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Comparative analysis of Proximate and Anti-fungal Activities on Palm Oil Treated Ash Extracts of *Musa sapientum* and *Musa paradisiaca* Peels collected from Local Market in Akwa Ibom State, Southern Nigeria

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ABSTRACT: Extracts from banana and plantain parts (flowers, bracts, ripe, unripe fruits, leaves, and stems) have bioactive constituents used as therapies for different human ailments. Although similar in growing on large herbs, elongated leaves, and producing edible fruits, they differ in taste and need for processing. This study used standard methods to evaluate differences due to palm oil treatment on the proximate and anti-fungal activities of ash extract of Musa sapientum and Musa paradisiaca peels collected from local market in Akwa Ibom State, Southern Nigeria. Results show that the moisture content of banana (M. sapientum) peel ash extract was 1.68 ±0.001 and 1.34 ±0.002 % with and without palm oil treatment, respectively. Also, the moisture content of plantain (Musa paradisiaca) was 1.29 ±0.002 and 1.17 ±0.003 % with and without palm oil treatment, respectively. However, the crude fibre, ash, and protein contents of ash extracts (M. paradisiaca and M. sapientum) decreased ($p < 0.05$) with a palm oil treatment. Conversely, palm oil amendment increased the ash extracts' lipid, carbohydrate, and energy values. Ash extracts (M, paradisiaca, and M. sapientum) increasingly inhibited the growth of typical palm oil fungal species in a concentration-dependent manner. Their anti-fungal activities show they could be used as natural food preservatives or therapeutic agents in fungal disease conditions.

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There is increasing interest in functional foods and ingredients with potential use in precision medicine and shelf life extension. These interests are derivable due to the vast health-promoting benefits of plant-based foods (and their bioactive contents)- with or without processing (Xing *et al.*, 2023; Olovo *et al.*, 2021; Mokbel and Fumio, 2005; Jayaprakasha *et al.*, 2001). Plants and plant parts' bioactive compounds exhibit nutritive, health-promoting, colouring, and preservative properties and are applicable as natural

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spices, food adjuncts, natural preservatives, colourants, and therapeutic agents against several diseases (Udofia *et al.,* 2023; Akan *et al.,* 2022; Uffia *et al.,* 2021; Akpanikot *et al*., 2019). The World Health Organization (WHO) data estimate that 80 % of the global population primarily depends on traditional medicine for their primary healthcare needs. Their efficacy depends on diverse mechanisms triggered by plant extracts or their active components, increasing the interest in different medicinal plants (Andrew *et al*., 2012; Jachak and Saklani, 2007). Numerous research studies have explored medicinal plants for their anti-oxidant constituents and potentials, such as vitamins C, E, and B and flavonoids. Vitamin C is a free-radical scavenger and has been shown to inhibit lipid peroxidation in liver and brain tissue in animals (Udo *et al.,* 2023). Natural antioxidants are found in plant or animals that retard oxidative rancidity of oil, fats and fat soluble components, protecting and at the same time delaying the development of unpleasant flavors and odors resulting from oxidation process (Uffia *et al.,* 2024a).

Several medicinal plants are known for their antilithiatic, anti-oxidant, anti-microbial, anti-diabetic, anti-ulcer, anti-diarrhoeal, hypocholesterolemic, hepatoprotective, anti-snake venom, wound healing, hair growth promoting, anti-fungal, and antihemorrhagic activity: plants of the *Musaceae* family are notable (Jahan *et al*., 2010). The intake of plant and plant parts (flowers, bracts, ripe fruits, unripe fruits, leaves, and stems) extracts and their bioactive constituents ameliorate many human ailments. Likewise, peels and other vegetative parts (apart from the fruits) are used in animal feeding (Heuzé *et al.* 2016). Bananas and plantain peels are underutilized sources of phenolic and anti-oxidant compounds fit for incorporation in foods and formulation of functional foods (Heuzé *et al.* 2016). Retrospective reports show they are commonly used as a home remedy for several skin problems, including allergies, bruises, and skin irritation (FAO, 2021). These benefits make them suitable candidates for many medical and biotechnology products.

Palm oil is the world's most widely produced edible vegetable oil and has been used for food preparation for over 5,000 years. Crude palm oil (CPO, also known as red palm oil, RPO) is naturally reddish because it contains a high amount of beta-carotene and other health-promoting compounds, such as triacylglycerol (TAGs), vitamin E, and phytosterols. However, impurities, such as phospholipids, free fatty acids (FFAs), gums, and lipid oxidation products, can be removed through refining processes (Awak *et al*., 2017). Its nutritional and preservative properties are well-documented, and it is currently enjoying strong appeal worldwide as a cooking aid because it is free of artery-clogging trans-fats (Chandrasekharan *et al.,* 2000; Uffia *et al.,* 2024b). Hence, the objective of this paper is to evaluate the proximate and anti-fungal activities of ash extract of *Musa sapientum* and *Musa paradisiaca* peels treated with palm oil collected from a local market in Akwa ibom State, Southern Nigeria.

MATERIALS AND METHODS

Sample Collection and Preparation: Healthy plantain, banana fruit bunches, and about 2 liters of palm oil were purchased from a local market in Akwa-Ibom State, Southern Nigeria. The peels of the fruits were removed, washed with clean running water, and sliced into smaller pieces of 2.0 mm thickness using a sterile kitchen knife. These were further divided into two portions and sundried for four weeks. The portions were later coarsely powdered in a Willy Mill to 60-mesh size and used for solvent extraction in the Department of Biochemistry laboratory for analysis.

Proximate Composition Analysis: The proximate composition (nutrient) was determined with their respective methods as described by (AOAC, 2012) at the University of Uyo, Uyo. Nigeria. The analysis involved wet digestion, distillation, and titration. The moisture content was determined using an open-air oven, Crude protein by Kjeldahl method, Total fat by acid hydrolysis, and Ash and Fibre by enzymatic gravimetric method. Carbohydrate was determined according to the difference method by calculation. Statistical analysis was carried out on the average triplicate data to evaluate the significance of the nutrient.

Anti-fungal assay and susceptibility test: Typical fungal isolates were isolated from palm oil samples by serially diluting and plating 1 ml from dilution factors 10^3, $10^{4,}$ and 10^5 into separate sterile Petri dishes. An appropriate quantity of potato dextrose agar (PDA) was poured, swirled gently to mix, and allowed to set. The plates were then incubated at room temperature for 3-5 days, and appropriate growths were observed after 2-5 days (Nitave *et al.,* 2014). Purified fungal isolates were stored in McCartney bottles (in a 4 ^oC refrigerator) and labeled (Prakash *et al.,* 2017). The macroscopic characteristics of the fungal species were recorded and compared with details in the identification guide by Oyeleke and Manga (2008), while the microscopic characteristics were determined using lactophenol cotton blue stain as Okorondu *et al.* (2010) described.

Fungal susceptibility testing: We used the agar well diffusion method to determine the susceptibility of fungal isolates from palm oil to the ash extracts (Mansour *et al*., 2015). The 0.5 McFarland's standard was used to inoculate each isolate in a sterile plate. Ash extracts were then added to holes centrally perforated (3 mm) on solidified potato dextrose agar (PDA) plates. The holes were made using a sterile cork borer, while graduated (0.5, 0.25, and 0.125 mg/ml) of the ash extracts were added per isolate. The set-up was incubated for four days at 28 ^{o}C. The incubated plates were monitored for radial fungal growth, and the lowest ash extract concentration that inhibited fungal growth was recorded as growth inhibition concentration (expressed in percentage).

RESULTS AND DISCUSSIONS

The proximate analysis data of plantain (*Musa paradisiaca*) and banana (*Musa sapientum*) peel ash extracts showed very similar content values, significantly higher than those for oil samples (save for lipid and energy contents). Anhwange *et al.* (2009) reported that the moisture content of foods or processed products indicates their freshness and shelf life potential. In Table 1, the banana peels seem to have higher moisture contents than the plantain peels; however, palm oil amendment significantly (p > 0.05) increased the moisture contents of the ash extracts. The moisture content of banana ash extract was 1.68 ±0.001 and 1.34 ±0.002 % with and without palm oil amendment, respectively. The moisture contents of plantain ash extract were 1.29 ±0.002 and 1.17 ±0.003 % with and without palm oil amendment, respectively. This aspect of the results was similar to that obtained in works by Almeida *et al.* (2010) and Awak *et al.* (2017). Essentially, adding palm oil increased the moisture content of the ash extract samples.

The ash content of the banana (*M. sapientum)* peel ash extract with and without palm oil treatment was recorded at 23.64 ±0.001 and 24.30 ±0.00 %, respectively. The ash content of the plantain (*M. paradisiaca*) peel ash extract with and without oil treatment was recorded at 24.50 ±0.006 and 26. 11 ±0.002 %, respectively. Our study's ash content values were slightly higher than that of Puraikalan (2018) and Ogunlade *et al.* (2021). The ash content values for the extract samples became lower after the palm oil amendment. Results in Table 1 show that banana extracts had higher ash content than plantains, suggesting richer mineral content. Palm oil amendment also decreased the crude fiber content of extract samples (p < 0.05). In comparison, banana peel ash extract was 21.72 ±0.004 and 22.18 ±0.004 % with and without palm oil amendment. Those of plantain peel ash extract were 22.31 ±0.002 and 23.64 ±0.006 % with and without palm oil amendment. These crude fiber values were slightly lower than those reported by Wang *et al.* (2008) but higher than those reported by Puraikalan (2018) and Ogunlade *et al.* (2021). However, fibers aid digestion; therefore, supplementing food with these peel products could be a good option.

The protein content of banana peel ash extract with and without palm oil amendment was recorded at 2.45 ±0.003 and 4.23 ±0.003 %, respectively. These were slightly lower than the protein values obtained from plantain peel ash extract with and without palm oil amendment (3.26 ±0.004 and 5.25 ±0.004 %, respectively). The protein content results from this study varied from those of the Awak *et al.* (2017) study. After the palm oil amendment, the authors reported increased protein content in the cocoyam sample. However, our results were slightly lower than those reported by Puraikalan (2018) but higher than those reported by Ogunlade *et al*. (2021), and with lipid content, banana peel ash extract with and without palm oil treatment recorded 3.66 ±0.003 and 2.60 ±0.003 %, respectively. Plantain peel ash extract recorded 2.34 ±0.002 and 1.81 ±0.004 %, respectively, for lipid content with and without palm oil treatment. These lipid content values after palm oil amendment were slightly higher than those reported by Adeniyi *et al.* (2009). Although our values are somewhat lower than those reported by Puraikalan (2018), they fall within the value range obtained from a study conducted by Ogunlade *et al*. (2021).

The carbohydrate content in banana peel ash extract was slightly higher than those obtained from plantain peel ash extract. The carbohydrate content in banana peel ash extract with and without palm oil treatment was 48.53 ±0.012 and 47.26 ±0.25 %, respectively. Those from plantain peel ash extract with and without oil treatment were 46.99 ±0.0011 and 37.94 ±0.015 %, respectively. Carbohydrate content values from our work varied with those from Awak *et al.* (2017). After the palm oil amendment, the authors reported reduced carbohydrate content in cocoyam portions. Although our values are within the value range in Puraikalan (2018) report, they were slightly lower than those from Ogunlade *et al.* (2021).

Similarly, banana peel ash extract had a higher caloric value than plantain peel ash extract. The caloric value of banana peel ash extract with and without palm oil treatment was 227.46 ±0.245 and 224.38 ±0.542 Kcal, respectively. The caloric value of plantain peel ash extract with and without palm oil amendment was 236.86 ±4.56 and 189.05 ±1.31 Kcal, respectively. This was in variance with the reduced caloric value report with cocoyam portions in Awak *et al.* (2017). Our caloric values were slightly lower than those reported by Puraikalan (2018).

We tested the susceptibility of palm oil-associated fungal species on graduated concentrations of the peel ash extracts (see Table 2). Banana peel ash extract (at 1.00 mg/ml) significantly inhibited the growth of *Aspergillus fumigatus* (75 %), *Aspergillus niger* (100 %), *Rhizopus stolonifer* (56.67 %), and *Rhizopus oryzae* (76.67 %). The results above aligned with that of Okorondu *et al.* (2010). The authors observed a 100 % inhibitory action of 1.00 mg/ml *M. paradisiaca* peel methanol extract on *A. niger* and *R. stolonifera*. Plantain peel ash extract (at 1.00 mg/ml) inhibited *Aspergillus fumigatus* (60 %), *Aspergillus niger* (85 %), *Rhizopus stolonifera* (43 %), and *Rhizopus oryzae* (50.20 %); see Table 3. From Tables 2 and 3, the peel ash extracts inhibited the fungal species in a dose-dependent manner. The 0.125 mg/ml peel ash extract concentrations inhibited the lowest compared with the 1.0 mg/ml. *Aspergillus niger* was found to be more susceptible to peel ash extracts at higher concentrations. *M. paradisiaca* (plantain) peel ash extract demonstrated higher anti-fungal properties than *M. sapeintum* (banana) peel ash extract. The work of Nitave *et al.* (2014) concluded that anti-microbial agents of plant origin do not elicit undesirable side effects, and the work of Okorondu *et al.* (2010) attributes their action to alkaloids, flavonoids, and tannins contents of these peel ash extracts.

Table 1: Proximate composition of *Musa paradisiaca* (Plantain) *and Musa sapientum* (Banana) Peel ash treated with oil palm

Samples	Moisture (%)	Ash (%)	Fibre (%)	Protein (%)	Lipid (%)	CHO (%)	Energy (kcal)
Control (oil)	$0.19^{bc}\pm 0.001$	$0.23^{c}\pm 0.001$	-	$0.046^{d}\pm 0.002$	$90.49^{a}\pm 0.01$	$0.82^{d}\pm 0.07$	$891.53^{a}\pm 1.005$
B-Ash	$1.34^{b}\pm 0.002$	$24.30^{ab}\pm 0.004$	$22.18^{ab}\pm 0.004$	$4.23^{b}\pm 0.003$	$2.60^{c}\pm 0.025$	$47.26^{b}\pm 0.25$	$224.38^{bc}\pm 0.542$
P-Ash	$1.17^{c}\pm 0.003$	$26.11^{a}\pm 0.002$	$23.64^{a}\pm 0.006$	$5.25^{a}\pm 0.004$	$1.81^{e}\pm 0.004$	$37.94^{c}\pm 0.015$	$189.05^{c}\pm 1.310$
B-Ash + oil	$1.68^{a}\pm 0.001$	$23.64^{b}\pm 0.003$	$21.72^{b}\pm 0.004$	$2.45^{c}\pm 0.03$	$3.66^{b}\pm 0.003$	$48.53^{a}\pm 0.012$	$236.86^{b}\pm 4.56$
P-Ash + oil	$1.29^{ab}\pm 0.002$	$24.50^{ab}\pm 0.006$	$22.31^{ab}\pm 0.002$	$3.26^{c}\pm 0.004$	$2.34^{d}\pm 0.002$	$46.99^{ab}\pm 0.033$	$227.46^{bc}\pm 0.245$

*Mean with different superscripts in a column are significantly different at $p < 0.05$.
*B-Ash – Banana ash extract; *P-Ash – plantain ash extract; *B-Ash + oil – Banana ash extract with oil palm; *P-Ash + oil – plantain ash with oil palm

Table 2: Growth inhibition (%) of fungi by ash extract of *Musa paradisiaca* on oil palm isolates

Isolates	Extract Concentration (mg/ml)			
	1.0	0.5	0.025	0.125
Aspergillus fumigates	75.00	60.00	50.00	40.00
Aspergillus niger	100.00	70.00	53.33	26.67
Rhizopus stolonifera	56.67	26.67	10.00	07.00
Rhizopus oryzae	76.67	56.67	26.67	20.00

**Data represents the mean of triplicate determinations; *Reduction in radial fungal growth as compared with control and expressed as a percentage*

Table 3: Growth inhibition (%) of fungi by ash extract of *Musa sapientum* on oil palm isolates

Isolates	Extract concentration (mg/ml)			
	1.0	0.50	0.025	0.125
Aspergillus fumigates	60.00	45.67	43.40	35.32
Aspergillus niger	85.50	54.67	40.00	22.00
Rhizopus stolonifera	43.00	23.54	05.00	3.670
Rhizopus oryzae	50.20	42.40	20.58	14.00

**Data represents the mean of triplicate determinations: *Reduction in radial fungal growth as compared with control and expressed as a percentage*

Conclusion: Results from this study suggest that the peel ash extracts of *Musa paradisiaca* and *Musa sapeintum* could be novel and reliable nutrient sources with good anti-fungal properties. In the search for natural food additives with functional properties, ground peels could be used in food formulations due to their nutritional and preservative properties. Additionally, reusing these hitherto "agro-waste" is part of waste management. With palm oil treatment, plantain and banana peel ash extracts had higher lipid, carbohydrate, and energy values, making the products better for delivering total energy.

Declaration of conflict of interest: The authors declare no conflict of interest in this work.

Data Availability Statement: Data are available upon requestfrom the first author or corresponding author or any of the other authors.

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