

Comparative Phytochemicals and Antioxidant Activity of Solvent Extracts from Leaves and Fruit Peels of *Luffa aegyptiaca*

Muhammad Rabi Modibbo¹; Abdullahi Nasiru²; Aminu Idi²; Moses Zira Zaruwa¹; and Abubakar Yahaya¹

¹Department of Biochemistry, Faculty of Natural and Applied Sciences, Nasarawa State University Keffi, P.M.B. 1022, Nasarawa State, Nigeria. ²Department of Biochemistry, Faculty of Basic Medical Sciences, Bayero University Kano, P.M.B. 3011, Kano, Nigeria.

Corresponding author: modibbomr@nsuk.edu.ng

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Abstract

Luffa aegyptiaca (Mill.) is a member of the Cucurbitaceae family, found mostly in tropical Africa, including Nigeria, and some parts of India. The present study aimed to compare the phytochemical and antioxidant composition of various solvents (*n*-hexane, ethyl acetate, and methanol) extracts of *L. aegyptiaca* leaves and fruit peels. The leaves and fruit peels of *L. aegyptiaca* were processed and subjected to serial extraction using an ultrasonic-assisted method, and the phytochemical and antioxidant compositions of different extracts obtained were determined using standard procedures (*n*=3). The result showed that methanol yielded the highest percentage of extracts from both the leaves (6.0%) and fruit peels (4.8%) compared to *n*-hexane (2.2% leaves and 1.7% fruit peels) and ethylacetate (1.1% leaves and 0.4% fruit peels) (methanol > *n*-hexane > ethylacetate). Phytochemicals were relatively more abundant in the solvent extracts of the leaves, especially the methanol extract, compared with the fruit peel extracts. Antioxidant analysis showed that all extracts exhibited concentration-dependent activities in scavenging DPPH free radicals and chelating Fe²⁺. However, relatively higher antioxidant activities were observed in methanol extracts compared with the ethylacetate and *n*-hexane extracts (methanol > ethylacetate > *n*-hexane). Findings from the present study revealed that the leaves of *L. aegyptiaca* have comparatively higher phytochemical and antioxidant activities than the fruit peels, and the methanol extract is the best among the tested solvent extracts. Further research is therefore recommended to explore the practical applications of these findings in medical, nutritional, and industrial contexts, to pave the way for the use of *L. aegyptiaca* as a valuable resource in combating oxidative stress and related health issues.

Keywords: *Luffa Aegyptiaca*, Cucurbitaceae, Ultrasound Extractions, Phenolics, Flavonoids, Methanol Extract.

Introduction

Luffa aegyptiaca, commonly called sponge gourd or loofa, is a member of *Cucurbitaceae* family (Ani *et al.*, 2019). It is found mostly in tropical Africa, including Nigeria, and some parts of India (Ajuru and Nmom, 2017). In Nigeria, *L. aegyptiaca* is commonly found growing in dump sites and in polluted environments. Most parts of the plant (including leaves, stem

bark, seeds, and root) have been documented as effective and safe traditional treatment options for various diseases (Alagbe *et al.*, 2023; Al-Snafi, 2019). Studies have shown that the extracts of *L. aegyptiaca* possesses anti-inflammatory (Adeyeni *et al.*, 2020), antimicrobial (Alagbe *et al.*, 2023), anti-obesity (D'silva *et al.*, 2021), anti-diabetic (Shukla *et al.*, 2015), anticancer (Abdel-Salam *et al.*, 2018) properties among others.

Antioxidants are a class of chemical substances naturally found in our food which can prevent or reduce the oxidative stress of the physiological system (Duan *et al.*, 2019). A normal metabolism in the cells generates free radicals which are unstable, fleeting, and extremely reactive (Kok *et al.*, 2023). In many human diseases, the role of free radicals is highlighted as they cause damage to the cells of the body and contribute to various kinds of health problems, such as heart disease, diabetes, macular degeneration, and cancer (Tokgoz *et al.*, 2024). To conquer the oxidative stress, the use of anti-oxidants becomes mandate as it is associated with a reduction in the generation of reactive oxygen species and lipid peroxides, and decrease in oxidative stress, post-translational modification of proteins, and damage to the DNA (Chandana and Bhikshapathi, 2024). Phytochemicals are bioactive compounds that contribute to the medicinal properties of plants (Bhavsar *et al.*, 2023). The structures of these phytochemicals allow them scavenge free radical cells (Alara *et al.*, 2017). In recent years, several plants have been reported to contain phytochemicals and antioxidants that can protect a human system against different diseases.

Assessment of phytochemical and antioxidant properties of plant materials has been useful in assessment of therapeutic potential of plants. There are several comprehensive reports on phytochemical and antioxidant properties of different solvent extracts of various plants and plants parts. However, there is no single solvent generally considered standard for extraction as efficiency usually varies across different plants (Al-Farsi and Lee, 2008). While numerous studies have been conducted to elucidate the phytochemical and antioxidant properties of *Luffa* species, there are limited studies on the effect of different solvents on extraction efficiency of phytochemicals and antioxidant potentials of *L. aegyptiaca* despite its widespread local utilization for several medicinal purposes. The present study aims to compare phytochemical and antioxidant composition of various solvents extracts (n-Hexane, Ethylacetate, Methanol) of the leaves and fruit peels of *L. aegyptiaca*. This comparative analysis will provide valuable information on suitable solvent for extraction and optimization of therapeutic potentials of *L. aegyptiaca*.

Materials and Methods

Sample Collection

The leaves and fruits of *L. aegyptiaca* were collected from Keffi local government area of Nasarawa State. The plant was identified and authenticated at the Department of Plant Science and Biotechnology in Nasarawa State University, Keffi. A voucher specimen (voucher No. NSUK/PSB/045) was identified.

Preparation of Extracts

The collected fresh fruits and leaves were washed to remove dead materials and dust. The fruit was peeled, and the peels were allowed to dry for two weeks with the leaves under a shade, after which they were pulverised. Thereafter, the pulverised products were subjected to extraction using a Digital Ultrasonic Cleaner (40kHz, 220V).

Extraction was carried out serially using three (3) different solvents (n-hexane, ethylacetate, and methanol) in order of increasing polarity. 200g each of the pulverised leaves and fruit peels were separately added to the sonicator chamber containing 1000ml n-hexane and thoroughly mixed. The sonicator was then switched on and allowed to run for 20 minutes at 25°C, after which the extracts were collected in a clean beaker and the solid residues were allowed to dry completely at room temperature of 31 °C for 24 hours. The operation was further repeated on the dried residue using ethylacetate and finally methanol, each with 800ml of the solvent. After the extraction is completed, the three (3) extracts each of the leaves and fruit peels were filtered using whatman filter paper I (11µm) under vacuum and evaporated at room temperature. Finally, the dried extracts were weighed and kept in the refrigerator until use for analysis (Idi *et al.*, 2022).

Qualitative Phytochemical Screening

Qualitative phytochemical screening of the solvent extracts was carried out according to standard method as described by Trease and Evans (2002). The extracts were tested for the presence of cardiac glycosides, alkaloids, phytosterol, flavonoids, phenols, tannins and saponins.

Determination of Extraction Yield

The percentage yield of dried extracts of the samples were calculated using the following formula.

$$\% \text{Yield} = \frac{W_1}{W_2} \times 100$$

Where W₁ = weight of crude extract (g)

W₂ = weight of plant materials (g)

Quantitative Phytochemical Screening

Total phenolic contents (TPC): the TPC of the extracts were determined using Folin-Ciocalteu reagent and evaluated spectrophotometrically following the method described by Ebrahimzadeh *et al.* (2008). Accordingly, the extracts were diluted to various concentrations (200, 400, 600, 800, and 1000 µg/mL) and 0.5 ml of each dilution was separately mixed with 5 mL of Folin-Ciocalteu reagent (to get a ratio of 1:10 dilution), and then left to stand for 5 minutes before being neutralized with 4 mL of 1M Na₂CO₃ solution. The phenols were then measured using UV-Vis spectrophotometer at 765 nm after the solution was allowed to stand for an additional 15 minutes. The concentrations of phenolic

compounds in the extracts were expressed as mg of Gallic Acid Equivalents (GAEs) per gram of the dry extract.

Determination of Total Flavonoid Content (TFC): total flavonoid content was determined using method described by Ononamadu *et al.* (2019). Accordingly, 3.4 mL of 30% v/v methanol, 0.15 mL of 0.5M NaNO₂, and 0.15 mL of aluminum chloride (0.3M AlCl₃.6H₂O) were sequentially added to a test tube containing 0.3 mL of the extracts. The solutions were allowed to stand for 5 minutes, after which 1 mL of 1M NaOH was added and shaken. Absorbance of the resulting solutions were measured against the blank at 506 nm. The calculation of flavonoid content in Quercetin Equivalent (QE) was performed using a standard calibration curve created with quercetin.

Determination of Total Tannin Content (TTC): total tannins contents of the extracts were determined by the Folin-Ciocalteu method Ononamadu *et al.* (2019). Accordingly, 7.5 mL of distilled water and 0.5 mL of Folin-Ciocalteu phenol reagent were added to a test tube containing 0.1 mL of the sample extracts and shaken. After 5 minutes, 1 mL of 2% Na₂CO₃ solution was added and mixed thoroughly. The mixture was kept in the dark at room temperature for 30 minutes to develop colour. The absorbance for the test and standard solutions were measured against a blank at 725 nm. The standard curve for tannin was made using tannic acid standard solution and the tannin content was expressed as milligrams of tannic acid equivalence (TAE) per gram of dried crude extract.

Antioxidant Activity of Tested Extracts

DPPH radical scavenging: The DPPH scavenging effects of *L. aegyptiaca* extracts were determined according to the method of Brand-Williams *et al.* (1995). DPPH (2, 2-diphenyl-1-picrylhydrazyl) is a free radical stable at room temperature which produces a violet solution in ethanol. DPPH is reduced in the presence of antioxidant compounds, producing a colorless ethanol solution. To estimate the DPPH radical scavenging activity, 1 ml of each extract at a final concentration of 1, 0.5, 0.25, 0.125 mg/ml was taken in independent test tubes and 1 ml of 0.2 mM DPPH - ethanol solution was added. Ethanol and DPPH alone served as control. The mixture was vortexed vigorously and kept in dark for 30 minutes. Following incubation, absorbance of each sample was measured at 517 nm. All tests were performed in triplicate and the percentage inhibition was calculated using the following formula:

$$\% \text{Inhibition} = \frac{A \text{ control} - A \text{ extracts}}{A \text{ control}} \times 100$$

Where A = absorbance at 517nm

The concentration of the plant extracts required to scavenge 50% of the radicals (IC₅₀) was calculated by using the percentage scavenging activities at four different concentrations of the extract.

Metal Chelating Capacity: The metal chelating capacity of *L. aegyptiaca* extracts were determined following the modified method of Tokgoz *et al.* (2024). The experiment was performed using various end-stage extracts, specifically 62.5 µg/ml – 1000 µg/ml. Following

the established procedure, 50 µL of each extract was introduced into separate wells within a microplate. Afterward, 185 µL of water, 5 µL of 2 mM FeCl₂, and 10 µL of 5 mM ferrozine were added to these wells. The mixture was then kept at room temperature for 10 minutes, and spectrophotometric measurements were taken at 562 nm. The metal chelating activities of the extracts were calculated as a percentage using the formula.

$$\text{Metal Chelating Activity} = \frac{\text{Control Absorbance} - \text{Extract Absorbance}}{\text{Control Absorbance}} \times 100$$

The concentration of the plant extracts required to chelate 50% of the Fe²⁺ (IC₅₀) was calculated by using the percentage scavenging activities at several different concentrations of the extract.

Statistical Analysis

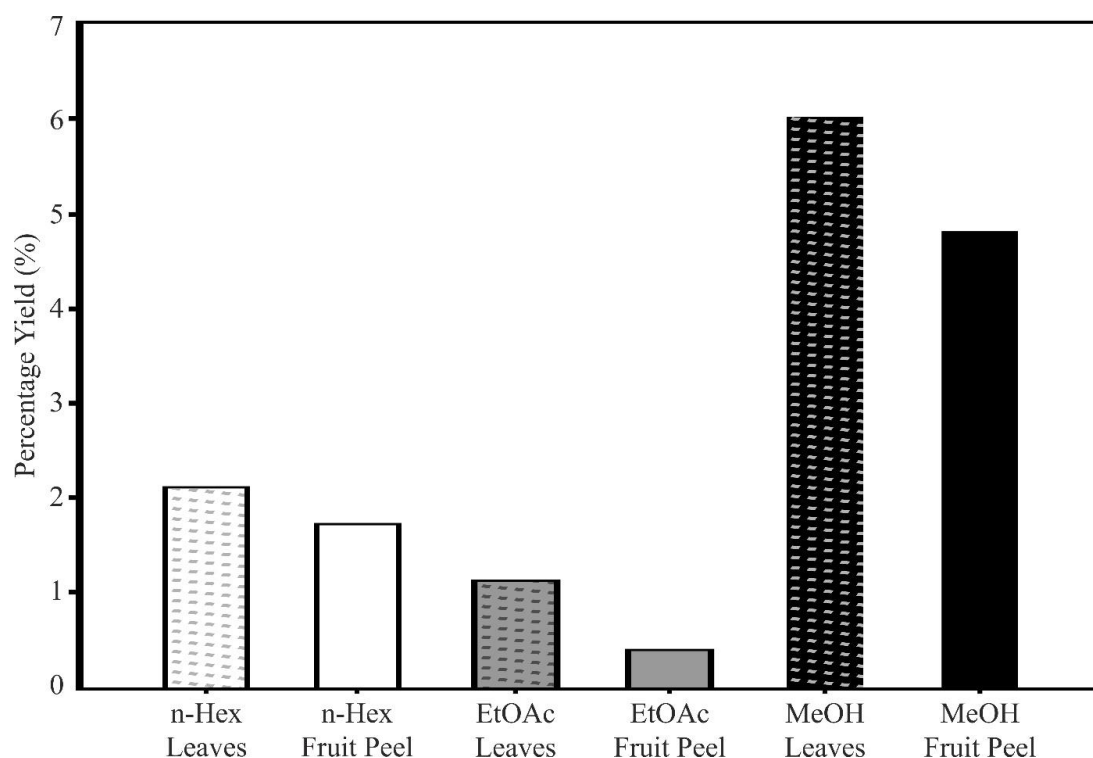
The data obtained were analysed using the Statistical Package for Social Sciences (SPSS) version 20.0 software, and are presented as mean ± standard deviation. One-way ANOVA was used to compare the means between different solvent extracts within a group, whereas t-test was used to compare the means between similar solvent extracts between the two groups. A *p* value of <0.05 was considered statistically significant.

Results

Table 1: Yield (%) of extracts of *L. aegyptiaca* leaves and fruit peel after serials extraction

Extracts	Percentage Yield (%)		
	n-Hexane	Ethylacetate	Methanol
Leaves	2.2 ± 0.8	1.1 ± 0.3	6.0 ± 2.3
Fruit Peels	1.7 ± 0.9	0.4 ± 0.1	4.8 ± 1.4

Values are expressed as mean ± standard deviation (n=3)



Key: n-Hex= n-Hexane, EtOAc= Ethylacetate, MeOH= Methanol.

Figure 1: Yields (%) of extracts of *L. aegyptiaca* leaves and fruit peel after serial extraction

As indicated in figure 1 above, methanol yielded the highest percentage of extracts from both the leaves (6.0%) and fruit peels (4.8%) of *L. aegyptiaca* followed by n-hexane (2.2% leaves and 1.7% fruit peels). Ethylacetate yielded the lowest percentage of extracts (1.1% leaves and 0.4% fruit peel). It is also clear from this study that the leaves of *L. aegyptiaca* yield more solvent extracts compared to the fruit peels (figure 1).

Table 2: Qualitative phytochemical screening of different solvent extracts of *L. aegyptiaca* leaves and fruit peels

Extracts		Tests						
		Phenols	Flavonoids	Tannins	Saponins	Alkaloid	Phytosterol	Cardiac glycoside
Leaves	n-Hex	+	+	+	-	+	-	+
	EtOAc	+	+	+	-	+	+	+
	MeOH	+	+	+	+	+	+	+
Fruit Peel	n-Hex	+	+	+	-	+	-	+
	EtOAc	+	+	+	-	+	+	+
	MeOH	+	+	+	+	-	+	+

Key: += Detected, - = Not detected, n-Hex= n-Hexane, EtOAc= Ethylacetate, MeOH= Methanol,

The result of qualitative phytochemical screening showed that solvent extracts of the leaves and fruit peels of *L. aegyptiaca* have a wide range of secondary metabolites including phenols, flavonoids, tannins, saponins, alkaloids, phytosterols and cardiac glycosides (Table 2). However, saponins were not detected in n-hexane and ethylacetate extracts of both leaves and fruit peels. Similarly, phytosterols were not detected in n-hexane extracts of both leaves and fruit peels. The result also showed that methanol extract of fruit peels lacks alkaloids. It was generally observed that methanol extract of the leaves contain more phytochemicals.

Table 3: Quantitative phytochemical screening of different solvent extracts of *L. aegyptiaca* leaves and fruit peels

Extracts		Tests		
		Total Phenol content (TPC) (mg/gGAE)	Total Tannins Content (TTC) (mg/gTAE)	Total Flavonoids content (TFC) (mg/gQE)
Leaves	n-Hex	3.735 ± 0.01 ^{b*}	0.082 ± 0.00 ^{b*}	1.269 ± 0.00 ^{b**}
	EtOAc	7.526 ± 0.21 ^{b**}	0.135 ± 0.00 ^{b**}	2.107 ± 0.01 ^{b***}
	MeOH	12.581 ± 0.10 ^{b***}	0.687 ± 0.00 ^{b***}	0.734 ± 0.00 ^{b*}
Fruit Peels	n-Hex	1.802 ± 0.01 ^{a*}	0.073 ± 0.00 ^{a**}	0.625 ± 0.00 ^{a**}
	EtOAc	4.479 ± 0.01 ^{a**}	0.060 ± 0.00 ^{a*}	0.604 ± 0.00 ^{a**}
	MeOH	8.757 ± 0.61 ^{a***}	0.283 ± 0.00 ^{a***}	0.173 ± 0.00 ^{a*}

Values expressed as mean ± standard deviation (n=3). Values within the same group with different (*) superscripts are significantly different (p< 0.05). Values for similar solvent with different alphabets (a/b) subscripts are significantly different (p< 0.05).

Key: n-Hex= n-Hexane, EtOAc= Ethylacetate, MeOH= Methanol, GAE= Gallic Acid Equivalent; QE=Quercetin Equivalent; TAE= Tannic Acid Equivalent.

The result of the total phenol, tannins, and flavonoid contents of different solvent extracts of the leaves and fruit peels of *L. aegyptiaca* is presented in Table 2 above. Among the three solvent extracts of the leaves of *L. aegyptiaca*, methanol extract has significantly (p< 0.05) higher phenol (12.581 ± 0.10 mg/gGAE) and tannin (0.687 ± 0.00 mg/gTAE) contents followed by ethylacetate extracts (7.526 ± 0.21 mg/gGAE and 0.135 ± 0.00 mg/gTAE, respectively). The n-hexane extract has the lowest phenol (3.735 ± 0.01 mg/gGAE) and tannin (0.082 ± 0.00 mg/gTAE) contents. Conversely, the methanol extract has the lowest flavonoid contents (0.734 ± 0.00 mg/gQE) compared with the other solvent extracts. The

highest flavonoid content was present in the ethylacetate extract (2.107 ± 0.01 mg/gQE) followed by n-hexane extract (1.269 ± 0.00 mg/gQE).

Similar to the leaves, the methanol extract of the fruit peels of *L. aegyptiaca* also has the highest phenol (8.757 ± 0.61 mg/gGAE) and tannin (0.283 ± 0.00 mg/gTAE) contents compared with the remaining solvent extracts. The n-hexane extract has lowest phenol content (1.802 ± 0.01 mg/gGAE) whereas the ethylacetate extract has the lowest tannin content (0.060 ± 0.00 mg/gTAE). However, the n-hexane extract of the fruit peels has the highest flavonoid content (0.625 ± 0.00 mg/gQE) followed by the ethylacetate extract (0.604 ± 0.00 mg/gQE). The lowest flavonoid content of the fruit peel was present in the methanol extract (0.173 ± 0.00 mg/gQE). All differences are statistically significant ($p < 0.05$). Moreover, the solvent extracts of the leaves of *L. aegyptiaca* possesses significantly ($p < 0.05$) higher phytochemical (phenols, tannins, and flavonoids) concentrations compared with corresponding fruit peels extracts (Table 3).

Table 4: Antioxidant activities of different solvent extracts of *L. aegyptiaca* leaves and fruit peels

Extracts		IC ₅₀	
		DPPH (µg/ml)	MCC (mg/ml)
Leaves	n-Hex	$16.099 \pm 8.82_a$	$2.111 \pm 1.87_a^*$
	EtOAc	$15.744 \pm 6.54_a$	$3.276 \pm 0.73_a^*$
	MeOH	$3.183 \pm 2.16_a$	$0.403 \pm 0.08_b$
Fruit Peels	n-Hex	$115.295 \pm 3.49_b^{***}$	$11.021 \pm 1.54_a^*$
	EtOAc	$50.890 \pm 3.97_b^{**}$	$6.479 \pm 2.47_a^*$
	MeOH	$32.735 \pm 0.32_b^*$	$0.208 \pm 0.04_a$
Standard		2.279 ± 1.49 (Ascorbic Acid)	0.055 ± 0.04 (Citric acid)

Values expressed as mean $\pm$ standard deviation (n=3). Values within the same group with different (*) superscripts are significantly different ($p < 0.05$). Values for similar solvent with different alphabets (a/b) subscripts are significantly different ($p < 0.05$).

Key: DPPH= 2,2'-diphenyl-1-picrylhydrazyl, MCC= Metal chelating capacity, n-Hex= n-Hexane, EtOAc= Ethylacetate, MeOH= Methanol, L= Leaves; F= Fruit Peel.

Solvent extracts of *L. aegyptiaca* leaves and fruit peels inhibited 2,2'-diphenyl-1-picrylhydrazyl (DPPH) radicals and chelates Fe²⁺ in a concentration dependent manner. The concentrations of the plant extracts required to scavenge 50% of radicals and chelate 50% of Fe²⁺ were presented in Table 4 above as their respective IC₅₀ values. The IC₅₀ values of the extracts are inversely related to their antioxidant activities (i.e lower IC₅₀ value indicates a higher antioxidant activity). The result of the present study showed that methanol extract of leaves of *L. aegyptiaca* has the highest, but statistically insignificant ($p > 0.05$), radical scavenging activity (IC₅₀ = 3.183 ± 2.16 µg/ml) followed by ethylacetate and n-hexane extracts (IC₅₀ = 15.744 ± 6.54 and 16.099 ± 8.82 µg/ml, respectively). The radical scavenging

activities of all extracts of the leaves do not differ significantly ($p > 0.05$) from that of standard ascorbic acid ($IC_{50} = 2.279 \pm 1.49 \mu\text{g/ml}$). Additionally, the methanol extract of the leaves also demonstrated the highest metal chelating activity ($IC_{50} = 0.403 \pm 0.08 \text{ mg/ml}$) than the corresponding n-hexane and ethylacetate extracts ($IC_{50} = 2.111 \pm 1.87$ and $3.276 \pm 0.73 \text{ mg/ml}$, respectively). The metal chelating activities of the n-hexane and ethylacetate extracts were significantly lower ($p < 0.05$) than that of the standard citric acid ($IC_{50} = 0.055 \pm 0.04 \text{ mg/ml}$).

When compared with the standard ascorbic acid ($IC_{50} = 2.279 \pm 1.49 \mu\text{g/ml}$), all solvent extracts of the fruit peel of *L. aegyptiaca* showed significantly lower radical scavenging activities ($p < 0.05$). Similar to the pattern observed among the solvent extracts of the leaves, methanol extract of the fruit peels also has the highest radical scavenging activity ($IC_{50} = 32.735 \pm 0.32 \mu\text{g/ml}$) followed by ethylacetate extract ($IC_{50} = 50.890 \pm 3.97 \mu\text{g/ml}$) and finally n-hexane extract ($IC_{50} = 115.295 \pm 3.49 \mu\text{g/ml}$). Furthermore, methanol extract demonstrated the highest metal chelating activity among the solvent extracts of the fruit peel ($0.208 \pm 0.04 \text{ mg/ml}$). The metal chelating activity of the standard citric acid ($IC_{50} = 0.055 \pm 0.04 \text{ mg/ml}$) does not differ significantly ($p > 0.05$) from that of the methanol extract, but is significantly higher ($p < 0.05$) than that of the ethylacetate and n-hexane extract ($IC_{50} = 6.479 \pm 2.47$ and $11.021 \pm 1.54 \text{ mg/ml}$, respectively).

The result of this study also indicated that solvent extracts of the leaves possess significantly higher ($p < 0.05$) radical scavenging activity than the fruit peels, but their metal chelating activities do not differ significantly ($p > 0.05$) except for methanol extracts (Table 4).

Discussion

The present study was conducted to ascertain the phytochemicals and antioxidant compositions of three different solvent extracts of the leaves and fruit peels of *L. aegyptiaca*. Plant extraction is a critical step in evaluating the functional properties of plants (Abdelbakya and Diab, 2021). Optimal extraction of phytochemicals from plants and antioxidant properties of the extracts depend largely on the solvent used for extraction (Chatepa *et al.*, 2024). Among the three solvents used in the present study, methanol yielded the highest percentage of extracts followed by n-hexane and ethylacetate (methanol > n-Hexane > ethylacetate). This is likely due to higher solvent strength and polarity of methanol, which increases solubility of phytochemicals in the solvent (Lee *et al.*, 2024). The leaves of *L. aegyptiaca* generally yielded more extracts than the fruit peels (figure 1), suggesting the presence of more soluble phytochemicals in the leaves.

Medicinal plants have opened a new era of phytomedicine that is increasingly gaining recognition around the world (Coopoosamy *et al.*, 2023). The medicinal properties of these plants are largely attributed to their biologically-active phytochemicals (Parkash *et al.*, 2018). In the present study, the solvent extracts of the leaves and fruit peels of *L. aegyptiaca* were assessed for their phytochemical contents (table 2 and 3). The result indicated the presence of wide variety of phytochemicals including phenols, tannins, flavonoids, cardiac

glycosides, alkaloids, saponins, and phytosterols (table 2). More phytochemicals were detected in the methanol extracts followed by ethylacetate and n-hexane extracts in both leaves and fruit peels (methanol > ethylacetate > n-hexane). These phytochemicals have been reported to have several biological effects such as antioxidant, anti-inflammatory, antimicrobial, anticancer, anti-allergic activities among others (Gulçin *et al.*, 2010; Gutierrez *et al.*, 2014). Further quantitative estimation of total phenols, tannins, and flavonoid contents revealed the differences in concentrations of these phytochemicals among the different solvent extracts of the leaves and fruit peels (table 3). Methanol extract of the leaves has the highest phenol content than the ethylacetate and n-hexane extracts (methanol > ethylacetate > n-hexane). The same trend was observed in the total phenol content of the fruit peel extracts. Additionally, the methanol extract of the leaves has the highest tannin content followed by the ethylacetate and n-hexane extracts (methanol > ethylacetate > n-hexane). Among the fruit peel extracts, the methanol extract has the highest tannin content while the ethylacetate extract has the lowest (methanol > n-hexane > ethylacetate). It has been reported that methanol is more efficient in extracting phytochemicals from plants than other extraction solvents (Chatepa *et al.*, 2024). However, methanol extract of the leaves has the lowest flavonoid contents whereas the ethylacetate extract has the highest (ethylacetate > n-hexane > methanol). Similarly, methanol extract of the fruit peels has the lowest flavonoid, but the highest flavonoid contents was present in the n-hexane extract (n-hexane > ethylacetate > methanol). El Mannoubi (2022) also reported that the solvent with least polarity in his study had the highest concentration of flavonoids.

Phenolic compounds are important plant constituents with redox properties. They have attracted special attention because they are useful against oxidative stress which is implicated in the pathogenesis of many diseases including cancer, and cardiovascular diseases (Ayele *et al.* 2022). Tannins and their derivatives are phenolic compounds considered to be primary antioxidants or free radical scavengers (Alabri *et al.*, 2013). Flavonoids are polyphenolic secondary metabolites with broad spectrum of biological activities, particularly radical scavenging, anti-inflammatory and antimicrobial activities (Ayele *et al.* 2022; Akullo *et al.*, 2023).

Antioxidants constitute a group of molecules that, owing to their stable structures, can neutralize free radicals and reduce their harmful impacts. Hence, they prevent cell damage by their so-called free radical scavenging properties (Kiss *et al.*, 2025). Numerous studies have shown that the increased intake of plant-based antioxidant compounds have positive effects on the health and contributes to enhanced resistance to various diseases (Martemucci *et al.*, 2022; Akbari *et al.*, 2022). In the present study, antioxidant properties of the different solvent extracts of the leaves and fruit peels of *L. aegyptiaca* were determined using DPPH method and metal chelating capacity. DPPH method is an easy, rapid, stable and sensitive way to determine antioxidant activity (Baliyan *et al.*, 2022). DPPH forms purple colored solution and gives characteristics absorption band on 517 nm in the visible region. The degree of reduction in absorbance is the indicator of the increased

antioxidant capacity of the extract (Baliyan *et al.*, 2022). Many metals, such as iron and copper, can catalyze the generation of reactive oxygen species (ROS) through Fenton and Haber-Weiss reactions, which can cause oxidative damage to cells and tissues. Plant extracts with metal chelating properties can bind to these metals, reducing their availability to participate in these harmful reactions (Benchikh *et al.*, 2022). Measuring metal chelating capacity is important for identifying extracts that can mitigate metal-induced oxidative stress (Aydin *et al.*, 2022).

The result of the present study indicated that methanol extracts of both leaves and fruit peels have maximum DPPH radical scavenging capacities, and thus higher antioxidant activities, followed by ethylacetate and n-hexane (methanol > ethylacetate > n-hexane) (Table 4). Liao *et al.* (2025) also reported that methanol extracts had higher antioxidant activities compared with other solvent extracts used in their studies. Although all solvent extracts of the leaves and fruit peels in this study have lower radical scavenging activities compared with the standard ascorbic acid, the differences generally observed with the leaves extracts were not statistically significant ($p > 0.05$). Furthermore, assessment of the metal chelating capacities of the leaves extracts (Table 4) also revealed the presence of maximum Fe^{2+} chelating activities, and thus higher antioxidant activities, in methanol extracts followed by the n-hexane and ethylacetate (methanol > n-hexane > ethylacetate). This trend is slightly different among the extracts of the fruit peels, as n-hexane showed the lowest Fe^{2+} chelating activities (methanol > ethylacetate > n-hexane) (Table 4). Besides the methanol extracts, all solvent extracts of the leaves and fruit peels have significantly lower metal chelating capacities compared with the standard citric acid ($p < 0.05$). There is positive correlation between the metal chelating activity of a plant extract and its phytochemical constituents (Ebrahimzadeh *et al.*, 2008). Generally, the result of the present study indicated that extracts of the leaves have higher antioxidant activities than extracts of the fruit peels. However, it was noted that the methanol extract of the fruit peels has higher Fe^{2+} chelating activity than that of the leaves. The reason for this reversal is still unclear. It has been reported from several studies that antioxidant activities of plant extracts are largely determined by their phytochemical constituents, especially phenolic compounds (Tourabi *et al.*, 2023; Chatepa *et al.*, 2024). The presence of the maximum antioxidant activities in the extracts of leaves of *L. aegyptiaca*, particularly the methanol extract, may be due to their higher total phenol and tannin contents (table 3).

The present study therefore supports the findings from several studies suggesting that various solvents used in extraction can result in variation in phytochemical composition and antioxidant activity of plant extracts (Abdelbakya and Diab, 2021).

Conclusion

The present study demonstrated that the leaves and fruit peels of *L. aegyptiaca* are good sources of phytochemical and antioxidant, justifying the ethno-medicinal use of the plant in the management of several diseases. The study also revealed that methanol is the best extraction solvent among the tested solvents, as it has the highest yield, and its extracts

showed relatively higher phytochemical and antioxidant activities. Furthermore, the leaves of *L. aegyptiaca* showed relatively higher phytochemical and antioxidant activities than the fruit peels. The present study underscores the importance of solvent selection in extracting bioactive compounds from plant materials, and also support the findings from several studies suggesting that various solvents used in extraction can result in variation in phytochemical and antioxidant properties of plant extracts.

It is also worth noting that there are several limitations to the present study. Firstly, only three (3) out of severally available solvents were employed in this study, thus limiting generalizability of the findings. Additionally, only phenols, tannings and flavonoids of the extracts were quantitatively determined among the phytochemicals detected. Finally, the study employed traditional approach for assessment of phytochemical and antioxidant activities. While these methods are robust, they do not provide precise identification and quantification like automated techniques such as HPLC.

Recommendations and Future Directions

- i. More detailed studies should be conducted with different solvents to enable generalizability of findings.
- ii. Further phytochemical study should be conducted using automated techniques HPLC or LC-MS/MS for precise identification and quantification of specific compounds in *L. aegyptiaca*.
- iii. Further research should be conducted to explore the practical applications of the findings from the present study in medical, nutritional, industrial contexts, in order to pave way for the use of *L. aegyptiaca* as a valuable resource in combating oxidative stress and related health issues.

References

- A.I. Dirar, D.H.M. Alsaadi, M. Wada, M.A. Mohamed, T. Watanabe, and H.P. Devkota. (2018). Effects of Extraction Solvents on Total Phenolic and Flavonoid Contents and Biological Activities of Extracts from Sudanese Medicinal Plants. *South African Journal of Botany*, 1-7. DOI: <https://doi.org/10.1016/j.sajb.2018.07.003>
- Abdelbakya, A. S., and Diab, Y. M. (2021). Effect of Various Extraction Methods and Solvent Types On Yield, Phenolic and Flavonoid Content and Antioxidant Activity of *Spathodea nilotica* Leaves. *Egyptian Journal of Chemistry*, 64(12):7583 – 7589. DOI: 10.21608/EJCHEM.2021.96557.4518
- Abdel-Salam, I. M., Ashmawy, A. M., and Hilal, A. M. (2018). Chemical Composition of Aqueous Ethanol Extract of *Luffa cylindrica* Leaves and Its Effect on Representation of Caspase-8, Caspase-3, and the Proliferation Marker Ki67 in Intrinsic Molecular Subtypes of Breast Cancer In Vitro. *Chem Biodivers*, 15:e1800045. <https://doi.org/10.1002/cbdv.201800045>
- Adeyeni, E. G., Ayodele, E. T., and Adedosu, T. A. (2020). Phytochemical Constituents and Antimicrobial Activities of Ethanolic Extract of *Luffa Cylindrica* Seed. *Ilorin Journal of Science*, 7(2), 127 – 143.
- Ajuru, M., and Nmom, F. (2017). A Review on the Economic Uses of Species of *Cucurbitaceae* and their Sustainability in Nigeria. *American Journal of Plant Biology*. 2:17–24.

- Akbari, B., Baghaei-Yazdi, N., Bahmaie, M., and Mahdavi, A.F. (2022). The Role of Plant-Derived Natural Antioxidants in Reduction of Oxidative Stress. *BioFactors*, 48:611–633. <https://doi.org/10.1002/biof.1831>.
- Akullo, J. O., Kiage-Mokua B. N., Nakimbugwe, D., Ng'ang'a, J., and Kinyuru, J. (2023). Phytochemical Profile and Antioxidant Activity of Various Solvent Extracts of two Varieties of Ginger and Garlic. *Heliyon* 9, e18806. <https://doi.org/10.1016/j.heliyon.2023.e18806>
- Alabri, T. H. A., Al Musalami, A. H. S., Hossain, M. A., Weli, A. M., and Qasim Al-Riyami. (2013). Comparative Study of Phytochemical Screening, Antioxidant and Antimicrobial Capacities of Fresh and Dry Leaves Crude Plant Extracts of *Datura metel* L. *Journal of King Saud University – Science*. DOI: <http://dx.doi.org/10.1016/j.jksus.2013.07.002>
- Alagbe, J. O., Samson, B., Nwosu, G. C., Agbonika, D. A., and Cincinsoko, K. M. (2023). Characterization of Bioactive Compounds in *Luffa aegyptiaca* leaf Ethanolic Extracts Using Gas Chromatography and Mass Spectrometry. *Drug Discovery*, 17: e10dd1011 doi: <https://doi.org/10.54905/diss.v17i39.e10dd1011>.
- Alara, O.R., Abdul Mudalip, S.K., and Olalere, O.A. (2017). Optimization of Mangiferin Extracted from *Phaleria macrocarpa* Fruits Using Response Surface Methodology. *J. Appl. Res. Med. Aromat. Plants*. 5: 82–87.
- Al-Farsi, M.A., Lee, C.Y. (2008). Optimization of Phenolics and Dietary Fibre Extraction from Date Seeds. *Food Chem*, 108:977-985
- Al-Snafi, A.E. (2019). Constituents and Pharmacology of *Luffa cylindrica*- A Review. *IOSR Journal of Pharmacy*, 9(9), 68-79.
- Ani, E., Adekunle, A., Ike, C., and Nwafor, L. (2019). Ex-situ Characterization of Fungi Associated with *Luffa aegyptiaca* in Lagos State. *Eurasia J Biosci*. 13:1589–1596.
- Anyasor, G.N., Ogunwenmo, K.O., Oyelana, O.A., and Akpofunure, B.E. (2010). Phytochemical Constituents and Antioxidant Activities of Aqueous and Methanol Stem Extracts of *Costus afer* Ker Gawl (*Costaceae*). *African Journal of Biotechnology*. 9(31):4880-4884.
- Aydin, D., Yalçin, E., and Çavuşoğlu, K. (2022). Metal Chelating and Anti-Radical Activity of *Salvia ofcinalis* in the Ameliorative Effects Against Uranium Toxicity. *Scientific Reports*, 12:15845. <https://doi.org/10.1038/s41598-022-20115-9>
- Ayele, D. T., Akele, M. L., and Melese, A. T. (2022). Analysis of Total Phenolic Contents, Flavonoids, Antioxidant and Antibacterial Activities of *Croton macrostachyus* Root Extracts. *BMC Chemistry*, 16:30. <https://doi.org/10.1186/s13065-022-00822-0>
- Baliyan, S., Mukherjee, R., Priyadarshini, A., Vibhuti, A., Gupta, A., Pandey, R. P., and Chang, C-M. (2022). Determination of Antioxidants by DPPH Radical Scavenging Activity and Quantitative Phytochemical Analysis of *Ficus religiosa*. *Molecules*, 27, 1326. <https://doi.org/10.3390/molecules27041326>
- Benchikh, F., Benabdallah, H., Amira, H., Amira, I., Mamache, W., and Amira, S. (2022). Free Radical Scavenging, Metal chelating and Antiperoxidative Activities of M. communis Berries Methanol Extract and its Fractions. *Turkish Journal of Agriculture - Food Science and Technology*, 10(6): 1089-1094. DOI: <https://doi.org/10.24925/turjaf.v10i6.1089-1094.5062>
- Bhavsar, S., Modi, N., and Thakor, M. (2023). Evaluation of Antioxidant Potential and Phytochemical Characterisation of Peel Extracts of *Luffa acutangula* and *Luffa cylindrica*. *International Association of Biological and Computational Digest*. <https://doi.org/10.56588/iabcd.v2i1.178>
- Brand-Williams, W., Cuvelier, M.E., and Berset, C. (1995). Use of a Free Radical Method to Evaluate Antioxidant Activity. *Lebenson Wiss Technol*, 28:25-30.
- Chandana, L., and Bhikshapathi, D.V. (2024). Ethnopharmacological Investigation of *Pleurotus ostreatus* for Anti-Oxidative and Anti-Inflammatory Activity in Experimental Animal. *Asian J Pharm Clin Res*, 17(4):37-41.

- Chatepa, L. E. C., Mwamatope, B., Chikowe, I., and Masamba, K. G. (2024). Effects of Solvent Extraction on the Phytoconstituents and in vitro Antioxidant Activity Properties of Leaf Extracts of the Two Selected Medicinal Plants from Malawi. *BMC Complementary Medicine and Therapies*, 24:317 <https://doi.org/10.1186/s12906-024-04619-7>
- Cooposamy, R., Singh, K., Naidoo, K., and Nadasan, D. S. (2023). The Role of Phytomedicine: Bridging the Gap Between the Past, Present, and Future. *Journal of Medicinal Plants for Economic Development*, 7(1), 197. <https://doi.org/10.4102/jomped.v7i1.197>
- D'silva, W. W., Biradar, P. R., and Patil, A. (2021). *Luffa cylindrica*: a Promising Herbal Treatment in Progesterone Induced Obesity in Mice. *Journal of Diabetes & Metabolic Disorders*, 20, 329–340 <https://doi.org/10.1007/s40200-021-00749-8>
- Duan, L., Rao, X., and Sigdel, K.R. (2019). Regulation of Inflammation in Autoimmune Disease. *J Immunol Res*. 74:1-23. <https://doi.org/10.1155/2019/7403796>.
- Ebrahimzadeh, M. A., Pourmorad, F., and Bekhradnia, A. R. (2008). Iron Chelating Activity, Phenol and Flavonoid Content of Some Medicinal Plants from Iran. *African Journal of Biotechnology*, 7 (18), 3188-3192.
- El Mannoubi, I. (2022). Impact of Different Solvents on Extraction Yield, Phenolic Composition, in vitro Antioxidant and Antibacterial Activities of Deseeded *Opuntia stricta* fruit. *Journal of Umm Al-Qura University of Applied Sciences*, 9:176–184 <https://doi.org/10.1007/s43994-023-00031-y>
- Gulçin, I., Elias, R., Gepdiremen, A., Chea, A., and Topal, F. (2010). Antioxidant Activity of Bisbenzylisoquinoline Alkaloids from *Stephania rotunda*: cepharanthine and fangchinoline. *Journal of Enzyme Inhibition and Medicinal Chemistry*. 25(1):44–53.
- Gutierrez, D., Bah, M., Garduño, M., Mendoza, S., and Serrano, V. (2014). Anti-Inflammatory and Antioxidant Activities of Methanol Extracts and Alkaloid Fractions of four Mexican Medicinal Plants of *Solanaceae*. *African Journal of Traditional, Complementary and Alternative Medicines*, 11(3):259–267.
- Idi, A., Atiku, M. K., Alhassan A. J., and Muhammad, I. U. (2022). Effect of Solvents Fractions of *Cucurbita maxima* Cuticular Lipids on Metabolic Biomarkers of Cardiovascular Disease. *European Journal of Medicinal Plants*, 33(8), 1-9. DOI: 10.9734/EJMP/2022/v33i830481
- Kiss, A., Papp, V. A., Pál, A., Prokisch, J., Mirani, S., Toth, B. E., and Alshaal, T. (2025). Comparative Study on Antioxidant Capacity of Diverse Food Matrices: Applicability, Suitability and Inter-Correlation of Multiple Assays to Assess Polyphenol and Antioxidant Status. *Antioxidants* 2025, 14, 317. <https://doi.org/10.3390/antiox14030317>
- Kok, O., Emsen, B., and Surmen, B. (2023). Screening of in vitro Cytotoxicity and Antioxidant Potential of Selected Endemic Plants in Turkey. *J Taibah Univ Sci*. 17:22-31. <https://doi.org/10.1080/16583655.2023.2217369>.
- Lee, J-E., Jayakody, J.T.M., Kim, J-I., Jeong, J-W., Choi, K-M., Kim, T-S., Seo, C., Azimi, I., Hyun, J., and Ryu, B. (2024). The Influence of Solvent Choice on the Extraction of Bioactive Compounds from Asteraceae: A Comparative Review. *Foods*, 13, 3151. <https://doi.org/10.3390/foods13193151>
- Liao, C-H., Fu, H-X., Tu, K-H., Zheng, J-H., Shih C-H., and Lin, Y-S. (2025). Impacts of Extraction Solvents and Processing Techniques on Phytochemical Composition and Antioxidant Property of Mulberry (*Morus spp.*) Leaves, *Cogent Food & Agriculture*, 11:1, 2451731, DOI: 10.1080/23311932.2025.2451731
- Martemucci, G., Costagliola, C., Mariano, M., D'andrea, L., Napolitano, P., and D'Alessandro, A.G. (2022). Free Radical Properties, Source and Targets, Antioxidant Consumption and Health. *Oxygen*, 2, 48–78.
- Nurlinda, Handayani, V., and Rasyid, F. A. (2021). Spectrophotometric Determination of Total Flavonoid Content in *Biancaea sappan* (*Caesalpinia sappan* L.) Leaves. *Jurnal Fitofarmaka Indonesia*, 8(3) 1-4 <http://jurnal.farmasi.umi.ac.id/index.php/fitofarmakaindo/index>

- Ononamadu, C. J., Sule, M. S., Alhassan, A. J., Ibrahim, A., Imam, A. A., Ihegboro¹, G. O., and Owolarafe, T. A. (2019). Methanol-Extract/Fractions of *Dacryodes edulis* Leaves Ameliorates Hyperglycemia and Associated Oxidative Stress in Streptozotocin-Induced Diabetic Wistar Rats. *Journal of Evidence-Based Integrative Medicine*, 24: 1-12. DOI: 10.1177/2515690X19843832
- Parkash, J., Prasad, D. N., Shahnaz, M., and Dev, D. (2018). Herbs as Traditional Medicines: A Review. *Journal of Drug Delivery and Therapeutics*, 8(5), 146–150. <https://doi.org/10.22270/jddt.v8i5.1910>.
- Shukla, V., Nanjappaiah, H. M., Patil, V. P., and Hugar, S. (2015) Protective Effect of *Lufa cylindrica* Fruit Extracts on Alloxan Intoxicated Diabetic Rats. *RGUHS J Pharm Sci*, 5, 9–15.
- Tokgoz, A., Emsen, B., & Dogan, M. (2024). The efficacy of allelopathy of select lichens on antioxidant potential and multiplication of *Ceratophyllum demersum* L. *Research Square*, 12:1-24. <https://doi.org/10.21203/rs.3.rs-4298885/v1>.
- Tourabi, M., Metouekel, A., Ghouizi, A. E. L., Jeddi, M., Nouioura, G., and Laaroussi, H. (2023). Efficacy of various extracting solvents on phytochemical composition, and biological properties of *Mentha longifolia* L. leaf extracts. *Scientific Reports*, 13:18028. <https://doi.org/10.1038/s41598-023-45030-5>
- Trease, G.E., and Evan, W.C. (2002). *Textbook of Pharmacognosy*. 15th Edn. London: Saunders Publishers. Pp.229:393