**TOPIC: COMPARATIVE STUDY OF ANTIBACTERIAL EFFECT OF THE ASH EXTRACT OF *Musa parasidiaca* and *Musa sapientum* PEELS ON PALM OIL**

**ABSTRACT**

The comparative study of antibacterial effect of the ash extract of *Musa paradisiaca* and *Musa sapientum* peels on palm oil *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 anti-nutrients present in the ash extract of the two Musa species peels.*

**Background of the study**

Palm oil (from the African palm oil, (*Elaeis guineensis)* can be traced back to more than 5000 years ago in Egypt *(*Kiple *et al.,* 2000*).* Palm oil *(Elaeis guineensis)* was long recognized in West African countries. 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 (Vijay *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.,* 2007; Emmanuel and Mudiakeoghene, 2008).

**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 wastes 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.

Furthermore, there had been an increasing interest in knowing the antimicrobial properties as well as the anti-nutritive 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 antibacterial effect of the ash extract of *Musa paradisiaca* and *Musa sapientum* peels on oil palm as well as the influence of oil palm on the anti-nutritive properties of the peels.

**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 antibacterial effect of the ash extract of *Musa paradisiaca* and *Musa sapientum* peels.

**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 antibacterial and anti-nutritive properties. This study also gives an insight on the importance of using agricultural wastes in preservation of food substances over synthetic compounds.

**Aim and Objectives of the Study**

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

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.

**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.,* 2000*).* 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. 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.



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

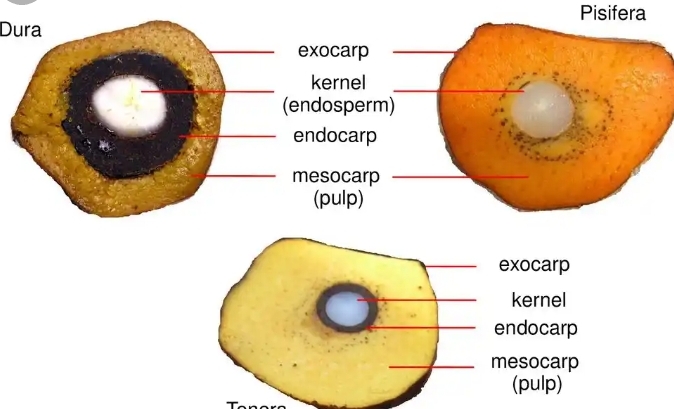
**ECONOMIC IMPORTANT OF OIL PALM**

* **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

* **Non Food Industry**

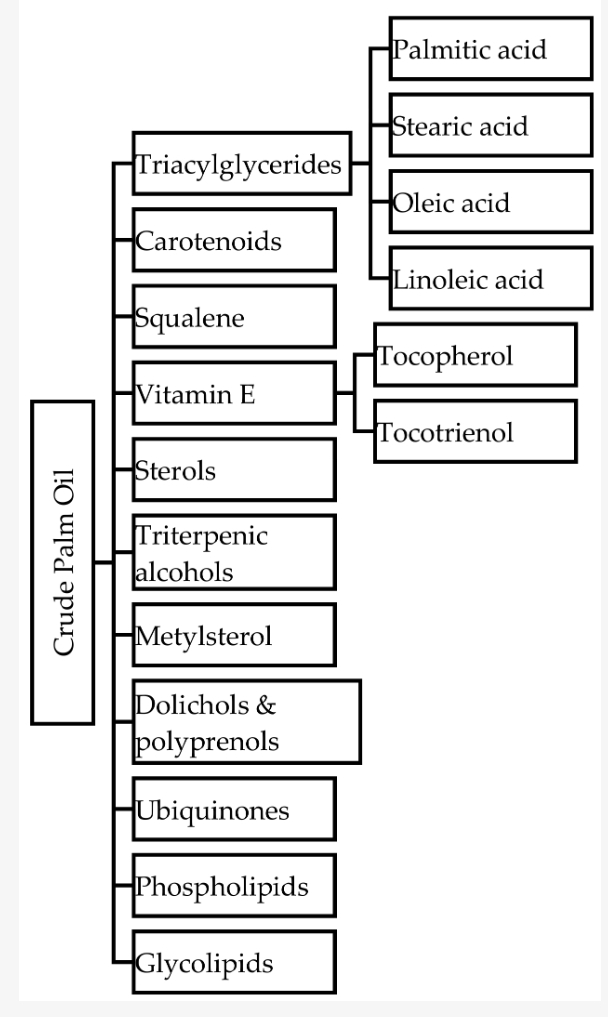
Palm oil products also find wide applications in the non-food sector, especially in the production of soaps and detergents, pharmaceutical products, cosmetics and oleochemical products. Around 70% of personal care products including soap, shampoo, makeup, and lotion, contain ingredients derived from 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.



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

* **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 *et al.,* 2006).



**Figure 3: Crude Palm Oil constituents**

**PHARMACOLOGICAL PROPERTIES OF MUSA SPECIES PEELS**

* ***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, (2003) 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 (2003) 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 *Musa 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 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).

* ***Anticancer activity***

Vijaya *et al*. 2017 reported that plantain peel aqueous extract-synthesized gold nanoparticles inhibited in 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 Mustafa (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.

* ***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).

* ***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 suggested as responsible for this effect due to their fundamental role in metabolism, bodily fluids and structural tissues composition.

* **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).

* **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 *Musa paradisiaca* leaves, its potent activity may be attributed to the presence of these phytoconstituents (Sanjeev *et al.,* 2012).

* **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 (Surbhi *et al.,* 2013).

* **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).

* **Antimicrobial properties**

In recognition of the role and importance of herbal medicine, World Health Organisation (WHO) has over the years 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 organized 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* 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.

* ***Mutagenecity***

It was reported the mutagenic effect of *Musa 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).

* ***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).

* ***Phytochemicals 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 1.1: 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*

**MATERIALS AND METHODS**

**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.

**EXPERIMENTAL 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.

**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.

**ANTIBACTERIAL ASSAY**

* ***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.

* ***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.

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

**Table 1.2: 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 |

* ***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.

**ANTINUTRTIVE ANALYSIS**

* ***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.

* ***Determination of alkaloid***

This was done by the alkaline precipitation gravimetric method described by Harbourne, (1973). 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.

* **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

* **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.

* ***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.

* + - ***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 bringing 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.

**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).

**RESULTS AND DISCUSSION**

**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 sapientum* 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 *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 1.3 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**.

**Anti-nutrients composition of ash extract of *Musa paradisiaca and* *Musa sapientum* peels as influence by palm oil**

* **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.

* **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).

* **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); Lawal and Adewale, (2004) who attributed the decrease in oxalates content of plants material to thermal heat and presence of other mineral elements.

* **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 1.4. 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**.

**CONCLUSION AND RECOMMENDATION**

**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.

**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.

**REFERENCES**

Abdel Aziz S. Ahmed O., Abd El-Twab M., Al-Muzafar H., Amin K. and Abdel- Gabbar M. (2020). Antihyperglycemic effects and mode of actions of *Musa paradisiaca* leaf and fruit peel hydroethanolic extracts in nicotinamide streptozotocin-induced diabetic rats. *Evid Based Complement Altern Medical,* (9): 276 - 343.

Abdel Ghany T., Ganash M., Alawlaqi M., Al-Rajhi A. (2019). Antioxidant, antitumor, antimicrobial activities evaluation of *Musa paradisiaca* L. pseudostem exudate cultivated in Saudi Arabia. *Bio-NanoScience*, 9:172–178.

Anhwange B. (2008). Chemical Composition of *Musa sapientum* (Banana) Peels. *Journal for food Technology,* 6 (6); 263-266.

Arun K., Madhavan A., Reshmitha T., Thomas S. and Nisha P. (2018) *Musa paradisiaca* inflorescence induces human colon cancer cell death by modulating cascades of transcriptional events. *Food Function,* 9:511–524

Ashok, K., Aditya, L. and Semwal, D. (2016). Effect of Microwave Drying on Nutritional and Antinutritional Factors of Dolichod Lablab Beans". *International Journal of Science Engineering and Technology,* 41 (5), 711-715

Asma, B. Nabil, K and Nourhène, B. (2011)."Effect of Microwave Treatment on Physical and Functional Properties of Orange *(Citrus Sinensis)* Peel and Leaves". *Food Processing & Technology,* 2 (2), 100-109

Asoso O., Akharaiyi C., Animba L. (2016). Antibacterial activities of plantain (*Musa paradisiaca*) peel and fruit*. Der Pharmacological Lett,* 8:5–11

Awak, E.**,** Udofia, O., Akan, O., Uffia, I. and Udoekong, N. (2017). Proximate and Anti-Nutrient Compositions of Cocoyam (*colocasia esculenta*): the Effect of Cooking and Dietary Palm Oil Treatments. *International Journal of Biochemistry Research & Review,* 19(1): 1-7

Borges M., Alves D., Raslan D., Piló-Veloso D., Rodrigues V., Homsi-Brandeburgo M., de Lima M. (2005). Neutralizing properties of *Musa paradisiaca* L. (Musaceae) juice on phospholipase A2, myotoxic, hemorrhagic and lethal activities of crotalidae venoms. *Journal of Ethnopharmacol,* 98: 21–29.

Chodera E., Goel R. and Ibu J. (2007). Effect of flavanoid fractions of *Solidago virgaurea* L. On diuresis and levels of electrolytes. *Acta. Pol.Pharm,* 48: 35-37

Chokoeva A., Zisova L., Chorleva K., Tchernev G. (2016). *Aspergillus niger -* a possible new etiopathogenic agent in Tinea capitis, Presentation of two cases. *Brazilian Journal Infect Dis,* 20:303–307.

Choong, M. (2012). "Waste not the palm oil biomass". The Star Online*. Available at:* [*http://www.apsnet.org/apsstore/shopapspress/Pages/43143.asp*](http://www.apsnet.org/apsstore/shopapspress/Pages/43143.asp)

Correa M., Mesomo M., Pianoski K., Torres Y., Corazza M. (2016). Extraction of inflorescences of *Musa paradisiaca* L. using supercritical CO2 and compressed propane. *Journal of Supercrit Fluids,* 113:128–135

Duita P., Das A. and Banerji N. (2004). Tetracyclic Triterpenoid from *Musa paradisiaca. Phytochemistry*, 22 (11):2563-2564.

Duncan, D.B., (1955). Multiple Range and F-Tests. *Biometrics, 11:1-42*

Emaga G., Anhwange B. and Lewis A. (2007). Effects of the stage of maturation and varieties on the chemical composition of banana and plantain peels. *Food Chemistry,* 103: 590–600

Emmanuel, O. and Mudiakeoghene, O. (2008). The use of antioxidants in vegetable oil-A review. *African Journal of Biotechnology,* 7(25): 4836-4842.

Enrol, D., Mechmet, U., Ferda, C., Dimitra, D., Gulhan, V.U. Mosschos P. and Atalay, S. (2007). Antimicrobial and antioxidantive activities of essential oils and methanol extract of Saliva cryptantha and Saliva multicaulis, *Journal. Food Chemistry,* 84: 519-525.

Fahim M., Anhwange B. (2019). TLC-bioautography identification and GC-MS analysis and antioxidant active compounds in Musa × paradisiacal L. fruit pulp essential oil. *Phytochemical Analysis,* 30:332–345.

Famakin O., Fatoyinbo A., Ijarotimi O., Badejo A., Fagbemi T. (2016). Assessment of nutritional quality, glycaemic index, antidiabetic and sensory properties of plantain (*Musa paradisiaca*)-based functional dough meals. *Journal of Food Science Technology,* 53:3865–3875.

Feumba, D., Ashwini, R. and Ragu, S. (2005)."Chemical composition of some selected fruit peels". *European Journal of Food Science and Technology,* 4 (4) 12-21.

Fitz-Gibbon S. (2013) *Propionibacterium acnes* strain populations in the human skin microbiome associated with acne. *J. Investigating Dermatol.*, 133:2152–2160

Goel, R. K (2003). Anti-Ulcerogenic Effect of Banana Powder (*Musa sapientum*var. paradisiaca) and Its Effect on Mucosal Resistance. *Journal of Ethnopharmacol.*18:33-44.

Hans Spross (2018). "Does EU biofuel deal compromise the environment for trade with Southeast Asia?” *Available at: https://en.m.wikipedia.org/wiki/Palm\_oil.*

Harborne, (1973). *Phytochemical Methods*: *A Guide to Modern Techniques of plantAnalysis*. Chapman and Hall Ltd: London.

Helen, B. (2007). The oil for Ape scandal: How palm oil is threating the orangutan. Friends of the Earth.

Ho LH, Noor Aziah A. and Rajeev B (2012). Mineral composition and pasting properties of banana pseudo-stem flour from *Musaacuminata* X balbisiana CV. Awak grown locally in Perak, *Malaysia. International Food Research Journal* 19(4):1479-1485.

Houghton PJ, and Skari K (2009). The effect of Indian plants used against snakebite on blood clotting. *Journal for Pharmacology.* 44:1054–60.

Hutchings, R., Athanasiadous, S, Kynazakis, I, Gordon, J (2003). Can animals use foraging behaviour to combat parasites? *Procedure of Nutrition Society*, 62(2):301.

Imam M. Z, Akter S. (2011). *Musa* *paradisiaca* L. and *Musa sapientum* L., a phytochemical and pharmacological review. *Journal of Applied Pharmaceutical Science.* 1:14–20.

Inuwa, M., Aina, O., Baba,G., Aimola, I and Toyin, A (2011). Comparative determination of Antinutritional factors in groundnuts and palm oil. *Advanced Journal of Food Science and technology*, 3(4): 275 - 279

Iyawe, H. and Azih, M. (2011). Total Phenolic content and lipid peroxidation potentials of some tropical antimalarial plants. *European Journal of medical plants*, 1:33-39.

Jain D. M, Ketiku A.O and Perfumi M (2007). Study of antacid and diuretic activity of ash and extracts of *Musa sapientum*L. Fruit peel. *Pharmacology. Management* 3(10): 116-119.

Jawla S, Kumar Y, Khan M (2012). Antimicrobial and antihyperglycemic activities of *Musa paradisiaca* flowers. *Asian Pac Journal of Trop Biomed* 2: 914–S91

Jong, H (2020). "Top Indonesian Palm Oil Developments". *Mongabay Journal of sciences.* 3(2): 32 -56

Karadi RV, Arpan S, Pranav P, Parvez A (2011). Antimicrobial activitiesof Musa paradisiaca and Cocos nucifera. *International Journal of Res Pharmacology and Biomedical Science.* 3(1):264-267.

Karuppiah, P and Mustafa, M (2013). Antibacterial and antioxidant activities of *Musa* sp. leaf extracts against multidrug resistant clinical pathogens causing nosocomial infection. *Asian Pac Journal of Trop Biomed* 3:737–742.

Ketiku, A.O (2005). Chemical composition of unripe (green) and ripe plantain (*Musa paradisiaca*). *Journal of Science. Food and Agriculture.* 24(6):703 –707.

Khanahmadi, S and Janfeshan, D (2006). The usefulness of palm oil and its origin. *Journal of Botany*. 23(3): 43 -54.

Kiple, F.; Conee, O., Kriemhild, E. (2000). The Cambridge World History of Food. *Cambridge University Press.* p. II.E.3. ISBN 978-0521402163.

Kiple, F.; Conee, O., Kriemhild, E. (2000). The Cambridge World History of Food. *Cambridge University Press.* p. II.E.3. ISBN 978-0521402163.

Kirk A. and Sawyer, O. 1998Chemical composition of unripe (green) and ripe plantain (*Musa paradisiaca*). *Journal of Science. Food and Agriculture.* 24(6):703 –707.

Koh, C. S. (2006). Commets on draft document: Diet, nutrition and other prevention of chronic diseases. *Available at;* [*http://www.who.int/dietphysicalactivitymedia/en/gsfao\_cmo\_068*](http://www.who.int/dietphysicalactivitymedia/en/gsfao_cmo_068).

Krishnan SSC, Subramanian IP, Subramanian SP (2014) Isolation, characterization of syringin, phenylpropanoid glycoside from *Musa paradisiaca* tepal extract and evaluation of its antidiabetic effect in streptozotocin induced diabetic rats*. Biomed Prev Nutr* 4:105–111

Kumar S, Mishra CK, Ahuja A, Rani A, Nema N (2012) Phytoconstituents and pharmacological activities of *Musa Paradisiaca* Linn. *Asian Journal of Pharmacy* 4:199–204

Ladeji, O. Akin, C and Hanson A (2004). Umaru" Level of antinutritional factors in vegetables commonly eaten in Nigeria". *African Journal of Natural Sciences,* pp. 71-73.

Lawal, S and Adewale, K (2004). "Effect of acetalation and succinylation on solubility profile, water absorption capacity, oil absorption capacity and emulsifying properties of municina bean (Mucuna prilens) protein concentrate". *Nahrung/Food,* 48(2), pp. 129 –136.

Loh Soh Kheang; Choo Yuen May; Cheng S.; Ma Ah Ngan (2006). Recovery and conversion of palm olein-derived used frying oil to methyl esters for biodiesel. *Journal of Palm Oil Research. 34(3): 12 - 32*

Lopez V., Jager, K, Akerreta, S., Cavero, Y., Calvo, M. (2011). Pharmacological properties of *Anagallis arvensis L.* (“scarlet pimpernel”) and *Anagallis foemina Mill.* (“blu e pimpernel”) traditionally used as wound healing remedies in Navarra (Spain). *Journal of Ethnopharmacology*; 134: 1014-1017.

Matthäus, Bertrand (2007). "Use of palm oil for frying in comparison with other high-stability oils". *European Journal of Lipid Science and Technology.* 109 (4): 400–409.

Mecance A. and Widdowsan N., (1953). Phytate in food. *Journal of Science*, 1:23

Mohapatra, D., Mishra S., Sutar, N (2010). Banana and its by-product utilization: an overview. *Journal of Scientific and Industrial Research.*269:323–329.

Mokbel, S and Fumio, H (2005). Antibacterial and antioxidant activities of banana fruit peel. *American journal of Biochemistry and Biotechnology.* 1(3); 125

Mokbel, S and Fumio, H (2005). Antibacterial and antioxidant activities of banana fruit peel. *American journal of Biochemistry and Biotechnology.* 1(3); 125

Mukhopadhyaya, H (1987). Effect of Banana Powder (*Musa sapientum*var. paradisiaca) on Gastric Mucosal Shedding. *Journal of Ethnopharmacology*. 21:11-19.

Nahian, D., Rafsan, I, Nurul, S (2016). "Production of Biodiesel from Palm Oil and Performance Test with Diesel in CI Engine".

Nelson, V., Ploetz, N and Kepler, S(2008 ). "Tracing antiquity of banana cultivation in Papua New Guinea". *The Australia & Pacific Science Foundation.*

Nimri, F., Meqdam, M. and Alkofahi, A(1999). Antibacterial activity of Jordanian medicinal plants. *Pharmaceutical Biology*. 37 (3), 196-201.

NPR (2018). Palm oil in the food supply What you should know almitic

Okorondu, I, Sokari, G, Akujobi, O, Braide, W (2010). Phytochemical and antibacterial properties of *Musaparadisiaca* stalk plant. *International Journal of Biological Science*, **2**(3): 128-132.

Orie N. (1997). Direct Vascular Effects of Plantain Extract. *Journal of sciences*: 9-13.

Osim E., Ibu J and Goel R. (1990). The effect of plantain and banana extracts on blood pressure and heart rate in albino rats*. Nigerian Journal of Physiology and Science.* 6: 114-119.

Osim, E. And Ibu, O (1991). The Effect of Plantains (*Musa paradisiaca*) on DOCA-Induced Hypertension in Rats. *Pharmaceutical Biology*.29 (1): 9-13

Padam B, Tin H, Chye F, Abdullah M (2012) Antibacterial and antioxidativeactivities of the various solvent extracts of banana (*Musa paradisiaca* cv. Mysore) inflorescences. *International Journal of Biological Science* 12:62–73

Padam B, Tin H, Chye F, Abdullah M (2012) Antibacterial and antioxidativeactivities of the various solvent extracts of banana (*Musa paradisiaca* cv. Mysore) inflorescences. *International Journal of Biological Science* 12:62–73

Pari, L and Umamaheswari, J (2009). Antihyperglycaemic activity of *Musa sapientum*flowers: effect on lipid peroxidationin alloxan diabetic rats. *Phytother Research,* 14(2): 136-8.

Parugganan, Michael D.; Fuller, Dorian Q (2001). "The nature of selection during plant domestication". Nature. *Nature Research*. 457 (7231): 843–848.

Perfumi M, Massi M and de Caro G (2008). Effects of Banana Feeding on Deoxycorticosterone-Induced Hypertension and Salt Consumption in Rats. *Pharmaceutical Biology*. 32(2); 115-125.

Perry, A, Lambert P (2011). *Propioni bacterium acnes*: infection beyond the skin. Expert Rev Anti Infect *Thermophysiology* 9:1149–1156

Prakash B, Sumangala CH, Melappa G, Gavimath C (2017). Evaluation of antifungal activity of banana peel against scalp fungi. *Mater Today 4:*11977–11983

Rabbani V., de Caro, G and Orie, N. (2010). Clinical studies in persistent diarrhea: dietary management with green banana or pectin in Bangladeshi children. *Gastroenterol.*121 (3): 554-560.

Rabbani, H., Teka, T., Saha, K, Zaman, B., Majid, N., Khatun, M., Wahed, A., Fuchs, J (2012). Green banana and pectin improve small intestinal permeability and reduce fluid loss in Bangladeshi children with persistent diarrhea. *Sciences.*49 (3):475-84.

Robert-Jan, B and Alissa, C ( 2018). "EU to phase out palm oil from transport fuel by 2030". *Availableat: https://en.m.wikipedia.org/wiki/Palm\_oil.*

Ruger, W., Klinker, J. and Hammond, G. (2002). Abilities of some antioxidants to stabilize soybean oil in industrial use conditions. *Journal for American Oil Chemistry Society.* 79(7): 733-736.

Salau, B (2010). Methanolic Extract of *Musa sapientum*Sucker Moderates Fasting Blood Glucose and Body Weight of Alloxan Induced Diabetic Rats. *Asian Journal. Exp. Biol. Science.*1 (1): 30-35.

Sanjeev K, Andrade. B., Perazzo, F., and Maistro, E. (2012). Phytoconstituents and Pharmacological activities of *Musa paradisiaca* Linn. *Asian Journal of Biochemical and Pharmaceutical Research.* 2(4):203-4

Saravanan, K, Aradhya, S (2011). Polyphenols of pseudostem of different banana cultivars and their antioxidant activities. *Journal for Agricultural and Food Chemistry* 59:3613–3623

Subrata, B, Anusua, C., Joysree, D., Sheikh, R., Manik, C., Kumar, K (2011). Investigation of antibacterial activities of ethanol extracts of Musa paradisiaca Lam. *Journal of Applied Pharmacology and Science,* 1: 133-135

Surbhi G., Lewis, D. and Shaw G. (2013). Analgesic activity of aqueous extract of *Musa paradisiaca*. *Der Pharmacia Sinica*: 2(4), 74.

Taha, M., Kohnen, C., Mallya, S., Kou, Y, Zapata, A, Ramirez-Arcos, S (2018) Comparative characterization of the biofilm-production abilities of *Staphylococcus epidermidis* isolated from human skin and platelet concentrates. *Journal for Medical and Microbiology* 67:190–197.

Tian, L. and White, P. (1994). Antioxidant activity of Oat extracts in soybean and cottonseed oils. *Journal American Oil Chemistry Society* 71: 1079-1086.

Tsuchiya, H, Sato, M, Linuma, M, Yokoyama, J., Ohyama, M., Tanaka, T, Takase I, Namikawa I (1994). Inhibition of the growth of carcinogenic bacteria *in vitro* by the plant flavonones. *Experimentia*, 50: 846-849

Tullis, Paul (2019). "How the world got hooked on palm oil". *Available at:* [*https://en.m.wikipedia.org/wiki/Palm\_oil*](https://en.m.wikipedia.org/wiki/Palm_oil)*.*

Ullah, J., Hamayoun, M., Ahmed T., Ayub, M. and Zarafullah, M. (2013).Effect of light, natural and synthetic antioxidants on edible oils and fats. *Asian Journal of Plant Sci.* 2(17-24): 1192-1194.

Vijaya S, Presanna K, Vijayalakshmi, R (2015) Antioxidant activity of banana flavonoids. *Fitoterapia* 79:279–282

Waalkes B. (2001). Serotonin, Norepinephrine, and Related Compounds in Bananas. *Science*127 (3299); 648-650.

WHO (2013). Benefits of plantain in Human Diet. http://who.org/ *Benefits of plantain in Human Diet.*

Wikipedia (2013). Palm Oil origin, importance and chemical composition. [*http://en.wikipedia.org/wiki/palmoil.*](http://en.wikipedia.org/wiki/palmoil.%20Retrieved%2024/07/2007) *.*