Disparity in Antioxidant Activities of Some Selected Plant Waste Oil

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Abstract
Agro-industrial residues are often discarded despite being rich in bioactive compounds with potential antioxidant properties. Valorizing such wastes as natural sources of antioxidants could offer both environmental and economic benefits while providing safer alternatives to synthetic antioxidants. This study aimed to evaluate the antioxidant activities of oils extracted from Apple (Malus domestica Borkh) seed, tangerine (Citrus reticulata) seed, Plantain (Musa paradisiaca) peel, Date (Phoenix dactylifera) seed, Groundnut (Arachis hypogaea) hull, and Pear (Persea americana. L.) seed. Antioxidant activities were assessed through Ferric Reducing Antioxidant Power (FRAP) and 2,2-diphenyl-1-picrylhydrazyl (DPPH) assays. Data obtained were subjected to one way Analysis of Variance (ANOVA) to compare activities among the oils. In the DPPH assay, date seed oil exhibited the strongest scavenging activity, followed by plantain peel oil, while groundnut hull oil showed the lowest. In the FRAP assay, pear seed oil demonstrated the highest reducing power, whereas groundnut hull oil again recorded the lowest activity. Plantain peel oil ranked consistently high in both assays. The findings suggest that plant waste oils, particularly date seed, pear seed, and plantain peel oils, represent promising natural sources of antioxidants. Their utilization could reduce agro-waste burdens while supporting applications in food, pharmaceutical, and cosmetic industries.

Keywords: *Antioxidant activity; DPPH assay; Ferric reducing antioxidant power (FRAP); Natural antioxidants; Plant waste oils; Radical scavenging; Waste valorization*

Introduction

The overproduction of reactive oxygen species (ROS) and free radicals during normal cell activity leads to oxidative stress, which is involved in many chronic and degenerative diseases including cancer, cardiovascular disorders, diabetes, and neurodegeneration. Antioxidants play a crucial role in mitigating oxidative stress by neutralizing free radicals and thereby protecting biological systems from damage (Jakubczyk *et al*., 2020). Plants are remarkable sources of bioactive compounds, many of which exhibit potent antioxidant activity. In particular, seeds, peels, and other plant byproducts that are often discarded as waste have been found to contain phenolics, flavonoids, fatty acids, and other phytochemicals with radical scavenging and reducing properties (Alongi *et al.,* 2019). In recent years, studies on grape seed oil, mango kernel fat, and citrus peel extracts have demonstrated the promise of plant-derived waste materials as functional ingredients for food preservation, nutraceutical formulations, and cosmetic applications (Martin *et al*., 2020; Jin *et al*., 2020; Kesbiç *et al*., 2022).

Despite this progress, many common fruit and seed wastes remain underexplored for their antioxidant potential. For example, apple seeds and pear seeds, though rich in oils and polyphenolic compounds, are frequently discarded during juice processing (Khalil and Mustafa, 2020; Mushtaq *et al.,* 2019). Tangerine seeds, another abundant byproduct of citrus industries, contain bioactive lipids and phenolics that could offer antioxidant benefits (Maciel *et al*., 2023). Similarly, date seeds, which account for 10–15% of the fruit's weight, are typically discarded in large volumes despite reports of their high antioxidant content (Mrabet *et al.,* 2020). Plantain peels, commonly discarded in tropical regions, are known to contain flavonoids and phenolic acids, while groundnut hulls, an agricultural residue generated in significant quantities, are often underutilized despite evidence of their bioactive constituents (Tsado *et al*., 2021).

To characterize antioxidant activity, a variety of in vitro assays have been developed, each capturing different mechanisms of action. Among the most widely used are the 2,2-diphenyl-1-picrylhydrazyl (DPPH) assay, which measures free radical scavenging capacity (Brand-Williams *et al.,* 1995), and the Ferric Reducing Antioxidant Power (FRAP) assay, which evaluates the reducing ability of antioxidants to convert ferric (Fe^{3+}) to ferrous (Fe^{2+}) ions in the presence of a TPTZ (2,4,6-tripyridyl-s-triazine) complex (Benzie and Strain, 1996). These complementary assays offer a more comprehensive understanding of antioxidant potential since they probe both radical neutralization and electron-donating properties.

Agro-industrial residues are produced in huge quantities worldwide, posing environmental, economic, and management challenges. Interestingly, many of these wastes contain bioactive compounds with important properties that can be harnessed for human health and industrial use (Alongi *et al.,* 2019; Dang *et al.,* 2019). Proper valorization of such residues offers dual benefits by reducing pollution and providing sources of high-value byproducts. As such, assessing the antioxidant potential of selected plant waste oils is both timely and necessary to promote sustainability while identifying novel natural sources of health-promoting compounds. The objective of this study was therefore to evaluate the antioxidant properties of oil extracts from six different plant wastes.

2 Materials and method

Study Location

The study was carried out in Pharmaceutical Chemistry laboratory, Faculty of Pharmacy, University of Ibadan, Ibadan, Oyo state, Nigeria.

Sample Collection and Preparation

Apple seeds, tangerine seeds, pear seeds, plantain peels, date seeds, and groundnut hulls were manually separated from adhering pulp, thoroughly washed to remove dirt and then air-dried at room temperature for 10 days after which they were packed in zip lock bags and stored at room temperature air-dried at room temperature for 10 days. The dried materials were pulverized mechanically using a stainless grain laboratory pulveriser into fine powder and stored in airtight containers at 4 °C until oil extraction.

Oil Extraction

The dried blended samples were subjected to extraction using Soxhlet extraction method to obtain the fixed oil. The respective weight of the dried blended samples were packed into a Soxhlet apparatus, connected to a running water and allowed the extraction process for 3hrs. The oil extract was then concentrated using evaporator (Heidolph Laborata 400 efficient, made in Germany, model 517-01002-002) at 40^0C.

Ferric ion reducing antioxidant power (FRAP) assay

Ferric ions reducing power was performed according to the method of Oyaizu (1986) with modifications. Hydroalcoholic extract in different concentrations ranging from 100ul to 500ul were mixed with 2.5 ml of 20 mM phosphate buffer and 2.5 ml 1%, w/v potassium ferricyanide, and then the mixture was incubated at 50 °C for 30 min. Afterwards, 2.5 ml of 10%, w/v trichloroacetic acid and 0.5 ml 0.1%, w/v ferric chloride were added to the mixture, which was kept aside for 10 min. Finally, the absorbance was measured at 700 nm. Ascorbic acid was used as positive reference standard. All assays were run in triplicate way and averaged.

DPPH Radical Scavenging Assay

The free radical scavenging activity of the oils was evaluated using the DPPH method as described by Brand-Williams *et al.* (1995) with slight modifications. Absorbance was measured at 517 nm using a UV–V is spectrophotometer and the following concentrations of the extracts were prepared; 0.05, 0.1, 0.5, 1.0, 2.0 and 5 mg/ml in methanol (Analar grade). Vitamins C was used as the antioxidant standard at concentrations of 0.02, 0.05, 0.1, 0.2, 0.5 and 0.75 mg/ml. I ml of the extract was placed in a test tube, and 3 ml of methanol was added followed by 0.5 ml of 1 mM DPPH in methanol. A blank solution was prepared containing the same amount of methanol and DPPH. The radical scavenging activity was calculated using the following formula:

$$\% \text{ inhibition} = \{[Ab-Aa]/Ab\} \times 100$$

where Ab is the absorption of the blank sample and Aa is the absorption of the extract.

Statistical Analysis

Data obtained were subjected to one way Analysis of Variance (ANOVA).

3 Results

DPPH Radical Scavenging Activity

The DPPH assay revealed distinct differences in radical scavenging activity among the samples (Fig. 1). At lower concentrations (50 and 100 µg/mL), plantain peel oil exhibited the highest scavenging capacity, whereas groundnut hull oil consistently displayed the lowest activity. At higher concentrations (150, 200, and 250 µg/mL), date seed oil demonstrated the strongest radical scavenging activity, surpassing all other samples, while groundnut hull oil remained the least active. Overall, the order of DPPH scavenging efficiency across the tested oils was: date seed > plantain peel > apple seed > tangerine seed > pear seed > groundnut hull.

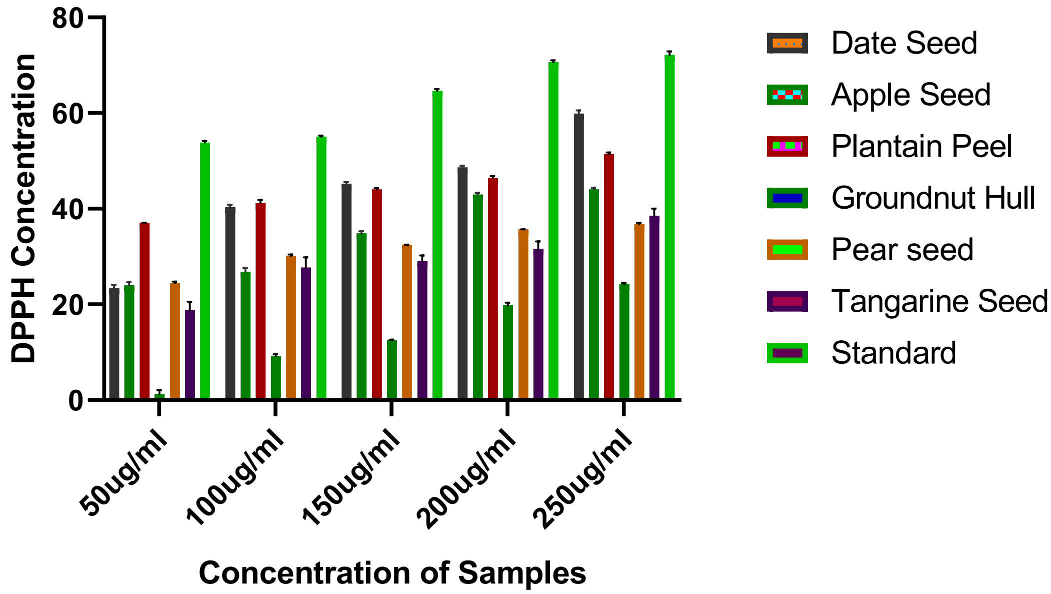

Figure 1: The scavenging power assay of the selected agricultural wastes

Ferric Reducing Antioxidant Power (FRAP)

In the FRAP assay, the reducing power of the samples also varied significantly (Fig. 2). Across all concentrations, groundnut hull oil consistently exhibited the lowest activity. Pear seed oil generally demonstrated the strongest ferric reducing capacity, except at 20 µg/mL where plantain peel oil was slightly higher, and at 40 µg/mL where pear seed and plantain peel oils recorded nearly equal values. The overall ranking of antioxidant activity based on FRAP was: pear seed > tangerine seed > date seed > plantain peel > apple seed > groundnut hull.

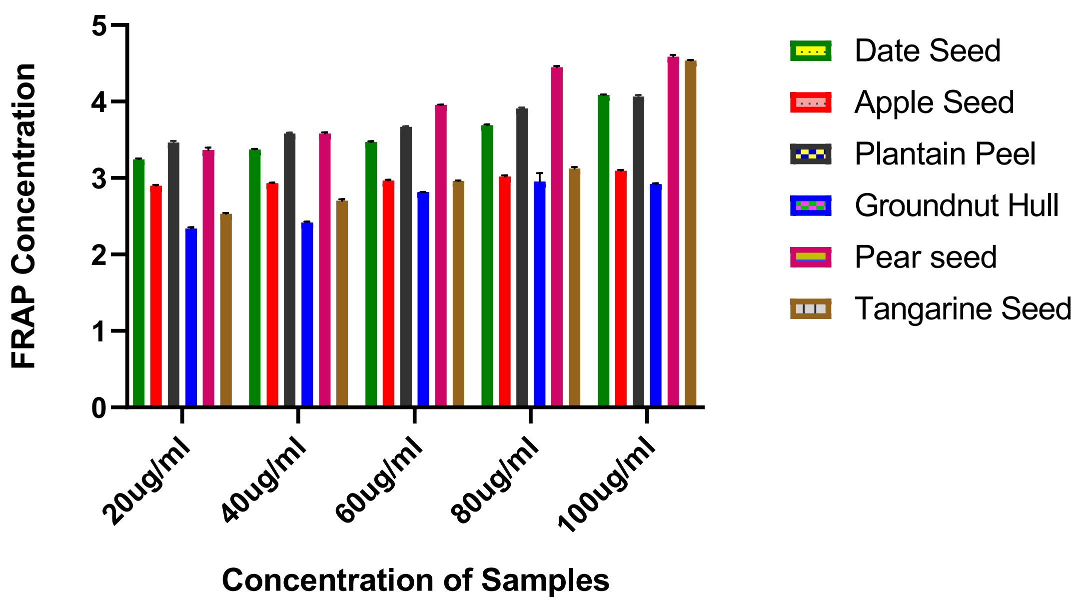

Figure 2: The ferric ion antioxidant power assay for the selected agricultural wastes

Discussion

The present study demonstrated that oils extracted from selected plant wastes exhibit varying degrees of antioxidant activity as assessed by DPPH and FRAP assays. These variations reflect differences in the phytochemical composition of the respective plant parts, which are known to influence radical scavenging and reducing capacities.

Among the tested samples, date seed oil showed the strongest radical scavenging activity in the DPPH assay. This is consistent with earlier reports that date seeds are rich in phenolic compounds, flavonoids, and unsaturated fatty acids that contribute to free radical neutralization (Himanshu *et al.*, 2024). Similarly, plantain peel oil ranked highly in both assays, supporting previous findings that banana and plantain peels are abundant in polyphenols and carotenoids with potent antioxidant effects (Tsado *et al*., 2021). In contrast, groundnut hull oil consistently showed the lowest activity, suggesting that its bioactive compound profile may be limited or present in low concentrations compared to other plant residues. The relatively strong performance of apple seed oil, especially in DPPH, aligns with earlier studies indicating that apple seeds contain bioactive phenolic compounds and essential fatty acids with antioxidative properties (Abid and Tawffiq, 2022).

The FRAP assay revealed that pear seed oil had the highest reducing power, surpassing other samples at most concentrations. Pear seeds have been reported to contain high levels of phenolic acids and flavonoids, particularly chlorogenic acid and catechin, which may account for their strong ferric ion-reducing capacity (Al-Naqeb *et al*., 2021). Tangerine seed oil also showed moderate antioxidant capacity, consistent with reports that citrus seeds harbor polyphenolic constituents and limonoids with notable biological activity (Tung *et al*., 2020).

The relative rankings of samples differed between the two assays. While DPPH primarily measures hydrogen or electron donation to neutralize stable free radicals, FRAP evaluates electron-donating ability toward ferric ions (Munteanu and Apetrei, 2021). The observed differences therefore suggest that certain oils may be more efficient radical scavengers, whereas others are stronger reducing agents, highlighting the importance of using complementary assays when assessing antioxidant potential. Overall, the findings indicate that underutilized plant waste oils such as those from date seed, pear seed, and plantain peel represent promising sources of natural antioxidants. Their potential applications extend to food preservation, nutraceuticals, cosmetics, and pharmaceuticals, where natural antioxidants are increasingly sought after as safer alternatives to synthetic compounds (Stokes *et al*., 2020).

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