**COMPARATIVE STUDY OF ANTIBACTERIAL EFFECT OF THE ASH EXTRACT OF *MUSA PARADISIACA AND MUSA SAPIENTUM PEELS* ON OIL PALM**

**A RESEARCH PROJECT**

**BY:**

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**DECLARATION**

This project is authentic and original work carried out by; **MARK, ABASIOFIOK FRIDAY** with the Registration Number: **AK17/NAS/BIO/069** in partial fulfillment of the requirement for the award of Bachelor of Science (B. Sc) in Genetics and Biotechnology.

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**CERTIFICATION**

This is to certify that this research work “effect of oil palm on antinutrients composition and comparative study of antibacterial effect of the ash extract of *Musa paradisiaca* and *Musa sapientum* peels” is the original copy of research carried out by; **MARK, ABASIOFIOK FRIDAY** with the registration number; **AK17/NAS/BIO/069,** in the Department of Genetics and Biotechnology, Faculty Of Biological Sciences Akwa Ibom State University, Ikot Akpaden, under the supervision of Dr. Ifiok Uffia.

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**ABSTRACT**

The effect of oil palm on antinutrients composition and comparative study of antibacterial effect of the ash extract of *Musa paradisiaca* and *Musa sapientum* peels *were investigated. The Musa paradisiaca and Musa sapientum peels ash were assessed for antibacterial properties using agar well diffusion method. The higher growth inhibition zone was observed in Musa paradisiaca against E. coli (14.5±0.2mm), S. aureus (12.5±0.1mm), P. aeruginosa (11.6±0.3mm), B. cereus (10.7±0.2mm) and P. vulgaris (10.4±0.2) while ash extract of Musa sapientum peels was observed to exhibit moderate antibacterial activity against E. coli (11.6±0.4mm), S. aureus (10.5±0.2mm), P. aeruginosa (9.7±0.5mm), B. cereus (8.8±0.3mm) and P. vulgaris (9.6±0.2mm). The anti-nutrients; HCN, Tannin, Phytate, oxalate and alkaloid levels in the ash extract of the two samples were observed to be influenced by the oil palm. The HCN, Tannin, Oxalate and Alkaloid content of the ash extract of the Musa paradisiaca and Musa sapientum peels were significantly (p < 0.05) decreased when mixed with oil palm while the phytate content of the two samples were significantly (p > 0.05) increased on palm oil. The result of this work justify that Musa paradisiaca peels has the highest zone of inhibition compare to Musa sapientum and oil palm influenced the level of antinutrients present in the ash extract of the two Musa species peels.*

**CHAPTER ONE**

**INTRODUCTION**

**1.1 Background of the study**

As the people are becoming aware of the potency and side effect of synthetic preservatives, there is an increasing interest in the natural product remedies with a basic approach towards the used of agricultural wastes as preservatives, herbs and feed additives all over the world ( Vijai *et al.,* 2015). Musaceae species (plantain and Banana), are native to tropical Indomalaya and Australia and are likely to have been first domesticated in Papua New Guinea (Nelson *et al.,* 2008). They are grown in 135 countries primarily for their fruit and to a lesser extent to make fibre, banana wine, and banana beer and as ornamental plants (Wikipedia, 2013). Due to their antioxidation and antirancidity effect, Musa species peels are used as preservatives, animal feeds, soaps making as well as herbs. They are tropical herbaceous plants that grow up to height reaching 9 metres and are produced largely in the Asian, African, and South American regions; sweet fruits in the case of banana and for plantain are popularly cooked for food (Imam *et al.,* 2011). These plants have been implicated in agricultural and industrial uses which make them valuable to the bioeconomy (Mohapatra *et al.,* 2010). Banana and plantain fruits possess very thick coverings known as the peels; however, they have low dietary incorporation status as they constitute waste because they are usually disposed during the consumption of the fruit pulp. It is with the foregoing that this study has been designed to compare the antibacterial and antinutritive effects of these two related Musaceae species (banana and plantain) peels ash on oil palm. Crude palm oil is edible oil obtained from African oil palm (*Elaeis guineensis*). It has been long recognized in West African countries and among West African peoples it has long been in widespread use as cooking oil. The oil contains high amount of beta-carotene which makes the oil reddish in colour, however the reddish colour turns white when the oil is oiled for few minutes thereby destroying the carotenoids. It is one of the oils relatively high in saturated fats and thus it is a semi solid at room temperature because it contains almost equal proportion of saturated and unsaturated fatty acids contents. Palm oil as an edible and cooking oil has been discovered to have an excellent dietary energy source, very rich in vitamins A and E, stable in high temperature (good for frying) and cheap vegetable oil due to the oil palm’s productivity (Koh, 2006). However, owing to its high contents in saturated fatty acids such as lauric acid, mystritic acids and palmitic acid which are primary cholesterol elevating fatty acids. Palm oil promotes the risk of coronary heart disease such as hypertension, stroke, heart attaché and other cardiovascular diseases (Helen, 2007).In the other hand, the use of synthetic antioxidants such as; Butylatedhydroxylanisole(BHA), Butylatedhydroxyl toluene(BHT), Propylgallate(PG) and citric acid to prevent lipid oxidation have been established (Cuvelier *et al,* 1992; Ruger *et al,* 2002; Khanahmadi and Janfeshan, 2006; Ullah *et al,* 2013). But it has been discovered that some of these antioxidants especially BHT and BHA are carcinogenic thereby they are being discouraged in International market as food additives. This leads to provoking interest in seeking for safer means of natural antioxidants of plant origin that will serve the same purpose of preventing oil rancidity, as well as food additives (Tian and White 1994; Erol *et al.,* 2004; Emmanuel and Mudiakeoghene, 2008).

**1.2 Statement of Problem**

In the past years, doubt on the safety of inorganic substances arose and become so alarming due to some health effects on human. This led to more investigations and researches in using natural and organic substances which may serve the same purposes as the synthetic substances. However, there is high demand in using natural substances as antimicrobial, feed additives, antioxidants in the biotechnology and food industries respectively. Natural antibacterial particularly found in fruit and vegetables have gain interest among consumer and the scientific community because epidemiological studies have indicated that frequent consumption of natural Antimicrobial substances is associated with the lower risk of cardiovascular and cancer (Renoud *et al.,* 1998).

Furthermore, there had been an increasing interest in knowing the antimicrobial properties as well as the antinutritive values of related fruits due to their health promoting properties in the food and agricultural Biotechnology industry. A large number of researches have been demonstrated either on the phytochemical properties or the minerals composition of *Musa paradisiaca* and *Musa sapientum* peels of different origin. This statements show that antibacterial properties of this two species of Musaceae may be differs despite their geographical area and origin. This study is to compare effect of oil palm on antinutrients composition and antibacterial effect of the ash extract of *Musa paradisiaca* and *Musa sapientum* peels.

* 1. **Justification of study**

Plantain and banana peels plays major role in preservation and increasing the shelf life of many substances because of their antimicrobial and antirancidity properties. As such, this study focuses on comparing the effect of oil palm on antinutrients composition and antibacterial effect of the ash extract of *Musa paradisiaca* and *Musa sapientum* peels.

**1.4 Significance of study**

This study was carried out to compare if there are any significant differences between the two ash extracts of musaceae species (plantain and banana) peels on oil palm base on antimicrobial and antinutritive properties. This study also gives an insight on the importance of using agricultural wastes in preservation and antimicrobial over synthetic compounds.

* 1. **Aim and Objectives of the Study**

The aim of the study is to assess the effect of oil palm on antinutrients composition and compare the antibacterial effect of the ash extract of *Musa paradisiaca* and *Musa sapientum* peels.

The aim was accomplished by the following objectives below:

1. Compare the antibacterial effect of the ash extract of *Musa paradisiaca* and *Musa sapientum* peels on oil palm.
2. Assess the effect of oil palm on anti-nutritives composition of the ash extract of *Musa paradisiaca* and *Musa sapientum* peels ash
3. Explore the antimicrobial properties of the Musa species peels using the ash so as to minimize the overuse of artificial preservatives and antimicrobial on palm oil.

**CHAPTER TWO**

**LITERATURE REVIEW**

**2.1 History and Origin of Oil Palm**

Palm oil (from the African palm oil, (*Elaeis guineensis)* can be traced back to more than 5000 years ago in Egypt *(*Kiple *et al.,* 2012*).* Palm oil *(Elaeis guineensis)* was long recognized in West African countries. It is used widely as cooking oil among West African peoples. In the seventeenth century European merchants trading with West Africa occasionally purchased palm oil for use in Europe, but due to the profit from slave-trading, palm oil remains rare outside West Africa.

They were decline in the Atlantic slave trade in the nineteenth century and the Europe’s demand for trade in materials rather than in humans which obliged African countries to seek for new sources of trading instead of slave trading (Purugganan *et al.,* 2009). This encourage the Asante confederacy, state owned slaves to build large oil palm trees plantations while in the neighboring kingdom of Dahomey, king Ghezo passed a law in 1856 forbidding his subject from cutting down palm trees (Ghezo, 2000).

Oil palms (*Elaeis guineensis*) were introduced to Java by the Dutch in 1848 and to Malaysia which was then the British colony of Malaya in 1910 by Scotsman William Sime and English banker, Henry Darby. However, the species of the palm tree, *Elaeis guineensis* was taken from Eastern Nigeria to Malaysia in 1961. The southern coast of Nigeria was originally known as “palm oil” this name was given by the first European that visited Nigeria for trading) which was later renamed “The Bight of Baifra.” Malaysia is the largest exporter of palm oil in the world that produces about 15 million tonnes of oil palm every year. Malaysia is now count for approximately 47% of global oil palm production and 54% of world exports. Furthermore, as one of the biggest producer and exporter of both palm oil and Palm oil products, Malaysia has play major role in accomplishing the needs and stay competitive in the world’s oil and fat market.

In 2004, Malaysia produced closely to 14 million tonnes of palm oil from its mere 3.8 million hectares of plantation area. This has contributed to more than 1/3 of the agricultural GDP or 2.9% of the national GDP. Palm oil obtained from the fruits is used in making soaps, cosmetics, candles, biofuels as well as lubricants and in the processing tinplate and coating of iron plates. Palm kernel oil from the seeds has different functions in the food as it is in the manufacturing of edible products such as; margarine, ice cream, chocolate, confections and breads (Encyclopedia, 2014).

Presently, oil palm (*Elaeis guineensis)* is crucial to the economies of many countries, especially Indonesia and Malaysia, from which large quantities of its products are exported in the form of oil, meal and other derivatives (Murphy 2019). More widely, oil palm is now cultivated in plantations across the humid tropics of Asia, Africa and the Americas, from where its products are exported to global markets.

**2.2 Classification and Description of Palm Oil**

The genus Elaesis consists of two species, the common oil palm (*Elaeis guineensis)* native to Africa and *Elaesis oleifera* (Kunth) cortes indigenous to South and Central America. Another specie is Elaesisodora or Barcellaodora, though it taxanomy has not been confirmed. *Elaeis guineensis* a monoecious, erect, one stemmed palm tree that is usually 20-30metre high, with an adventitious root system that forms a dense mat in the upper 35cm of the soil with only a few roots penetrating deeper than 1metre.The stems are cylindrical, up to 75cm in diameter which covers with a petiole bases in young palm tree. Juvenile leaves are lanceolate and entire but gradually becoming pinnate. Mature leaves are spirally arranged up to 7.5metre long. Inflorescences are unisexual, axillary, pedunculate until anthesis enclosed in two fusiform or ovate spathes 10-30cm long with flowers 3 merous and the male ones with numerous cylindrical spikes forming ovoid body (15-25cm) long and bearing flowers with 6 stamens, connate at base with linear anthers. The female ones subglobose (15-35cm in diameter), numerous lanceolate, spiny bracts containing cylindrical spikelet that spirally arrange the female flowers each containing two rudimentary male flowers (FAO, 2020).

The fruits are ovoid-oblong drupes, 2-5cm long that is tightly packed in large ovoid bunches with 1000-3000 fruits with a thin exocarp containing the kernel with embryo and solid endosperm.



**Figure 1: Fruits of oil palm (*Elaeis guinensis*)**

**2.2.1 Taxonomy of Oil Palm ((*Elaeis guineensis):***

Domain: *Eukaryota*

Kingdom: *Plantae*

Phylum: *Spermatophytam*

Subphylum: *Angiospermae*

Class: *Monocotyledonae*

Order: *Arecales*

Family: *Arecaceae*

Genus: *Elaesis*

Species: *Elaeisguneensis*

**2.2.2 Varieties of oil Palm**

There are three varieties of oil palm namely:

1. Dura oil palm
2. Pisiferaoil palm
3. Tenera oil palm

**2.2.3 Dura palm oil**

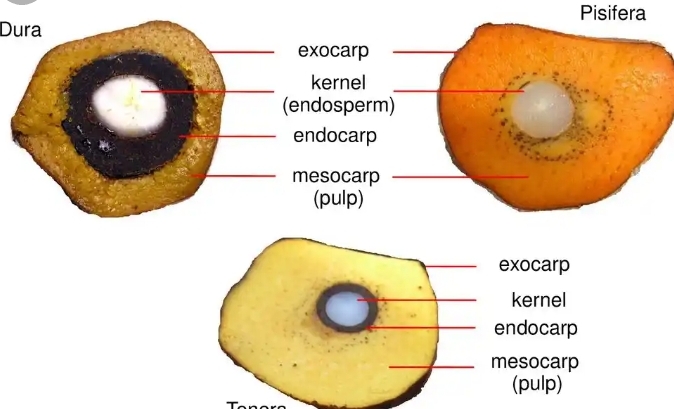
The dura palms have kernels with a thick shell (2-8mm) and produce approximately 5.3 tons of oil per hectare per year. Its thick shell has a higher caloric value which makes this palm shell have a better quality for use as boiler fuel. They produce large fruits bunches but contain 30% less oil than tenera fruit. They can be recognized by a very thick shell with no fibres in the mesocarp around the shell.

**2.2.4 Pisifera oil palm**

Pisifera palm fruits have no shell, they are typically female sterile and bunches prematurely rot prior to oil production (Hartley, 2010). They have leaves growing in an upward direction instead of to the side which makes the crown of the palm appear very narrow. Pisifera fruits have no fruit bunches since they are sterile. The palms of some pisifera grows very tall, no shell around the kernel, the fruit consist of only yellow mesocarp with some white kernel.

**2.2.5 Tenera oil palm**

Tenera palm oil is the cross between the two varieties of palm oil (dura and pisifera) with a relatively thin shell (0.5-3mm). It has kernel with a thin shell surrounded by a distinct fiber ring and can produce from 7.4 tons(Sharma and Tan, 2011) to as high as 13.6 tons of oil per hectare per year, as seen in elite individual.



**Figure 2: Diagram showing the three different varieties of oil palm**

**2.3. Processing of Oil Palm (*Elaeis guineensis*)**

Theoretically, the term “*processing*” is simply the conversion of a commodity from its raw state to a more acceptable form either manually or mechanically. However, in the case of oil palm, it involves changing the raw form of the product from fresh fruit bunches to palm oil and other important products, to make it ready for use. Oil processing in summary involves five processes which include (Poku, 2002):

1. Bunch reception
2. Threshing(removal of fruit from the bunches)
3. Sterilization of bunches
4. Mashing and pressing out the crude palm oil
5. Clarification and drying of oil

**2.3.1 Bunch Reception**

After harvesting the fresh fruits as either bunches or loose fruit, the fresh fruits or fresh bunch fruits can be separated either manually or mechanically, though the manual or the traditional method is very labourious which involves quartering and covering the palm bunches with plantain leaves overnight for easy separation of nuts from the spikelets (Ukwuteno, 2011). Mechanically, the fresh fruit is normally emptied into wooden boxes suitable for on a scale so that quantities of fruit arriving the processing site may be checked. The quality standard achieved is initially dependent on the quality of bunches arriving the mill which prevent deterioration.

**2.3.2 Threshing**

The fresh fruits bunch consists of fruit embedded in spikelets growing on a main stem. Manually, threshing is achieved by cutting the fruit laden spikelets from the bunch with the help of an axe or machete and then separate the fruits from the bunch by hand (Ukwuteno, 2011). However in a mechanized system, a rotator drum or fixed drum equipped with rotary beater bars which detached the fruits from the bunch, leaving the spikelets on the stem. In the other hand, small scale processors who lacks the capacity of using thresher can cooked the fresh fruit bunches with water to aid the same process as threshing.

**2.3.3 Sterilization of Bunches**

Here, the separated fruits are washed before boiling for about 1 hour, 30 minutes. According to Ukwutone (2011); sterilization or cooking means the use of high temperature wet-heat treatment of loose fruit. Hot water is usually involving in cooking while sterilization uses pressurized steam.

Below are some important of cooking or sterilization of oil palm:

1. Heat treatment of oil palm resulting from cooking or sterilization destroys oil-splitting enzymes and arrests hydrolysis and autoxidation.
2. Heating helps to solidify proteins in which the oil-bearing cells are microscopically dispersed. This helps the oil-bearing cells to come together and flow more easily on application of pressure (protein coagulation).
3. The moisture introduced by the steam acts chemically in breaking down the resins and gums that causes oil foaming during frying.
4. During sterilization of oil palm using high-pressure steam, the heat causes expansion of the nuts and when reduced the nuts contract leading to detachment of the kernel nuts from the shell wall.

**2.3.4 Mashing and pressing out the crude palm oil**

After sterilization, the fruits are digested or mashed for the purpose of releasing the oil palm from the fruit through rupturing or breaking down the oil-bearing cells. This can be done manually by pounding the fruits with a matching pestle in purposely-constructed wooden or

Concrete mortars or drums buried in the ground or macerated with feet in a canoe or canoe-like

Container. Mechanically, digester consisting of steam-heated cylindrical vessel fitted with a central rotating shaft carrying a number of stirring arms. The stirring arms aids in pounding the fruits by rotation process. However, mashing or digestion of the fruits at high temperature helps to reduce viscosity in the oil, destroying the fruits’ exocarp and complete the disruption of the oil (Nwalieji and Ojike, 2018).

In the traditional method, after the mashing process, water is added and the mix is well-shoveled up or mixed to wash the kernels very well, so that all nuts can be carefully removed by hand or using small baskets to grope or skim inside the palm fruit broth to remove kernel and fibres. The fibres are well shaken over or squeezed out in the sludge until oily foam floats to the surface of the sludge (Ukwuteno, 2011). While in the mechanical method, two methods are involve in extraction of oil from the digested materials; the ‘dry method’ and the ‘wet method’. The dry method involves the use of mechanically pressers to separate the fruits fibres and nuts from the oil by applying mechanical pressure. While the wet method uses hot water the leached out the oil.

**2.3.5 Clarification and drying of oil**

Here, the oil is separated from its entrained impurities. The fluid coming out from the press is a mixture of palm oil, water, and cell debris, fibrous material and non-oily solids. Manually, the broth or sludge is later boiled for some time to allow clean edible palm oil collect on the surface, leaving the sludge at the bottom of the pot. The floating oil is then decanted to separate the oil from the sludge by scooping up or tilting the pot in one direction so that the oil can flow out into containers for storage (Ukwuteno, 2011).

In the other hand, hot water is added to the press output mixture to thin it and the dilution provides a barrier causing the heavy solids to fall to the bottom of the container while the lighter oil droplets flow through the watery mixture to the top when heat is applied to break the emulsion. The diluted fibre is passed through a screen to remove coarse fibre and the screen mixture is boiled from one to two hours and then allowed to settle by gravity in the tank so that the palm oil will floats on top of the water and will be separated and rise to the top. The clear oil is then decanted into a reception tank for storage.

**2.3.6 Kernel Recovery**

The residue from the press consists of a mixture of fibre and palm nuts. The palm nuts are separated from the fibre by hand while the sorted fibre is covered and allowed to heat for about two to three days and the fibre is then pressed in spindle presses to recover a second grade oil which is very important in making of soap. The palm nuts are usually dried and sold to other operators that later process them for palm kernel oil.

**2.4. ECONOMIC IMPORTANT OF OIL PALM**

**2.4.1 Food Industry Use**

The highly saturated property of palm oil renders it solid at room temperature in temperate regions, making it cheap substitute for butter or hydrogenated vegetable oils in uses where solid fat is desirable, such as the making of pastry dough and baked goods (NPR, 2018). However, there are four main traditional uses of palm oil in food products which includes; cooking/frying oil, shortenings, and margarine and confectionary fats. Palm oil is popularly used in both solid fat products as well as in the liquid cooking oil sector especially in industrial frying applications. It offers several technical characteristics desirable in food applications, such as resistance to oxidation, which contributes towards longer shelf life of end products.Palm oil is ideally suited for use as an ingredient in shortenings and margarines as it has 20 – 22% solid fat content (SFC) at 20°C, which helps in the formulation of fat products with a plastic range. It tends to crystallize in small beta-prime crystals, a property desirable for some applications, in particular table and industrial margarines. Palm oil also has other functional attributes that make it a valuable ingredient in food formulations. In many applications, palm oil can be combined with harder fractions such as palm stearin to produce products of the required consistency without hydrogenation and is sometimes used as a minor ingredient in calf milk replacer. Common products made from palm oil and palm kernel oil, wholly or in blends with other oils include frying and cooking oils, shortenings, vegetable ghee or vanaspati, margarines and spreads

**2.4.2. Non Food Industry**

Palm oil products also find wide applications in the non-food sector, especially in the production of soaps and detergents, pharmaceutical products, cosmetics and oleochemical products. Around 70% of personal care products including soap, shampoo, makeup, and lotion, contain ingredients derived from palm oil (Tullis, 2019). Soap production is one of the most important applications of oils and fats and the traditional raw materials used were tallow and coconut oil. Due to the similarity in their fatty acid compositions, palm and palm kernel oil offer good and competitive alternatives to tallow and coconut oil, respectively as raw material for soap making (Nahian *et al.,* 2016). Fatty acids derived from the splitting process can be used directly in products like candle, cosmetics and in rubber processing. Fatty esters are used in various industries such as biodiesel, textile, and cosmetic, pharmaceutical, plastic and other applications. Though fatty alcohols as such find limited use, their derivatives; fatty sulphates are used extensively in the production of washing and cleaning products. Fatty amines are mainly used in the detergent industry as softening agents, in the mining industry as anti-caking agent, as biocides and in road building and other applications.

**2.4.3. Palm oil as Biodiesel**

Due to the increase in the price of fuel and increasing demand for alternative sources of energy in the Western world, the Malaysian government is refocusing the use of palm oil to the production of biodiesel to cater to the huge demand from European countries; it has encouraged the building of biodiesel plants. Strong demand for biodiesel from Europe as well as Colombia, India, South Korea and Turkey has fueled the industry's growth as more countries seek to reduce their reliance on fossil fuels. As of 2018, one-half of Europe's palm oil imports were used for biodiesel (Robert, 2018). Use of palm oil as biodiesel generates three times the carbon emissions as using fossil fuel (Hans Spross, 2015). There are pressures for increased oil palm production from Indonesian palm-based biodiesel programs. The biodiesel currently contains a 30:70 palm oil to conventional diesel ratio at the gas pumps (Matthäus, 2007).However, the Indonesian government is aiming to produce 100% palm oil biodiesel to transition out of using conventional diesel. They have estimated that they would need to establish approximately 15 million hectares of oil palm plantations to meet these future demands (Jong, 2020). The organic waste matter that is produced when processing oil palm, including oil palm shells and oil palm fruit bunches, can also be used to produce energy. This waste material can be converted into pellets that can be used as a biofuel (Choong, 2012). Additionally, palm oil that has been used to fry foods can be converted into methyl esters for biodiesel. The used cooking oil is chemically treated to create a biodiesel similar to petroleum diesel (Loh Soh Kheang, *et al.,* 2006).

**2.5 Chemical Composition of Oil Palm**

Crude palm oil extracted from the mesocarp is mainly composed of triacylglycerides (TAG)(Gee, 2007).Crude palm oil contains 50% saturated and 50% unsaturated fatty acids. The saturated fatty acid distribution in crude palm oil is 94% tiracylglycerides and 6% diacylglyceride. The major saturated fatty acids are represented in the majority by palmitic acid (45%) and stearic acid (3.5%). Unsaturated fatty acids consisted of oleic acid (>59%) and linoleic acid (>18%) (Sundram *et al.,* 2010). The minor components in crude palm oil are carotenoids (500–700 ppm), squalene, vitamin E, sterols, triterpenic alcohols, methylsterol, dolichols and polyprenols, ubiquinones, phospholipids and glycolipids(Goh,2011).

**2.5.1 Palmitic acids**

Palmitic acid, or hexadecanoic acid in IUPAC nomenclature, is the most common saturated fatty acid found in oil palm(Gunstone, *et al.,*2007). Its chemical formula is CH3(CH2)14COOH, and the total number of carbon atoms to the number of carbon-carbon double-bonds is 16:0. It is a major component of the oil from the fruit of oil palms (palm oil), making up to 44% of total fats (Gianfranca*et al.,* 2017).Palmitic acid is used to produce soaps, cosmetics, and industrial mold release agents. Because it is inexpensive and adds texture and "mouthfeel" to processed foods, palmitic acid and its sodium salt find wide use in foodstuffs. Sodium palmitate is permitted as a natural additive in organic products (Kingsbury*et al.,* 2008).These applications use sodium palmitate, which is commonly obtained by saponification of palm oil. To this end, palm oil, rendered from palm tree (species *Elaeis guineensis*), is treated with sodium hydroxide, which causes hydrolysis of the ester groups, yielding glycerol and sodium palmitate. Hydrogenation of palmitic acid yields cetyl alcohol, which is used to produce detergents and cosmetics.

**2.5.2 Oleic acid**

Oleic acid is a fatty acid that occurs naturally in various animal and vegetable fats and oils. It is an odourless, colorless oil, although commercial samples may be yellowish. In chemical terms, oleic acid is classified as a monounsaturated omega-9 fatty acid, abbreviated with a lipid number of 18:1 cis-9. It has the formula CH3(CH2)7CH=CH(CH2)7COOH(Thomas, 2000). The name derives from the Latin word “oleum” which means oil, It is the most common fatty acid in nature(Bailey, *et al.,* 2001). Oleic acid is used as a component in many foods, in the form of its triglycerides. It is a component of the normal human diet, as it is obtained from palm oil. As a sodium salt, Oleic acid is a major component of soap as an emulsifying agent. It is also used as an emollien (Carrasco, 2009). Small amounts of oleic acid are used as an excipient in pharmaceuticals, and it is used as an emulsifying or solubilizing agent in aerosol products (Smolinske, 2003).

**2.5.3 Myristic acid**

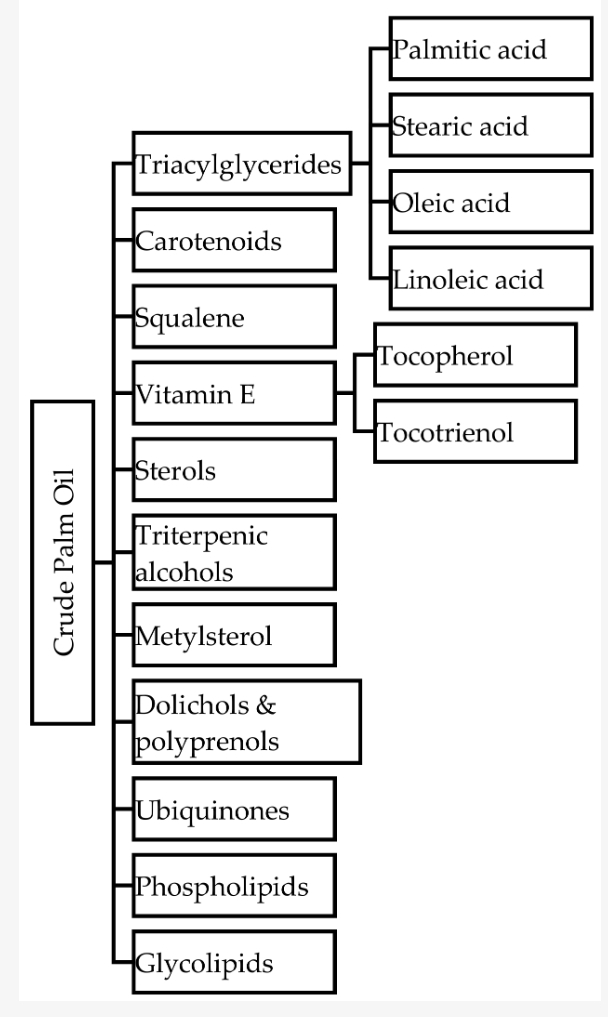
Myristic acid which has the IUPAC name: tetradecanoic acid is a common saturated fatty acid with the molecular formula CH3(CH2)12COOH.myristic acid is also found in palm kernel oil, coconut oil, butterfat, 8–14% of bovine milk, and 8.6% of breast milk as well as being a minor component of many other animal fats(Beare-Rogers, *et al.,* 2001). Its salts and esters are commonly referred to as myristates or tetradecanoates. It is named after the binomial name for nutmeg which means "Myristica fragrans", from which it was first isolated in 1841 by Lyon Playfair (Playfair, 2009).The myristic acid has a sufficiently high hydrophobicity to become incorporated into the fatty acyl core of the phospholipid bilayer of the plasma membrane of the eukaryotic cell. In this way, myristic acid acts as a lipid anchor in biomembranes(Cox, *et al.,*2005).

**2.5.4Triacylglycerol**

Triacylglerol is the basic unit of oils and fats that determines their characteristics. Triacyglycerol is a chemical compound consisting of three elements; carbon, hydrogen and oxygen. These elements makeup the molecules of fatty acids and glycerol that combines to form fat molecules known as triacylglycerol. Triglyceride (TAG) is formed by three fatty acids and esterified with glycerol, is an active form of storage of fatty acids. The carbon number of fatty acids in TAG can be grouped based on their length as each group possessed its own physiological and metabolic pathways. Fatty acids with 1 to 11 carbon chains are grouped as short-chain triglycerides, fatty acids with 7 to 12 carbon chains are known as medium-chain triglycerides and those with more than 13 carbon chains are long-chain triglycerides. Medium-chain triglycerides and long chain triacylglycerides have been under heavy investigation for their role of providing benefits and advantages in human metabolism, physiological response and nutrition, and pharmaceutical applications. From the metabolic point-of-view, the pathway taken by medium chian triacylglycerides and long chain triacylglycerides differed in terms of the route taken after digestion and their metabolism. Generally, medium chain triacylglycerides is favoured over long chain triacylglycerides due to its potential to accelerate transit time in the gastrointestinal tract (GIT) and imposing a lower physiological burden to be metabolised (Ledeboer, *et al.,*2005).

**2.5.5Carotene**

Red palm oil((*Elaeis guineensis)* is rich in carotenes such as; alpha-carotene, beta-carotene and lycopene which give it a characteristic dark red colour (Ming, *et al.,*2015) . palm oil that has been refined, bleached and deodorized from crude palm oil does not contain carotenes(Nagendran, *et al.,*2010). Oil palm is the largest source of natural carotenes(Goh, *et al.,*2011). There are 500-700ppm of carotenes in crude palm oil that is obtained from palm pressed fiber, a by-product from oil palm fruits milling(Choo and Ng, 2012).



**Figure 3: Crude Palm Oil constituents**

**2.6 HISTORICAL BACKGROUND OF MUSA SPECIES**

Musa species are native to tropical Indomalaya and Australia, and are likely to have been first domesticated in Papua New Guinea(Nelson and Ploetz, 2007) They are grown in 135 countries, primarily for their fruit, and to a lesser extent to make fiber, banana wine, and banana beer and as ornamental plants. The origin of the word "banana" probably derives from languages spoken in the coastal regions of Sierra Leone at the beginning of the sixteenth century. The Spanish word plátano from which the English term "plantain" may have derived (Simmonds, 2010 ) does not have a precise origin but is employed throughout the Spanish-speaking world and its meaning changes with location: in most of Central and South America, while the word banana is used as in English, plátano is reserved for the plantain, whereas in Mexico and Spain the latter including the Canary Islands, from which the banana is thought to have been carried to the New World (Galán Saúco, 2011), it is used for either bananas or plantains. The situation in Southeast Asia is somewhat different, where vernacular names do not differentiate between dessert and cooking bananas (kluai in Thailand, pisang in Malaysia and Indonesia, saging in the Philippines, chiao in China, or choui in Vietnam) (Valmayor *et al.,* 2010). The earliest modern plantations originated in Jamaica and the related Western Caribbean Zone, including most of Central America. It involved the combination of modern transportation networks of steamships and railroads with the development of refrigeration that allowed more time between harvesting and ripening. North American shippers like Lorenzo Dow Baker and Andrew Preston, the founders of the Boston Fruit Company started this process in the 1870s, but railroad builders like Minor C. Keith also participated, eventually culminating in the multi-national giant corporations like today's Chiquita Brands International and Dole (Koeppel, 2008).

These companies were monopolistic, vertically integrated and usually used political manipulation to build enclave economies. Their political maneuvers, which gave rise to the term Banana republic for states like Honduras and Guatemala, included working with local elites and their rivalries to influence politics or playing the international interests of the United States, especially during the Cold War, to keep the political climate favorable to their interests (Gittleson, 2018).The world's largest producers of bananas in 2017 were India and China, which together accounted for approximately 38% of total production). Worldwide, there is no sharp distinction between "bananas" and "plantains". Especially in the Americas and Europe, "banana" usually refers to soft, sweet, dessert bananas, particularly those of the Cavendish group, which are the main exports from banana-growing countries. By contrast, Musa cultivars with firmer, starchier fruit are called "plantains". In other regions, such as Southeast Asia, many more kinds of banana are grown and eaten, so the binary distinction is not as useful and is not made in local languages. Plantains are believed to have originated in Southeast Asia. Two groups of plantains are thought to have a common origin: the horn plantain and the French plantain. Both types grow in India, Africa, Egypt and tropical America. The French plantains also occur in Indonesia and Island of the Pacific. In some part of East Africa, plantain is an important beer-making crop, notably in central and eastern Uganda and Tanzania.

The term "banana" is also used as the common name for the plants that produce the fruit (Merriam, 2013). This can extend to other members of the genus Musa, such as the scarlet banana (Musa coccinea), the pink banana (Musa velutina), and the Fe'i bananas. It can also refer to members of the genus Ensete, such as the snow banana (Ensete glaucum) and the economically important false banana (Ensete ventricosum). A banana is an elongated, edible fruit – botanically a berry produced by several kinds of large herbaceous flowering plants in the genus *Musa* (In some countries, bananas used for cooking may be called "plantains", distinguishing them from dessert bananas. The fruit is variable in size, color, and firmness, but is usually elongated and curved, with soft flesh rich in starch covered with a rind, which may be green, yellow, red, purple, or brown when ripe. The fruits grow upward in clusters near the top of the plant. Almost all modern edible seedless (parthenocarp) bananas come from two wild species *– Musa acuminata* and *Musa balbisiana*. The scientific names of most cultivated bananas are *Musa acuminata, Musa balbisiana,* and *Musa × paradisiaca* for the hybrid *Musa acuminata* × *M. balbisiana*, depending on their genomic constitution.

**2.6.1 Botanical Description of Musaceae**

Members of the family Musaceae are perennials that frequently have sympodial (forked) fleshy rhizomes (underground stems). They may grow to 6 metres (20 feet) in height. A few species are epiphytic—i.e., supported by other plants and having aerial roots exposed to the humid atmosphere. The rolled-up sheathing bases of the leaves sometimes form an apparent short aerial stem.

* Musaceae exhibit the habit of Monocarpic gigantic herb.
* Musaceae has fibrous adventitious root system.
* The real stem of Musaceae is underground called rhizomatous (Robinson and Galán, 2010).
* Musaceae leaves are simple with a long and strong petiole. The leaf blade is large and broad with sheathy leaf base (Endress, 2010; Kirchoff, 2012)
* MusaceaeInflorescence is terminal branched spadix. Flowers are protected by large, brightly coloured spirally arranged, boat shaped bracts called spathe ( Kirchoff, 2012).
* The flower of the banana is also known as "Banana blossom" or "Banana heart”. The flowers are zygomorphic and epigynous (Skutch, 2005)

**2.6.2. Taxonomical Classification of *Musaceae***

Kingdom: *Plantae*

Division: *Magnoliophyta*

Class: *Liliopsida*

Order: *Zingiberales*

Family: *Musaceae*

Genus: *Musa*

Species: *Musa paradisiaca,Musa sapientum*



**Figure 4: Diagram showing the morphological view of banana**

**2.6.3 Cultivation and Distribution**

In different countries about 300 varieties of bananas are grown, of which a vast majority have been growing in Asian, Indo-Malaysian and Australian tropics and are now widely found throughout the tropical and subtropical countries. India, Philippines, China, Ecuador, Brazil, Indonesia, Mexico, Costa Rica, Colombia, Thailand are the top banana producing countries. It is extensively grown and cultivated as a fruit plant all over Bangladesh. The banana grows almost everywhere in the country throughout the year. The principal banana growing areas however, are Rangamati, Barisal, Rangpur, Dinajpur, Noakhali, Faridpur and Khulna (Rahman and Kabir, 2003). Banana plants thrive naturally on deep, lose, well-drained soils in humid tropical climates and they are grown successfully under irrigation in such semiarid regions as southern Jamaica. Bananas are cultivated in nearly all tropical regions of the world, particularly to Africa is the East African Highland Banana which is a stable starchy food for 80 million people and important source of income. There are 120 East Africa Highland Banana varieties in Uganda alone that are not found anywhere else in the world (Mallick, *et al.,* 2010). Plantain and banana are cultivated by the same method but are longer in length, have a thicker skin and contain more starch. They are also more stable food in Africa, Latin America and Asia. They are more important in the humid lowlands of West and Central Africa. One hundred of plantain grow deep in the African rainforest (Warnock *et al.,* 2007).

**2.7 Banana Peels**

Banana peel (banana skin) is the outer envelopes (covering) of banana fruit. They are the by-product of household consumption and banana processing (Espino *et al.,* 2000). Banana peels are used as food for animals, an ingredient in cooking, in water purification, for manufacturing of several biochemical products. Because of this removal of the banana peel, a significant amount of organic waste is generated (Babatunde, 2002). Banana peels are sometimes used as feedstock for cattle, goats, monkeys, poultry, rabbits, fish, zebras and several other species, typically on small farms in regions where bananas are grown. There are some concerns over the impact of tannins contained in the peels on animals that consume them (Happi *et al.,* 2011).

**2.7.1 Nutritional Value of Banana and Plantain Peel**

The nutritional value of banana and plantain peel depends on the stage of maturity and the cultivar; for example plantain peels contain less fibre than dessert banana peels, and lignin content increases with ripening (from 7 to 15% dry matter). On average, banana peels contain 6-9% dry matter of protein and 20 -30% fibre. Green plantain peels contain 40% starch that is transformed into sugars after ripening. Green banana peels contain much less starch (about 15%) when green than plantain

peels, while ripe banana peels contain up to 30% free sugars(Onwuka, *et al.,* 2003). Banana peels are also used for water purification to produce ethanol cellulose, laccase as fertilizer and in

composting(Oberoi *et al.,* 2011). Beside, culinary use with banana in Southeast Asian, Indian and

Venezuelan cuisine.

* + 1. **Pharmacological Properties of Musa Species Peels**

***2.7.2.1 Antiulcer activity***

Banana peel is used in the herbal medicine to treat peptic ulcer disease. The use of *Musa sapientum* in peptic ulcer as a component of herbal medicine has been evaluated and found effective (Salau, 2010). It was reported that pectin and phosphatidylcholine in green banana strengthens the mucousphospholipid layer that protects the gastric mucosa and also reported that the gastric mucosa protective activity of the banana is due to multiple active components (Goel, 2003). The natural flavonoid from the unripe banana *(Musa sapientum var. paradisiaca)* pulp, leucocyanidin, protects the gastric mucosa from erosions. Leucocyanidin and the synthetic analogues, hydroxyethylated leucocyanidin and tetraallyl leucocyanidin were found to protect the gastric

mucosa in aspirin-induced erosions in rat by increasing gastric mucus thickness(Dunjićet, 2000). Goel *et al*.,(1986) reported that banana pulp powder (*Musa sapientum* var. paradisiaca) showed significant antiulcerogenic activity in aspirin-, indomethacin-, phenylbutazone-, prednisolone-induced gastric ulcers and cysteamine- and histamine-induced duodenal ulcers in rats and guinea-pigs, respectively. The authors attributed the effect to increased mucosal thickness and increased [3H] thymidine incorporation into mucosal DNA that results in mucosal cellular proliferation and healing. Mukhopadhyaya (1987) also found the same effects like Goel in rat after orally administering banana pulp powder as aqueous suspension at 0.5 g/kg twice daily dose for 3 days. They also reported a significant decrease in gastric juice DNA content after the treatment(Houghton and Skari, 2009). Pannangpetch *et al*.,(2001) reported that the antiulcerative effect of banana may vary depending on different varieties of banana. They showed that the ethanolic extract of both *Mus sapientum* and *Musa paradisiaca* have significant gastro protective effect but only *Musaparadisiaca* promotes ulcer healing by a similar mechanism like prostaglandins(Mokbel and Fumio, 2005). Jain *et al*., (2007) also reported acid neutralizing capacity of *Musa sapientum*fruit peel ash in rats.

Histological studies showed that banana treatment sections showed a greater aggregation and intensity of pink spots when compared to controls. This study suggests that banana powder treatment not only strengthens mucosal resistance against ulcerogens but also promotes healing by inducing cellular proliferation. The active ulcerogenic ingredient was extracted from unripe plantain banana by solvent fractionation and identified by chromatography, spectroscopy and HPLC. As the flavanoid leucocyanidin and purified synthetic leucocyanidin demonstrated significant (p<0.05) protective effect against aspirin induced erosion. Extracts of plantain (*Musa sapientum* Linn. var. paradisiaca was studied on the accumulation of eicosanoids in incubates of human gastric and colonic mucosa. The ethanol extracts caused a concentration dependent increase in the eicosanoid but the water extract was ineffective. Methanolic extracts of plantain banana pulp was evaluated for its antiulcer and antioxidant activities in 2hr cold restraint stress and anti H. pylori activity in vitro. The extract (50mg/kg twice daily for 5 days) showed significant antiulcer effect and antioxidant activity in gastricmucosa homogenates where it reversed the increase in ulcer index, lipid peroxidation and superoxide dismutase values induced by stress (Jain *et al.,* 2007).

***2.7.2.2Anticancer activity***

Vijayakumar *et al*. 2017 reported that plantain peel aqueous extract-synthesised gold nanoparticles inhibitedin vitro A549 lung cancer cells at a dose between 25 and 100 μg/mL significantly relative to DMSO, saline,peel extract, and HAuCl4 where peel extract performed better than other controls. IC50 was estimated at 58 μg/ mL with the apoptotic pathway assumed to be responsible for cytotoxic activity. This study provides a scientific justification for the use of *M. paradisiaca* in traditional management of cancer and allied inflammatory conditions (Correa *et al.,* 2015; Krishnan *et al.,* 2014 and Maraschin, 2015) . Apart from lung cancer cell lines, the exudates of plantain pseudostem—which constitute around 31% of the plant mass (Saravanan and Aradhya 2011 )—have been shown to inhibit American Type Culture Collection (ATCC, Rockville, MD) strains of hpatocellular (HepG- 2) and human colon (HCT-116) carcinomas (Abdel Ghany *et al*.2019 ). At an IC50 of 29.4 μL, HepG-2 carcinoma was more sensitive with the highest cytotoxic effect to the cell lines which was observed at a dose of 100 μL. A related activity to this is the antioxidant effect plantain has. Abdel Ghany *et al*. (2019) reported that via DPPH scavenging assay, exudate of plantain pseudostem elicited protective activity against free radicals on a concentration-dependent rate with a IC50 of 2.2 μL. This result suggests that the pseudostem can serve as prooxidant and antioxidant due to the tannins and polyphenols present in the extract. Padam *et al*. (2012), Karuppiah and Mustaffa (2013), Saravanan and Aradhya (2011) corroborate this result. Specifically, gallocatechin, dopamine in peels (Vijayakumar *et al*.2017); (+)-catechin, gentisic acid, cinnamic, protocatechuic, ferulic, and caffeic acids (in pseudostem) gallic, syringic, ρ-coumaric, and ferulic acids, and catechol (in inflorescence) (Arun *et al*. 2018) which are antioxidants, have been reported in *Musa paradisiaca*. Apart from their ability to mitigate conditions resulting from reactive oxygen species, antioxidant effects are known to reduce the risk of cardiovascular and degenerative diseases and cancer(Saravanan and Aradhya 2011). This provides a preliminary justification to search for bioactive agents in *M. paradisiaca*. Apart from extracts, the essential oils derived from the fruit have been shown to possess antioxidant properties also. Fahim *et al*. (2019) reported that the essential oil obtained from the fruit contained α-thujene,α-pinene, sabinene, β-myrcene, α-terpinene, DL-imonene, tetradecanoic acid, α-copaene, caryophyllene, β-bisabolene, isocaryophyllene, β-pinene, 1,2-benzenedicarboxylic acid, hexadecanoic acid, 1-nonadecene, 6,9,12-octadecatrienoic acid which possess antioxidant, cytotoxic, and antitumour activity.

* + - 1. ***Antihypertensive activity***

The antihypertensive effect of *Musa paradisiaca* in albino rats was reported by Osim *et al*.,(1990). Later Osim and Ibu (1991) reported that banana diet has a mean arterial blood pressure lowering as well as onset preventing effect in rats with elevated blood pressure induced by desoxycorticosterone acetate (DOCA) administration. Perfumi *et al*.,(1994) reported that the antihypertensive effect of ripe banana pulp in deoxycorticosterone enantateinduced hypertensive rats which may be due to the high tryptophan and carbohydrate content of banana that increases serotonin levels and gives serotonin-mediatednatriorexic effect(Chodera *et al.,* 2007). However, Orie (1997) reported that serotonin produced a contraction in place of relaxation in isolated rat aortic rings. The aqueous extract of the ripe *Musa paradisiaca* fruit was found to give a concentration-dependent hypotensive effect in both noradrenaline and potassium chloride-contracted aortic rings isolated from rat. The effect was due to the nonspecific interference in calcium ion availability needed for the smooth muscle contraction that results in relaxation (Perfumi *et al.,* 2008).

***2.7.2.4 Antidiabetic activity***

Methanolic extracts of mature green fruit of *Musa paradisiaca* in normal and Streptozocin treated diabeticmice using Chlorpropamide as antidiabetic agent. MEMP (100-800 mg/kg, p.o) showed significant dose related (p<0.05–0.001) reduction in the blood glucose concentration in normal and diabetic mice. Chloropropamide (250 mg/kg p.o) also produced significant (p<0.01 and p<0.001) reduction in the blood glucose concentration in normal and diabetic mice (Emaga *et al.,* 2007). The antihyperglycemic activity was studied, where Oral administration of 0.15, 0.20 and 0.25 g/kg body weight of the chloroform extract of the *Musa sapientum*flowers for 30 days resulted in a significant reduction in blood glucose and glycosylated haemoglobin and an increase in total haemoglobin (Pari and Umamaheswari, 2009). The effect of Methanolic Extract of *Musa sapientum*Sucker on fasting blood glucose has been studied. Alloxan induced hyperglyceamic rats was evaluated and compared with that of glibenclamide as a reference drug, The fasting blood glucose was calculated using one touch life scan glucometer. The extract of *Musa sapientum*at all tested doses (5mgand 10mg kg-1/ day) significantly (p<0.05) lowered fasting blood glucose level in the treated rats compared with the diabetic but untreated rats - test control (Martin *et al.,* 2011).

Other than extracts and fractions, Shodehinde *et al*. (2015) report that unripe pulp of *M. paradisiacal* reduced blood glucose levels by inhibiting intestinal α-glucosidase, pancreatic α-amylase, and angiotensin-I-converting enzyme (ACE) in experimentally diabetic adult male Wistar rats after 14 days of oral administration due to the polyphenolic content. Syringin (50 mg/kg body weight) isolated from the ethanolic extract of plantain flower reversed diabetic indices in experimentally diabetic rats, upon oral administration with no observable acute toxicity after 30 days. It is hypothesised that syringin, a phenyl-propanoid glucoside with the chemical formula 4-[(1E)-3-hydroxyprop-1-en-1-yl]-2,6-dimethoxyphenyl- d-glucopyranoside, acts by maintenance of glucose homeostasis and C-peptide levels (Krishnan *et al*. 2014). It has also been suggested that anti-hyperglycaemic activity may also be mediated by the down-regulation of the inflammatory cytokines TNF-α and IL-1β while up-regulating the titres of transforming growth factor-α (TGF-α) in Inbred Charles–Foster albino rats induced with STZ-induced diabetes administered (orally) with 100 mg/kg of the ethanolic extract of unripe fruit (Kumar *et al*. 2013). These hypotheses have been reiterated by Abdel Aziz *et al*. (2020) though activity was attributed to phytol, stigmasterol, *β*-sitosterol, and vitamin E. Via a diet-based therapy, Famakin *et al*. (2016) report that plantain-based dough meals—supplemented with cassava fibre and soybean cake—resulted in lower blood glucose, implying that a plantain-based diet, in addition to chemotherapy, can successfully manage the condition though the concern about interaction will need to be addressed. The rich content of the micronutrients potassium and sodium in plantain has also been suggestedas responsible for this effect due to their fundamental role in metabolism, bodily fluids and structural tissues composition.

* + - 1. **Augmenting action on skeletal muscle contraction**

Augmentation action in skeletal muscles was studied by taking an extract obtained from juice expressed from the stem of the plantain banana tree (*Musa sapientum*L., var. paradisiaca) induces twitch augmentation in skeletal muscle. The mechanism of this action was investigated in the mouse hemi-diaphragm preparation. Directly evoked twitches and potassium induced (K+) contractures were both increased by the extract (Rabbani *et al.,* 2010).

**2.7.2.6 Analgesic activity**

The analgesic activity of aqueous extract of the plant was evaluated using the hot plate method and writhing test in mice. The hot plate method is useful in detecting centrally acting analgesics whereas acetic acid induced writhing method is useful to detect peripheral analgesic effects. Acetic acid, which is used as an inducer for writhing syndrome, causes analgesia by liberation of endogenous substances, which then excite the pain nerve endings. The fact that aqueous extract of *Musa paradisiaca* showed analgesic activity in both the models studied, indicate that this effect could be due to the presence of two components; one acting centrally and the other via peripheral route from the above results, it can be deduced that aqueous extract has shown dose dependent activity. As the phytochemical screening has shown the presence of carbohydrates, sterols, proteins, flavonoids, alkaloids in aqueous extract of *Musaparadisiaca* leaves, its potent activity may be attributed to the presence of these phytoconstituents(Sanjeev *et al.,* 2012).

**2.7.2.7 Antimalarial activity**

The decoction of the leaves of *M. paradisiaca* added to *Ocimum americanum* and *Ocimum gratissimum* is used as to treat malarial in Comores, Ngazidja. But *in vitro* study using *Plasmodium falciparum* chloroquine-resistant strain proves this plant ineffective in malaria (Kaou *et al.,* 2008).

* + - 1. **Antioxidant property**

The antioxidant behavior of the extracts was evaluated by using the thiocyanate method, ß-carotene bleaching method and 1, 1-diphenyl-2-picrylhydrazyl (DPPH) free radical elimination. Antioxidant activity of water extracts was comparable to those of synthetic antioxidants such as butylated hydroxyanisole and butylated hydroxytoluene and it shows a significant antioxidant property. The antioxidant effects of crude extracts from green banana and yellow peel were investigated and the results indicated that the extract of green peel recorded more significant activities than that of yellow peel at other solvents extracts(Surbhi *et al.,* 2013).

**2.7.2.9 Antimicrobial properties**

In recognition of the role and importance of herbal medicine, World Health Organisation (WHO) has over theyears carried out a number of strategic plans and passed resolutions aimed at improving the efficacy and quality of drugs of plant origin. The outcome of these has led to increased scientific inquiry into the basis and justification of their traditional uses (WHO 2013). One of the products of this endeavour is that since the release of the WHO’s first series of Traditional Medicine Strategy (2002–2005), significant advances have been recorded in the scientific understanding of traditional and complementary medicine. This has had the knock-on effect of initiation and development of technical standards and guidelines for organised herbal health service delivery (WHO 2013). There are a number of reports on antimicrobial activities of plantain (*Musa paradisiaca*), and several organisms including fungi and bacteria with parasites and viruses enjoying lesser attention have been used as test organisms. Asoso *et al*. (2016) reported the antimicrobial activities of plantain peel and fruit extracts against *Escherichiacoli*, *E. coli* ATCC 35218, *Staphylococcus aureus*, *S. aureus* ATCC 25923, *Salmonella typhi*, *Salmonella typhi* ATCC 22648, *Salmonella typhi* ATCC 23456, *Shigella dysentriae* ATCC 24162, *Klebsiella pneumonia* ATCC 34089, and *Bacillus subtilis* ATCC 21332 using agar well diffusion technique. Ethanolic extract of the peels had minimum inhibitory concentration (MIC) values between 150 and 200 mg/mL with the least being against *S. aureus* 25923 ATCC and the highest against *Salmonella typhi* 22648 ATCC and *Klebsiella pneumonia* 34089 ATCC. Ethanolic extracts of fruits had an MIC range of 200 and 300 mg/mL. Methanolic extract of peels on the other hand ranged from 100 mg/mL to 200 mg/mL, while methanolic extract of fruit yielded an MIC of 150 mg/ mL and 250 mg/mL. Extracts of acetone from both peels and fruits had no activity against the test isolates. While activity was recorded, discrimination was not observed on the basis of cell wall Gram reaction suggesting thatthe mechanism of activity was by a route other cell wall lysis. The opportunistic skin pathogens, *Propionibacteriumacnes* (Fitz-Gibbon *et al*. 2013; Perry and Lambert 2011) now known as *Cutibacterium acnes* (Dreno *et al*. 2018) and *S. epidermidis* (Taha *et al*. 2018), have been shown to be susceptible ethanolic extract of peel powder which makes it a potential antibacterial cosmetic agent. This potential usage is reinforced by Prakash *et al*. (2017) who reported inhibitory effect against *Aspergillus niger* now implicated in cases of *Tinea capitis* (Chokoeva *et al*. 2016). In addition to bacteria, Jawla *et al*. (2016) challenged

fungi with ethanolic and ethanolic and aqueous (1:1) extracts of *Musa paradisiaca* flowers using the micro dilution assay with MIC values of 5.62–25.81 μg/mL and 7.61–31.58 μg/mL, respectively. *Candida albidus* MTCC-2661 had an MIC of 6.49 and 7.61 μg/mL for ethanolic and ethanolic and aqueous extracts, respectively. *C. albicans* MTCC-183 had marginally higher values at 8.62 μg/mL for ethanolic extracts and 9.88 μg/ mL for ethanolic and aqueous (1:1) extracts. Bacterial isolates *Pseudomonas aeruginosa* ATCC-9027, *B. subtilis* MTCC-121, and *B. cereus* MTCC-430 had ethanolic MIC of 5.62, 6.82, and 7.95 μg/mL, while peak ethanolic MIC was observed with *Salmonella typhimurium* MTCC-98. *E*. *coli* MTCC-443 yielded peak MIC in ethanolic andaqueous (1:1) extracts with *Streptococcus pneumonia* MTCC-2672 ranking below it at 24.86 μg/mL marginally ahead of *Proteus mirabilis* MTCC-1429 with 22.13 μg/ mL. Generally, ethanolic extracts were active at lower concentration relative to ethanolic and aqueous (1:1) extracts an observation we attribute to a dilution effect of the water within the ethanolic and aqueous (1:1) extract. The authors went on to evaluate the acute and shortterm toxicity of extract on albino Wistar rat models with results indicating no toxicity and morbidity.

***2.7.2.10 Mutagenecity***

It was reported the mutagenic effect of *M. paradisiaca* fruit peel extract in mice assessed by the single-cell gel electrophoresis (SCGE) and micronucleus assays. The experiments showed DNA damaging property in peripheralblood leukocytes for 1500 and 2000 mg/kg body weight(Mokbel and Fumio 2005).

* + - 1. ***Anti-snake venom activity***

Borges *et al*. (2005) reported the *in vitro* neutralizing capacity of *Bothrops jararacussu* and *Bothrops neuwiedi* snake venoms by the stem juice of *M. paradisiaca*. The phospholypase A2 (PLA2) and hemorrhagic activities induced by the venom was inhibited by the extract as it forms unspecific complex with the venom protein. However, the *in vivo* activity of the extract in mice was not significant to protect against the venom (Borges *et al*., 2005).

***2.7.2.12Phytochemicals and Mineral Contents***

Several phytochemicals such as; Catecholamines(norepinephrine, serotonin and dopamine), typtophan, indole compounds and pectin have been in the pulp of musaceae(Shanmugavelu and Rangaswami, 2005). Several flavonoids and related compounds such as; Leucocyanidin, quercetin and its 3-Ogalactoside, 3-O-glucoside, and 3-O-rhamnosyl glucoside were isolated from the unripe pulp of plantain(Lewis and Shaw, 2003). Serotonin, nor-epinephrine, tryptophan, indole compounds, tannin, starch, iron, crystallisable and noncrystallisable sugars, vitamin C, B-vitamins, albuminoids, fats, mineral salts have been found in the fruit pulp of *Musa.paradisiaca* and *Musa. sapientum*(Waalkes, 2001). Carbohydrates have been isolated from *Musa. Sapientum*(Anhwange, 2008). Cellulose, hemicelluloses, arginine, aspartic acid, glutamic acid, leucine, valine, phenylalanine and threonine have been isolated from pulp and peel of *Musa. Paradisiaca*(Ketiku, 2005). Hemiterpenoid glucoside (1,1-dimethylallylalcohol), syringin, (**6S**, 9R)-roseoside, benzyl alcohol glucoside, (24R)-4α,l4 α,24-trimethyl-Sacholesta-8,25 dien-3β-o1 have been isolated from flower of *Musa. Paradisiacal* (Duita *et al.,* 2004).

**Table 2.1:Macro and micro elements found in Musa species in mg/100grams**

|  |  |
| --- | --- |
| **Elements** | **Mg/100 dry sample** |
| Sodium | 444.12±4.08 |
| Potassium | 944.12±1.41 |
| Calcium | 1335.33±14.1 |
| Magnesium | 255.00±2.83 |
| Phosphorus | 137.82±1.89 |
| Iron | 3.31±0.05 |
| Zinc | 8.05±0.05 |
| Manganese | 1.27±0.11 |

Values are presented as mean+SD.

Source: *Ho et al., 2012*

* 1. **Antinutritive Properties of Musa Species**

Antinutritive analysis is a test to determine the present of antinutrients in diary substances. This analysis is conducted to check the present of substances such as; tannins, phylates, lectins oxalates, etc. Antinutrients are found at some levels in almost all foods for a variety of reasons (Welch and Graham, 2010). The possibility now exist to eliminate antinutrients entirely using genetic engineering but since these compounds may also have beneficial effects, such genetic modifications could make the foods more nutritious but not improve people’s health.

**2.8.1 Saponins**

The average saponins content in six varieties of bananas and plantains was reported to be 2.4% (Adeniji *et al.,* 2012), which is close to the safe upper limit of 3.0%. the high saponin content of ripe bananas has the potential to increase intestinal permeability which is a known risk factor for the development of autoimmune diseases in genetically susceptible people(Fasano, 2011). To date, no studies of ripe bananas have yet been conducted to see how they may affect intestinal permeability. Interestingly, consumption of green, non-ripe bananas actually improves intestinal permeability (Rabbani *et al.,* 2012). However, this outcome likely does not occur with ripe bananas because unlike green bananas, ripe bananas contain little or no indigestible starch(the element underlying the therapeutic effect of green bananas upon intestinal barrier function.

**2.8.2 Thaumatin-Like Proteins (TLP)**

These proteins are known to increase cell membrane permeability (Barre *et al.,* 2007) and hence intestinal permeability. The Thaumatin-like proteins content of bananas is exceedingly high and may constitute 50% of all proteins in banana pulp(Leone *et al.,* 2013). Like saponins, TLPs are antinutrients which protect plants from fungal attack through a variety of mechanisms, including a dramatic increase in cell membrane permeability of potential pathogens and predators. No studies have been conducted to verify whether TLPs actually increase intestinal permeability in living humans, but both animal and tissue culture experiments point in this direction. Because of this information, people with autoimmune diseases should use caution when including bananas in their diets.

* + 1. **Lectin(Banlec-1)**

Plantains and bananas also contain a lectin called BanLec-I which was only discovered in 1990(. As with other antinutrients, BanLec-I likely function is to ward off predators due to its toxic effects(Peumans *et al.,* 2013). Banana lectin almost certainly crosses the gut barrier and enters circulation, as immune antibodies (IgG4) to it have been discovered in unexpected high frequencies in human blood(Koshte *et al.,* 2003). As with other lectins, it seems likely that BanLec-I may be involved with autoimmune diseases because of its ability to bind antigens (proteins) from gut borne food and bacteria(Koshte *et al.,* 2015) and drag them past the gut barrier in a Trojan Horse like manner. These lectin compounds, plus gut borne antigens, are then processed by immune system cells (dendritic cells) in a manner that likely evokes an immune response. For an autoimmune disease to develop in genetically susceptible people, a powerful pro-inflammatory response by the immune system must first occur. Well, you guessed it: banana lectin does precisely this in animal tissue experiments by stimulating production of the pro-inflammatory cytokines (localized hormones), interferon gamma, tumor necrosis factor alpha, and interleukin 218(Stojanović *et al.,* 2013). All of these experiments indicate that bananas may represent a dietary trigger for autoimmune patients.

* + 1. **Protease Inhibitors**

Plantains and Bananas not only contain substances which promote a leaky gut (saponins and TLPs), but they also contain compounds, protease inhibitors which prevent the gut's protein degrading enzymes from doing their job(Rao, 2012). Consequently, the cocktail of antinutrients in bananas sets off a series of immunological events which are suspected to underlie the development of many autoimmune diseases.

**2.8.5 Dopamine and Norepinephrine**

Musa species also contain high concentrations of the neurochemicals dopamine and norepinephrine (Kanazawa and Sakakibara 2016). Dopamine is a powerful antioxidant, and likely functions in bananas and plantains to protect the fruit from the oxidative stress that results from the strong sunlight and high temperatures found in tropical regions where bananas grow(Cordain *et al.,* 2017). Dopamine and norepinephrine from bananas have been found to alter the bacterial flora of the gut by promoting growth of harmful gram negative bacteria, such as: Escherichia coli, Shigella flexneri, Enterobacter cloacae and Salmonella typhimurium23. All of these bacteria contain a substance in their cell walls called lipopolysaccharide (LPS), which causes a powerful pro-inflammatory response in the immune system - providing LPS breeches the gut barrier and makes contact with immune cells called macrophages and dendritic cells. Because bananas contain saponins and TLPs, which likely increase intestinal permeability, it is possible that an altered gut flora containing more gram negative bacteria may promote chronic low level systemic inflammation as LPS binds to immune system cells. However, to date no such effect of bananas has ever been demonstrated in living people.

**2.9 Antibacterial Assay**

Antibacterial susceptibility test is often performed by clinical microbiology laboratories as a tool to aid in the selection of the optimal antibacterial agent. This test determines a microbe’s vulnerability to antimicrobial drugs or substances by exposing a standardized concentration of organism to specific concentration of antimicrobial drugs or substances. However, this test can be done for both bacteria, fungus and viruses. For some organisms, results obtained with one drugs or substances can predict results with similar substances. Thus, not all potentially useful drugs are tested. Susceptibility testing occurs in vitro and may not account for many in vivo factors such as; pharmacodynamics and pharmacokinetics, site-specific drug concentrations, host immune statusa and site specific host defence. Clinical laboratories currently employ several methods depending on the laboratory test menu that they provide. These approaches includes; agar well diffusion, disk diffusion and minimum inhibitory concentration methods(Calhoun *et al.,* 2008). They are many factors that affects the outcome of this process which includes; endpoint definition, inoculums size of the organisms, time of incubation, temperature of incubation .conclusively, the method of susceptibility test use in this research work is based on Agar well diffusion.

**CHAPTER THREE**

**MATERIALS AND METHODS**

**3.1. STUDY AREA**

The antibacterial analysis was conducted in Microbiology laboratory, Akwa Ibom State University, Ikot Akpaden, Mkpat Enin and the antinutritive analysis was carried out in Biochemistry Department, University of Uyo, Akwa Ibom State.

**3.2. MATERIALS**

Ash extract of unripe plantain *(Musa paradisiaca)* and banana *(Musa sapientum)* peels, Palm oil, Petri dishes, nutrient agar, Incubator, refrigerator, Mueller Hinton agar, water bath, Weighing balance and Autoclave.

**3.3. SAMPLE COLLECTION AND PROCESSING**

The unripe plantain (*Musa paradisiaca*) and banana *(Musa sapientum*) were purchased from Abak market and were peeled. The peels were sun dried for 3 weeks and burnt to ashes. The palm oil was obtained from oil palm mill in Abak Itenge in Akwa Ibom state. All the samples were taken to Microbiology and Biochemistry laboratory for analysis.

* 1. **ANTIBACTERIAL ASSAY**

***3.4.1 Isolation of bacteria from oil palm by serial dilution and pour plate method***

The unknown bacteria isolates were isolated from the palm oil using serial dilution and pour plate method. A stock culture of each sample was prepared by measuring 1ml of the sample into a conical flask containing 45 ml of distilled water. The suspension was shaken vigorously and allowed to settle. One milliliter was taken from the suspension and dispensed into test tubes containing 9.0 ml of sterilized distilled water. The samples were further serially diluted up to the appropriate dilution factors (10-3, 10-4 and 10-5). From the diluents, 0.1ml was aseptically inoculated into Petri dishes containing Nutrient Agar and was swirled to mix. The petri dishes were allowed to solidify and the bacterial plates were incubated at 37°C for 24 hours.

***3.4.2 Bacterial Purification (Sub-culturing)***

After 24hrs of incubation, the bacterial plates were observed for appropriate growth. Representative colonies were sub-cultured on the appropriate plates while pure cultures were obtained by repeated streaking of fresh colonies on appropriate media (nutrient agar). The pure cultures were maintained on agar slants containing nutrient agar at refrigeration temperature of 4°C for further use.

***3.4.3 Bacterial Identification (Biochemical Tests)***

**Table 3.1: Biochemical test for identification of different bacterial isolates**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Isolates** | **Shape** | **Indole test** | **Citrate test** | **Urease test** | **Coagulase test** | **catalase test** | **Probable microorganisms** |
| 1X10-1 | Rod | + | - | - | - | + | E. coli |
| 1X10-2 | Cocci | - | + | + | + | + | Staphylococcus aureus |
| 1X10-3 | Rod | - | + | - | - | + | Pseudomonas aeruginosa |
| 1X10-4 | Rod | - | + | + | - | + | Bacillus cereus |
| 1X10-5 | Rod | - | + | + | - | + | Proteus vulgaris |

* + 1. **Antibacterial susceptibility Test**

Antibacterial susceptibility test was carried out by Agar well diffusion method. After all the isolates were successfully identify, antibacterial susceptibility test was carried out on each of the isolates. The agar plate’s surfaces for each of the isolates were inoculated by spreading a volume of the microbial isolates over the Muller Hinton agar surface by sterile cotton swab. Then, the plated medium was allowed to dry at a room temperature for 3hrs (Lopez *et al.,* 2011). On each plate, equidistant wells were made with a 6mm diameter sterilized cork borer, 2 mm from edge of the plate. 5grams of the burnt ash from the musa species (plantain and banana) peels extract was aseptically introduced into the wells for each of the plate containing the identify isolates. Then, the agar plates were allowed for 40mins on the bench for pre diffusion followed by incubation at 37°C for 24 hours. The antimicrobial agents (peel’s extract) diffuse into the agar medium and inhibit the growth of each of the isolates that were early identified. The presence of inhibition zones was measured and recorded. The experiment was performed in triplicate.

**3.5 ANTINUTRTIVE ANALYSIS**

* + 1. ***Determination of tannins by folin- Denis colorimetric method***

5g of the banana and the plantain ash was dispersed into 50ml of distilled water in different beaker and was shaken. The mixture was allowed to stand for 30min at 28oC before they were filtered through whatman no. 42 grade of filter paper. 2ml of the extract was dispersed into 50ml volumetric flask. Similarly, 2ml standard tannin solution (tannic acid) and 2ml of distilled water were put in separate volumetric flask to serve as standard and the reagent was added to each flask and 2.5ml of saturated Na2CO3 solution was added (Kirk and Sawyer, 1998). The content in each flask was made up to 50ml with distilled water and was incubated at 20oC for 90mins. Their respective absorbance were measured in the spectrophotometer at 260nm using the reagent blank to calibrate the instrument at zero.

**3.5.2*Determination of alkaloid***

This was done by the alkaline precipitation gravimetric method described by Harbourne, (2007). 2 g of the two samples were weighed and dispersed into 10% acetic acid solution in ethanol to form a ratio of 1:10(10%). The mixture was allowed to stand for 4 hours at 28oC and then filtered via Whatman NO. 42 grade filter paper. The filter was concentrated to one quarter of its original volume by evapouration and was then treated with a drop wise addition of concentrated aqueous NH4OH until the alkaloid was precipitated. The alkaloid precipitated was received in a weighed filter paper, washed with 1% ammonia solution and dried in the oven at 80oC. Alkaloid content was calculated and expressed as a percentage of the weight of sample analyzed.

**3.5.3 Extraction of Cyanide by Wang and Filled method**

5g of the samples were grind into paste and the paste was dissolved in 50ml distilled water in a conical flask corked. Then the extraction was allowed to stay overnight and was filtered, the filtrate was used for cyanide determination.

* + 1. **Determination of cyanide(HCN)**

To 1ml of the filtrate in a corked test tube, 4ml of alkaline filtrate was added and incubated in a bath for 5 minutes. After the colour development (reddish brown colour), the absorbance at 490nm was read using spectrophotometer and the absorbance of the blank containing only 1ml of distilled water and 4ml of alkaline picrate solution.

* + 1. ***oxalates determination by titration method***

Determination of oxalates involves three major steps, namely; digestion, oxalate precipitation and KMnO4 titration.

* ***Digestion***

2.5g of the dried and ground samples was introduced into a 250ml beaker and 95ml of distilled water and 5ml 6NHCl was added to the beaker. The mixture was heated on a water bath at 50oC for 2 hours and the digest was filtered and diluted to 125ml with distilled water.

* ***Oxalate Precipitation***

50ml of the filtrate was taken into a 100ml beaker and then 4 drops of methyl red indicator was added and was evaporated to 25ml volume and filtered to remove part containing ferrous ion .the filtrate was treated with 5ml of concentrated NH4OH and was heated again to 90oC and 10ml of 5% CaCl2 solution was added while being stirred constantly. After heating, it was cooled and left overnight at 5oC and the solution was then centrifuged at 2500rpm for 5mins and the supernatant was decanted and the ppt obtained, was washed into a beaker with 10ml of 20%(v/v) H2SO4 solution and total volume was diluted to 125ml distilled water.

* ***Permanganate titration***

Aliquots of 125ml of the solution was heated near boiling point(90oC) and then titrated against 0.05N KMnO4 solution to a faint pink colour which persist for 10seconds. Then the calcium oxalate content was calculated using the formula; 0.05N KMnO4  = 2.2mg oxalate.

* + 1. ***Determination of phytate***

2.5g of the sample was taken into a conical flask, the extract with 50ml 3% TCA was swirled for 45mins and the suspension was centrifuged and transfer into 100ml conical flask. 4ml of FeCl3 solution (made to contain 2mg of ferric ion per ml in 3% TCA) was added to the aliquot by blowing rapidly the pipette (Mecance and Widdowsan, 1953). The tube and the content was heated in a boiling water bath for 45mins and was centrifuge for 15mins and the clear supernatant obtained was carefully decanted. The precipitate was washed twice by dispersing well in 25ml 3% TAC and heated for 10mins in water bath and was centrifuged, the precipitate was dispersed in a10ml of water and 3ml of 1.5M NaOH was mixed and the volume was bring to approximately 30ml with water and was heated with water bath for 30mins. Then was centrifuge and carefully decanted, the ppt was washed with hot water and was recentrifuged and decanted. Ppt was dissolved with hot 40ml 3.5M HNO3 and was transfer to 100ml standard flask. The tube was washed with hot water and the washing was collected in the same flask and the flask and the content was cooled at room temperature and diluted to volume with distilled water. The Fe(iron) of the solution was determined from the iron result assuming a 4:6 iron phosphorus molecular ratio. Appropriate calculation was carried out for determination of the phytic acid.

* 1. **Statistical Analysis**

All the data obtain was expressed as mean ± standard devaition and analyzed using One Way Analysis of Variance (ANOVA). Significant means was separated by applying Duncan multiple range post hoc test as outlined by Duncan (1955).

**CHAPTER FOUR**

**RESULTS AND DISCUSSION**

**4.1 Antibacterial effect of ash extract of *Musa paradisiaca* and *Musa sapientum* peels on oil palm**

In the present study, the evaluation of antibacterial activity of the ash extract of *Musa paradisiaca* and *Musa sapeintum* against the identified bacterial were studied using agar well diffusion. The data obtained from the antibacterial effects of the ash extracts of both *Musa paradisiaca* and *Musa sapientum* are presented in Table 4.1 respectively. The ash extract of both the *Musa paradisiaca* (plantain) and *Musa sapientum* (banana) peels shown antibacterial activity against all the identified bacterial from oil palm. The highest inhibition zone in mean was observed on ash extract of *Musa paradisiaca* peels ash against *E. coli(*14.5±0.2mm), *Staphylococcus aureus (*12.5±0.1mm), *Pseudomonas aeruginosa (*11.6±0.3mm), *Bacillus cereus*(10.7±0.2mm) and *Proteus vulgaris(*10.4±0.2mm) while ash extract of *Musa sapientum* peels was observed to exhibit moderate antibacterial activity against *E. coli*(11.6±0.4mm), *Staphylococcus aureus (*10.5±0.2mm), *Pseudomonas aeruginosa (*9.7±0.5mm), *Bacillus cereus(*8.8±0.3mm)and *Proteus vulgaris(*9.6±0.2mm) as shown in Table 4.1. This result further confirmed that ash extract from *Musa paradisiaca* peels was the most potent antibacterial extract on oil palm compare to ash extract of *Musa sapientum* peels which demonstrated moderate antibacterial activities (Table 4.1). However, this work corresponds with the findings of Karadi *et al.,* (2011) and Subrata Kumar *et al.,* (2011) who observed that plantain and banana peels have antimicrobial activities against pathogenic bacteria. The higher in growth inhibition zone of ash extract of *Musa paradisiaca* peels compare to that of banana peels may depends on the cultivars of the plantain and banana and geographical distribution. This may also be as a result of the degree of solubility of the active constituents in the solvents used during the experiment or culturing of the bacteria (*Karadi et al., 2011*).

The difference in potency may be due to the stage of collection of the plant sample, different sensitivity of the test strains of the bacteria and method of isolation of these strains from the oil palm. This result coincides with the findings of Nimri *et al.,* (1999). Antimicrobial properties of plants extract had been attributed to the presence of some antinutrients such as alkaloids, tannin and flavonoids. Our findings are supported by the reported results of Harborne, (1973); Tsuchiya *et al.,* 1994; Hutchings *et al.,* (2003); Okorondu *et al.,* (2010) who attributed the differences in antimicrobial properties of plants extract to the presence of phytochemicals or antinutritive values.

**Table 4.1 Antibacterial effects of ash extract of *Musa paradisiaca* (plantain) and Musa sapietum (banana) peels from oil palm isolates (mm**)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Musa species cultivars** | **Test organisms/ mean zone of inhibition** | | | | |
|  | **EC** | **SA** | **PA** | **BC** | **PV** |
| *Musa sapientum* | 11.6b±0.4 | 10.5b±0.2 | 9.7b±0.5 | 8.8b±0.3 | 9.6b±0.2 |
| Musa paradisiaca | 14.5a±0.2 | 12.5a±0.1 | 11.6a±0.3 | 10.7a±0.2 | 10.4a±0.2 |
|  |  |  |  |  |  |

**Test organisms: EC – *Escherichia coli,* SA – *Staphylococcus aureus,* PA – *Pseudomonas aeruginosa,* BC – *Bacillus cereus,* PV – *Proteus vulgaris.*Mean Inhibition zone includes the diameter of the well (6mm)**

**\*Means with different superscripts in a column are significantly different at p<0.05**.

**4.2 Effect of palm oil on Anti-nutrients composition of ash extract of *Musa paradisiaca and* *Musa sapientum* peels**

**4.2.1 Hydrogen Cyanide content**

Hydrogen cyanide is a great toxic substance formed by the activity of acids on metal cyanides (Ladeji *et al.,* 2004). The Hydrogen Cyanide (HCN) content was relatively high in ash extract of plantain (*Musa paradisiaca*) peels alone as shown in Table 4.2, which recorded 4.111±0.024mg/100g. However, these levels of Hydrogen Cyanide were significantly (p <0.05) decrease to 1.034±0.043mg/100g when mixed with palm oil. It was observed that palm oil played a more effective role in reducing Hydrogen Cyanide content in the ash extract of plantain (*Musa paradisiaca*) peels while the hydrogen cyanide content in ash extract of banana peels alone compare to that of plantain was relatively low and was reduced respectively when mixed with palm oil, this could be as a result of different phenolic content or origin of the two species (Iyawe and Azih 2011). This result shows that oil palm can reduced the Hydrogen cyanide content of ash extract of plantain and banana peels and that ash extract from plantain peels contain the highest level of Hydrogen cyanide compare to ash extract of banana peels. These results are in agreement with those reported by Feumba *et al.,* (2005), who reported that Hydrogen cyanide content in plantain peels- ash extract is higher than that of banana peels-ash extract and can be reduced when blended with oil palm.

**4.2.2 Tannin Content**

The level of tannins in ash extracts of plantain and banana peels are shown in Table 4.2. It was observed that the tannins content present in the ash extracts of plantain peels alone (1.396±0.014) was higher than that of the banana peels alone (0.752±0.010) while the ash extract of the plantain peels mixed with palm oil (0.045±0.004) was observed to contain a lower level of tannin compare to ash extract of the plantain peels alone and that of banana peels (0.020±0.003) respectively. This may be as a result of the phytochemicals present in the oil palm which may kick up or lower the level of tannin in the ash extract of both the plantain and the banana peels when mixed with oil (Inuwa et al. 2011).

**4.2.3 Phytate Content**

Phytic acid present in plant materials is known for its chelating impact on certain essential mineral elements such as; calcium, Magnesium, iron and zinc to form insoluble phytate salts (Ashok *et al.,* 2016). Data in table 4.2 showed the levels of phytates content in the ash extract of plantain and banana peels. It was observed that the phytate content of plantain peel-ash extract (5.398±0.014) alone was higher than the ash extract of banana peels alone (2.147±0.027) and the phytates content of the ash extract of the plantain peels (6.139±0.010) mixed with oil palm was also higher than that of ash extract of banana peels (3.744 ±0.025). These result was in line with the result obtained by Awak *et al.*, (2017) reported a significant decreased of anti-nutrients present in cocoyam when cooked with palm oil. The decrease or increase of the phytates content of these two musa species peels-ash extract maybe due to the formation of insoluble complexes about phytates and other compounds. Lawal and Adewale (2004) also attributed the increase and decrease of phytic acids contents in plants materials to low inositol and inositol phosphate by the action of free radicals generated during irradiation.

**4.2.4 Oxalate content**

Oxalates can bind to calcium in food thereby rendering calcium inaccessible for ordinary physiological activities. The results in Table 4.2 showed the oxalate content of ash extract of plantain peels alone (8.104±0.018) to be higher than the ash extract of banana peels alone(4.462±0.056) and the ash extract of the plantain(5.402±0.020)and banana peels(4.462±0.056) mixed with palm oil was observed to be lower than those without palm oil. Therefore, palm oil was proved to be effective against the reduction of oxalate level in the two ash extracts of Musaceae peels and was also observed that in the process of burning the peels to ash causes acute heat stress which destroys and reduced the oxalate content. This results are supported with the work of Asma *et al* (2011) and Lawal *et al.,* (2013) who attributed the decrease in oxalates content of plants material to thermal heat and presence of other mineral elements.

**4.2.5 Alkaloids content**

The alkaloids levels of ash extract of plantain and banana peels on oil palm are shown in Table 4.2 results showed that there is a significant (p < 0.05) decrease in the alkaloids content of plantain peels alone (0.93±0.002) compare to that of ash extract of banana peels alone (1.60±0.000) and the ash extracts of plantain peels and banana peels was reduced when mixed with palm oil which recorded 0.81±0.001mg/100g and 1.08±0.003mg/100g of alkaloids content. Therefore, palm oil was effective in reducing the alkaloid content in the two samples. This result was in line with the research result obtained by Ollor, et al., (2022) who observed that there was a decrease in the alkaloid content in bitter leaf extract treated with oil palm.

**Table 4. Effect of palm oil on Anti-nutrients composition of ash extract of *Musa paradisiaca and* *Musa sapientum* peels (mg/100g)**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Samples** | **HCN** | **TANNIN** | **PHYTATE** | **OXALATE** | **ALKALOID** |
| **Control(Oil)** | 0.004c±0.00 | 0.008c±0.001 | 1.186c±0.011 | 0.110d±0.005 | 0.000 |
| **B – ASH** | 2.412b±0.06 | 0.752b±0.010 | 2.147ab±0.027 | 4.462b±0.056 | 1.60a±0.000 |
| **B –ASH + OIL** | 1.137ab±0.014 | 0.020ab±0.003 | 3.744ab±0.025 | 3.157c±0.025 | 1.08b±0.003 |
| **P – ASH** | 4.111a±0.024 | 1.396a±0.014 | 5.398b±0.014 | 8.104a±0.018 | 0.93ab±0.002 |
| **P – ASH + OIL** | 1.034ab±0.043 | 0.045ab±0.004 | 6.139a±0.010 | 5.402ab±0.020 | 0.81ab±0.001 |

**\*Mean ± standard deviation of 3 determinants**

**\*HCN – Hydrogen Cyanide, B – ASH – banana ash only, B- ASH + OIL – Bananna ash and Oil palm, P –ASH- Plantain Ash only, P – ASH + OIL – Plantain Ash and Oil palm**

**\*Means with different superscripts in a column are significantly different at p<0.05**.

**CHAPTER FIVE**

**CONCLUSION AND RECOMMENDATION**

**5.1 Conclusion**

The results of this research work has justify that the ash extract of *Musa paradisiacal* (plantain) peels are good plant source of antibacterial on bacteria isolated from palm oil as compared to ash extract of *Musa sapientum* (banana) peels. The result further justify that oil palm plays an important role in reducing the anti-nutrients contents present in the ash extract of both *Musa paradisiaca* (planatain) and *Musa sapientum* (banana) peels.

**5.2 Recommendation**

Therefore, it could be recommended that the waste from *Musa paradisiaca* (plantain) and *Musa sapientum* (banana) be used as plant antibacterial as there is no side effect as compared to synthetic or inorganic substances and the ash extracts of plantain and banana peels should be a preferred alternative to antimicrobials and antioxidants due to the reported toxic effect of synthetic substances. I also recommend further research on the effects of palm oil on the antinutritive and antibacterial properties of other related plants.

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