linked networks have stable junctions, while physical networks have temporary junctions that results from either polymer chain entanglements or physical interactions such as ionic interactions, hydrogen bonds or hydrophobic interactions.

4 Classification based on physical appearance Hydrogel's appearance as matrix, film or microsphere: (a) Non-ionic (neutral). (b) Ionic (including anionic or cationic). (c) Amphoteric electrolyte (ampholytic) comprising both acidic and basic groups. (D) Zwitterion (polybetaines) consisting of both anionic and cationic groups in each structural repeating unit.

2.5.2 Preparation of hydrogels

Hydrogels can be prepared from either synthetic polymers or natural polymers. The synthetic polymers are hydrophobic in nature and chemically stronger compared to natural polymers. (LU, 2018)Their mechanical strength results in slow degradation rate, but on the other hand, mechanical strength provides the durability as well. (Peppas, 2019)

polymer	Synthetic monomers
chitosan	Hydroxyl ethylmeythacryate gelatin
gelatin	Vinyl acetate
alginate	Acrylic acid
Hyaluronic acid	N (2-Hydroxy propyl) methacrylate
Fibrin	N- Vinyl -2 – pyrrolidone
Chitosan	N-Isopropylarylamide

2.5.3 Characterization of hydrogels

Characterization of hydrogel generally, hydrogels are characterized for their morphology, swelling property, chemical structure and elasticity. The important features for characterization of hydrogels are as follows: (G, 2019)

Physical Appearance and pH Determination Hydrogel were inspected visually for their colour, homogeneity, Consistency and ph. pH of hydrogels is measured by using digital pH meter. PH meter must be calibrated before its use

Scanning Electron Microscopy (SEM) SEM can be used to provide information about the sample's composition, surface topography, and other properties such as electrical conductivity. Magnification in SEM can be controlled over a range of up to 6 orders of magnitude from about 10 to 16.

2.5.4 PROPERTIES OF HYDROGELS

Hydrophilic gels called hydrogels receive considerable attention for their use in the field of pharmaceutical and biomedical engineering. (widya Ernayati Kosimaningrum, 2020) **Swelling properties,** a small change in environmental condition may trigger fast and reversible changes in hydrogels. The alteration in environmental parameters like electric signal, pH, temperature, and presence of enzyme or other ionic species may lead to a change in physical texture of the hydrogels.

Mechanical properties the desired mechanical property of the hydrogels could be achieved by changing the degree of Cross linking and by increasing the degree of cross linking a stronger hydrogel could be achieved though the higher degree of cross linking decreases the % elongation of the hydrogels creates a more brittle structure

Bio compatible properties: is the ability of material to perform with an appropriate host response in specific applications. it basically consists of two element that is bio functionality that is to say ability of material to perform the specific task which it was intended for and bio safety that is appropriate host response not only systematic but also local, the absence of mutagenesis, cytotoxicity, and carcinogenesis (Nandini Sahu, 2020)

Advantages of hydrogels made from banana peel extract, gelatin, and chitosan

They possess a degree of flexibility very similar to natural tissue due to their significant water content. • Timed release of medicines or nutrients. • They are biocompatible, biodegradable

and can be injected. • Hydrogels also possess good transport properties and easy to modify. • Environmentally sensitive hydrogels have the ability to sense changes of pH, temperature, or the concentration of metabolite and release their load as result of such a change.

CHAPTER 3: Methodology

3.1 Research Design

The research was carried out in three parts that is to say extraction of the wound healing components, testing of the phytochemicals responsible for wound healing in different banana species and the hydrogel preparation.

3.1.1 Sample collection

The two different banana species were obtained from Tororo town that's both the ripe and unripe Musa acuminatum banana species and both ripe and unripe yellow banana species. The different banana species was peeled using a knife and the peels obtained used for research work

The banana peels were used for extraction using methanol with favorable polarities for phytochemicals to easily be extracted.

3.1.2 Materials

The materials to be used in this study include four different species of banana peels: kitchen knife, mesh sieve, manila paper, pestle and mortar, four beakers, rotary evaporator test tubes, funnel, filter paper, weighing scale, stirring rod 250ml measuring cylinder, and the main reagents to be used for laboratory analysis include 99.8 percent methanol, distilled water, Mayer's reagent, iron (iii) solution, 1 percent hydrochloric acid.

Figure 1 Musa acuminatum (bogibogi)

Figure 22 Musa asapietium (yellow banana)

3.1.3 Harvest and preparation of samples of banana peels

The sample collection was carried out in two weeks where the different banana species were obtained from the Tororo town market, peeled off and the peels brought to the laboratory where it was chopped into small size pieces and dried for a period of Five days. When the peels were. Dry, they were grinded for about Three minutes time to obtain powder form of the peels and the procedure was repeated for all the remaining different species. After grinding, powder form of different banana species was then sieved differently using mesh sieve. The residues then regrinded for each species.

The fine powder of each banana peel was weighed differently and the mass recorded in grams. The powder form of each species was then placed in different beakers and 200ml of methanol was then added and stirred after 30minutes. The mixture is left to settle for 24 hours and then stirred and filtered.

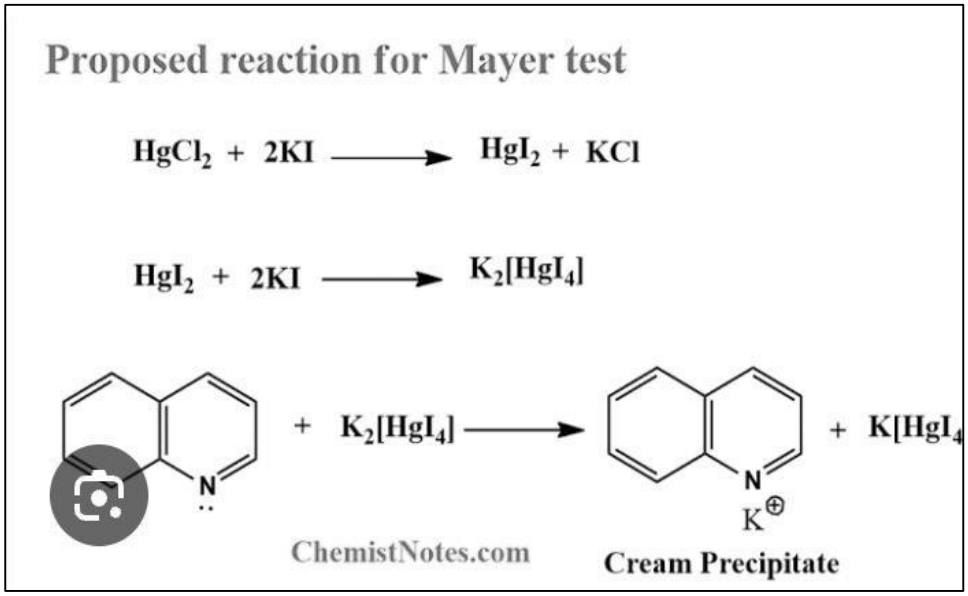
The filtrate was kept in different beakers and covered while 200ml of methanol was added to the residue stirred and left for 24 hours and then filtered. This procedure was repeated three times for each banana peel species. After both the filtrate and residue are kept for further analysis.

The filtrate of each different banana species was then concentrated using a rotary evaporator at pressure of 120rpm and temperature of 37degrees centigrade for two hours. The concentrated filtrate was then subjected to phytochemical analysis.

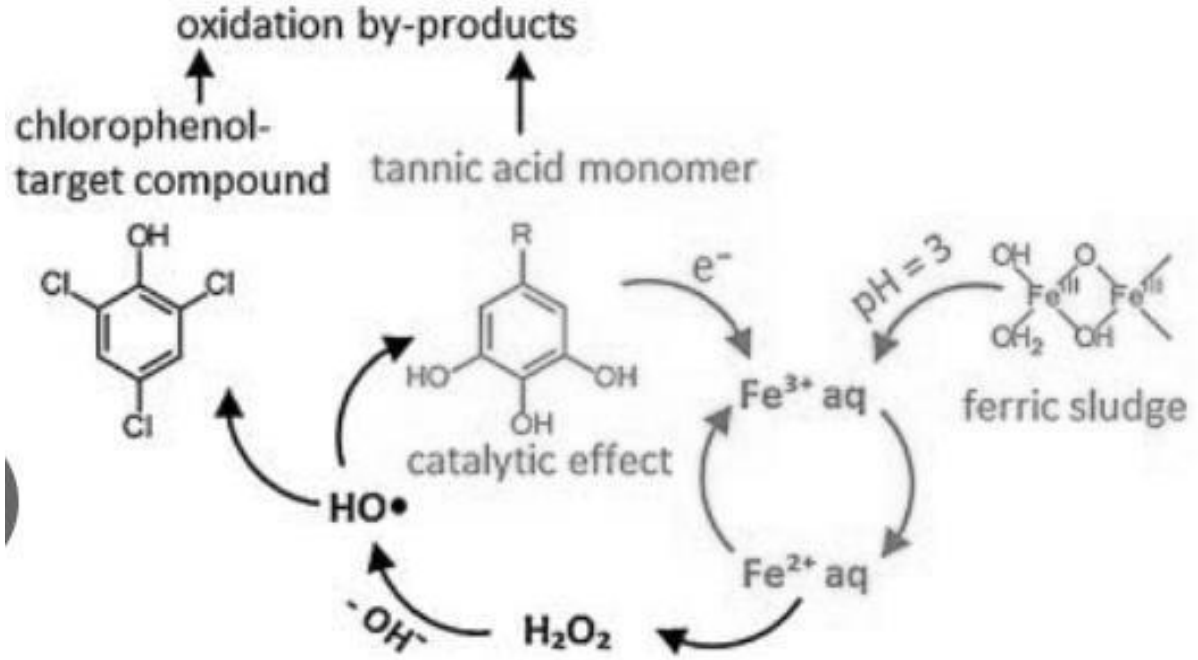
3.2.1 Phytochemical analysis of the components of banana peels extract

Qualitative analysis of components that is to say alkaloids, tannins, saponins and phenols using chemical reagents as follows.

3.2.1.1Alkaloids: 1ml of the extract was stirred with 1 percent hydrochloric acid in water bath and then followed by addition of Mayer's reagent (4 drops) in each of the test tubes containing ripe species A, B and unripe species D&C. The presence of white turbid solution that appeared was taken as indicator for Alkaloids.



Tannins. To one ml of each plant extract in different test tubes, distilled water was added followed by two drops of ferric chloride, greenish to black color that appeared was taken as evidence for the presence of tannins as shown in the equation below (Pizzolato, 1973)



Saponins: To each filtrate of plant extracts in different boiling test tubes, was boiled with distilled water in test tube, formation of stable form was taken as an indication of presence of saponins.

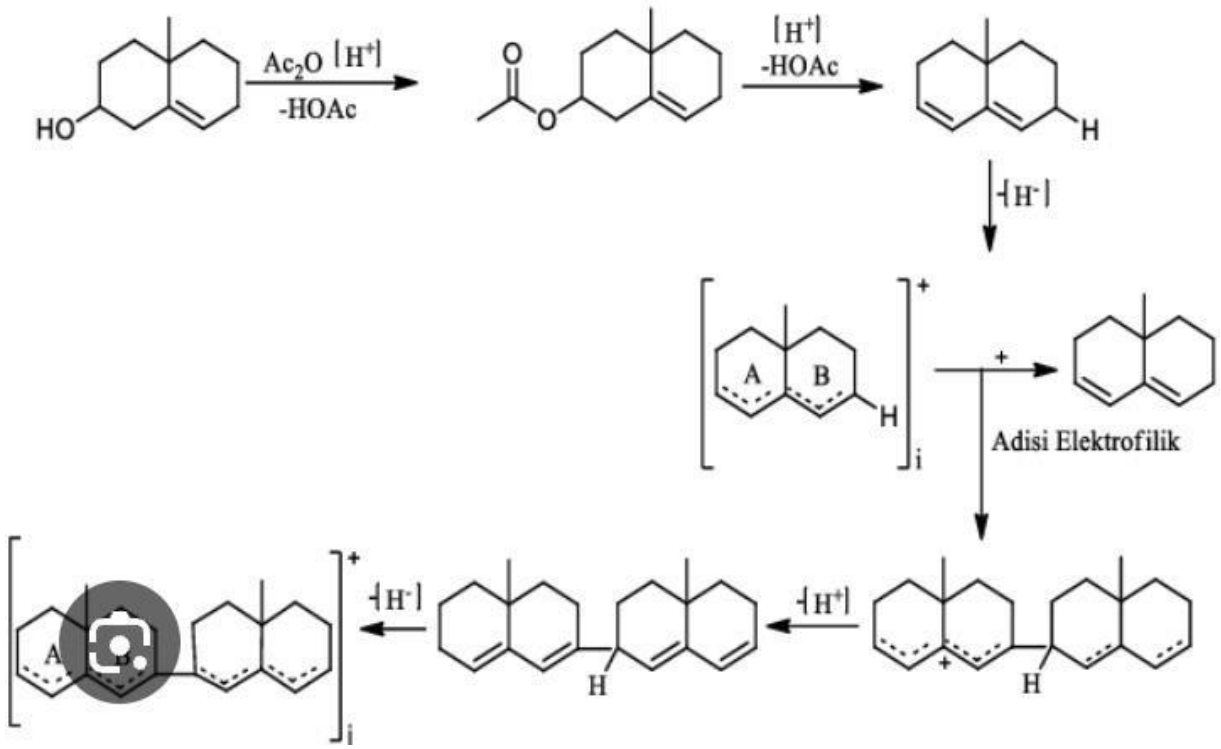
Phenols: Ferric chloride was added to the filtrate of each plant extract followed by distilled water; green blue color was used as evidence for presence of phenolic hydroxyl group.

Equation $3ArOH + FeCl3 \rightarrow Fe(OAr)3 + 3HCl$

Where AR is the phenol group

Terpenoids: To 2ml of each filtrate of the plant extract in separate test tubes was added acetic acid (0.5ml) followed by chloroform (0.5m). The concentrated sulphuric acid was added the blue green coloration in the extract solution would be taken as an indication

Presence of terpenoids.



Steroids: Lieberman's test was used where to 1ml of each filtrate of plant extracts in separate test tubes added acetic anhydride (2ml) was and then cooled well by keeping them in ice cold water. While still in ice cold water, each of the samples was treated with ice cold sulphuric acid (20) percent, ice cold sulphuric acid 50 percent and lastly ice-cold sulphuric acid 98.8 percent. Color change from violet to blue would be taken as an indication of presence of steroids

3.2.2 PREPARATION AND DEVELOPMENT OF HYDROGEL

Material. Chitosan pharmaceutical grade with 85-93% degree of acetylation was purchased from the market. Acetic acid

Gelatin purchased from Mbale town. Distilled water was obtained from the chemistry laboratory

Laboratory: Busitema University, Nagongera campus

Preparation of hydrogel. Beforehand, chitosan, gelatin, and the banana peel extract were prepared as the solutions.

Chitosan solutions were prepared by dissolving respectively 0.25 g, 0.5 g, 0.75 g, and 1 g of chitosan in 2.5 % v/v acetic acid solution by stirring using magnetic stirrer. Gelatin (10 g, 20 g, and 30g respectively) were dissolved in warm water (60oC) and mixed by keeping the solution temperature minimum at 40oC to avoid gelation. And the solution of extract was

prepared by dissolving 0.3g of each in 10ml of distilled water. The chitosan solution, the gelatin solution, and the extract solution were mixed.

Water was added to the mixture to give the final volume of 100 mL. Then the mixture was stirred thoroughly at 40oC. The resulting solution was cast on a glass plate by 2 – 4 mm in thickness.

Finally, the hydrogel was dried in the oven at 37oC overnight. Some hydrogels have been prepared by various proportions of chitosan, extract, and gelatin, as shown in Table 1.

Table 1. Chitosan, gelatin, and extract composition for hydrogel preparation.

SAMPLE	Chitosan	Gelatin(g)	Extract(ml)
Musa acuminatum ripe (RB)	0.5g 0.05g ,0.025g respectively	10g, 15g ,5g	2, 3 ,1 respectively
Musa acuminatum unripe (UB)	0.5 , 0.25	10, 10 5	3 , 4 2

Gel fraction determination. The determination of the gel fraction was conducted by a gravimetric method. The hydrogel was cut into small pieces and dried in the oven at 60oC until it reached a constant weight (W0). Then, the dried hydrogel was immersed in water and shocked for 24 hours at room temperature. Finally, the hydrogel was re-dried in the oven at 60oC to constant weight (W1).

The gel fraction was calculated using Eq. 1.

Gel fraction = $((W_1\text{-}W_0) \div W_0) \times 100$

Swelling index determination. The hydrogel was dried in the oven at 37oC overnight. The dried hydrogel weight was recorded as W0. Then the hydrogel was immersed in distilled water at room temperature. The hydrogel was weighed (Wt) every 30 minutes during 120 minutes.

Then, the swelling index was calculated using Eq. 2

Swelling index = *x* as shown below

$$((Wt - W0) \div W0) \times 100$$

3.2.3 MICROBIAL ACTIVITY

Preparation of the medium for bacteria growth

52g of the medium (mac) was suspended in liter of distilled water the solution was then boiled to dissolve it completely and then it was allowed to cool for 30 minutes. The solution was then transferred into durnren bottle and sterilized by auto cleaving at 120 ^{o}C for 15 minutes. And this helped to kill any microbe that was present in a medium the medium was then placed into a sterilized petri dish.

The solution was allowed to settle and then inoculations was carried out (microbes were introduced into medium) .The suitable environment was provided for the inoculated microbes

The mixture was the incubated for 48 hours

Antibacterial property determination and evaluation.

Antibacterial tests were conducted by using an inhibition using a disc of 0.9cm length zone method. The hydrogel sample was placed on the *E. coli* culture in a nutrient agar medium called maconge and incubated at 37^{o} C for 48 hours. The developed clear zone around the hydrogel was notified as the potential antimicrobial activity. Then, the bacterial colonies in the clear ozone layer were counted using a colony counter

CHAPTER 4: RESULTS AND DISCUSSION

4.0 Results

As a first step the qualitative phytochemical composition of extracts from two banana species were determined. The results (Figure 1) show the presence of key secondary metabolites representing flavonoids, saponin, phenols, steroids, terpenoids, and alkaloids Phytochemicals aqueous extract ethanol extract, acetone extract

CLASS OF PHYTOCHEMICAL	SAMPLE A	SAMPLE A1	SAMPLE B	SAMPLE B1
Alkaloids	+	-	+	+
Tannins	+	+	+	+
Saponins	_	-	+	+
Phenols	+	+	+	+
Steroids	+	_	-	+
Terpenoids	_	+	+	-

+ Phytochemical present - phytochemical absent

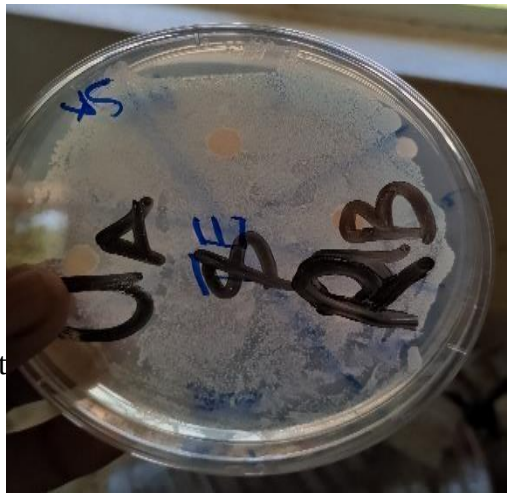
SAMPLE:A Musa sapientum (unripe) **and A1** (RIPE)

SAMPLE B Musa acuminate (unripe) **and B1** (RIPE**)**

Wounds can fail to heal as the results of the accumulation of bacteria such as staphylococcus. When an extract is able to to show zone of inhibition when carrying out antimicrobial activity then there is high possibility that it can have great or effect in wound healing process.

The figure below shows the antimicrobial activity of the two different banana species placed in medium contain Maconge with E. coli bacteria

Antimicrobial activity results figure 3 has minimum zone of inhibition of about 0.44mm while



nd ripe Musa acuminat

figure 4 has no zone of inhibition

Figure 4 unripe Musa asapietium peels

Hydrogels have greater absorbing and swelling properties therefore when placed in any solvents they can absorb that solvent making it used as means of drug delivery system and swell as for resistance, the diagram below shows hydrogel made up of banana peel extract, gelatin and chitosan placed in water for 5 minutes

Figure 5 hydrogel of chitosan, gelatin and Musa acuminatum dissolved in water

Hydrogels before dissolving in water have a gel like appearance and for figure 7 since it was made up of banana peel extract, chitosan and gelatin it's looked like pale yellow in color as shown below

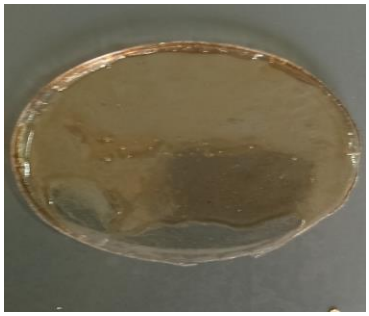


Figure 6 hydrogel *before placing in water*

Swelling index results was obtained as described in the methodology

EXTRACT	UB (10minutes)	UB (15 minutes)	20 minutes
Initial weight (W_O)g	1.5	1.89	1.85
Weight at t time (Wt.) g	1.89	2.6	2.68
(w_1-w_0) g	0.39	0.71	0.83
SWELLING INDEX (%)	26	37.6	83

4.0 DISCUSSIONS

Basing on the photochemical results, the banana species Musa acuminatum both ripe and unripe showed the presence of all the required chemicals responsible for wound healing that is alkaloids, tannins, saponins, phenols which play a great wound healing activity and Musa sapientum both ripe and unripe had no saponins one of the components that aid in wound healing process therefore even if it had some wound healing activity, it was very minimal. Hydrogels have gained a great interest in biomedical research and applications. They can Retain water in its three-dimensional network which capable of deforming as soft wet material with the structure that resembles extracellular matrix.

Hydrogels can respond to various external stimuli which comprise pH, chemical composition, temperature, pressure, and electrical field. These properties route the hydrogel application, especially for delivery drug system, wound dressing, and tissue engineering. Herein, we prepared gelatin/chitosan/ banana peel extract hydrogel through a simple Physical mixing

process at low temperature. Chitosan was previously dissolved in 2.5 % of acetic acid to turn into chitosan polycation. Chitosan polycation and gelatin (which tend to form polyanion), were cross-linked by polyelectrolyte complexation process to form 3D networking hydrogel.

The proposed chitosan-gelatin interaction to form hydrogel is illustrated in Fig. 5 The presence of ammonium ($NH3^{+}$) and hydroxyl (-OH) groups of chitosan results in hydrogen bonding with the amine (-NH-) and/ carboxyl (-COOH) groups of gelatins. The ionic bond between the ammonium groups ($NH3^{+}$) groups of chitosan and ionic carboxyl (-COO-) groups of gelatins. All those interactions result in a high order 3D structural bi-polymer system.

The resulting gelatin/chitosan/ extract of banana peel hydrogels have transparence soft film sheet with 2 - 4 mm thick (Nandini Sahu, 2020).

The swelling index of the incorporated with Musa acuminatum the ripe one was higher than that of the unripe one meaning it can easily release the extract faster as compared to that of the unripe type.

Considering swelling index results, it increases with an increase in time because as time goes on the absorption rate of water by hydrogels increases due to their high-level capacity of water holding and this makes it swell and increase in weight which later causes greater increase in the swelling index

4.1 Conclusions

This research discovered the three highly anti-oxidant and anti-inflammatory components in Musa acuminatum tannin, alkaloids saponins this therefore makes me conclude that Musa Acuminatum has very high effectives in wound properties as compared to Musa asapietium both ripe and unripe.

Much as there was minimum inhibition of the Musa acuminatum on E. coli bacteria it might have been as a result of poor extraction method or it needed several extraction solvents so that we can compare the microbial inhibition rate and it does not mean that it is not very effective in wound healing process therefore it calls for more to be done on the same banana species using different extraction methods it

Also, since hydrogel made up of banana peel extract, chitosan and gelatin showed a very great water holding capacity therefor this can be used as one of the delivery systems for

banana peel content and it means that when placed in moist wound it can easily release it s content due to its absorption capacity

4.2 RECOMMENDATIONS

Basing on the phytochemical results, microbial property, I recommend the Musa acuminatum species to be the one which can be used in wound healing properties at minimum inhibition concentration of 5mg/ml of unripe and 2mg/ml of ripe

Better method should be investigated on how best effectiveness of this banana species can be easily applied in the local society.

Recommend that quantification analysis should be done in order to compare the effectiveness of different banana species in wound healing

I also recommend that a wound should be created on the rat and apply the hydrogel incorporated with Musa acuminatum banana peel species to find out the rate of its effectives of the hydrogel to release the extract.

I suggest that hydrogels should be used as a delivery system for banana peel extract for wound healing applications since it has high temperature change, absorption rate and ph. changes and it should be tried out in wounds created on rabbits before application to humans

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