

Research Article

Evaluation of phytochemicals and antioxidant activities of the bark and fruit peel of *Citrus aurantifolia* (Lime Orange) grown in Olamaboro, Kogi State, Nigeria

L. O. Abuh*, U. E. Omale & L. Egene

Department of Integrated Science, Kogi State College of Education, Ankpa, Nigeria.

Abstract

The potency of *Citrus aurantifolia* in the treatment and prevention of several ailments have been in practice by traditional doctors within our local domains for decades. The need to elucidate the active ingredients responsible for its potency is pertinent. Hence, this study assesses the phytochemicals and antioxidant properties of *Citrus aurantifolia* fruit peels and bark. After the plant parts have been gathered, they were dried, pulverized, and extracted using absolute ethanol. The results of the phytochemical reveal the bark and fruit peel to contain carbohydrates, glycosides, saponins, phenolic compounds, tannins, flavonoids, proteins and amino acids. The percentage KMnO_4 radical scavenging effect for the antioxidant activities indicates that the bark and fruit peel of *Citrus aurantifolia* are potential antioxidants; with % KMnO_4 radical scavenging ability for the bark as 81.21% and the fruit peel as 87.57%; these shows great antioxidant potential as they compete favourably with the reference ascorbic acid 82.00% at EC_{50} . These findings are clear manifestation that the bark and fruit peel can scavenge and inhibit free radical effectively from the body and can be a good source of therapeutics for prevention and treatment of certain ailments for better health management. It is concluded that the free scavenging radical ability of this plant parts could be attributed to its rich bioactive substances and therefor a significant prove for its medicinal usefulness traditionally for disease management. Isolation and standardization into pure forms for purity enhancement and effective administration is highly recommended.

Keywords: Phytochemicals, Antioxidant, Lime orange, *Citrus aurantifolia* and Screening

1. Introduction

Citrus aurantifolia is a member of the Rutaceae family. Lime orange is the common name for it. This 5-meter-tall, heavily branched, green tree has short, stiff, sharp spines on its twigs. The alternating leaves range in shape from elliptic to oblong ovate. The petioles have little wings. The calyx cup is pointed and has four to six lobes; the flowers are tiny and white in bud. The fruit is an oval berry with a diameter of 3 to 6 cm. It occasionally has apical papillae, a thin peel that is greenish-yellow, is highly glandular, and has segments with yellow-green pulp and vesicles. It is also quite acidic, juicy, and aromatic. The seeds have white embryos and are tiny, smooth, ovoid, and plump (Michael, 2016).

Parts of *Citrus aurantifolia* are said to have a special medicinal potential. The active ingredients in them are what give them their therapeutic effect. Alkaloids, coumarins, flavonoids, terpenes, phenols, and other compounds are examples of phytochemicals, which are secondary metabolites (Al Namani *et al.*, 2018). *Citrus aurantifolia*'s

parts have been revealed to contain vitamins, minerals, antioxidant and other nutrients responsible for their anti-inflammatory and immune boosting benefits, they are attributed to help fight cellular damage, boost skin health, manage blood sugar and prevent kidney stones (healthessential, 2025). The peel in a preclinical investigation reveals it to significantly inhibit the growth of human liver cancer cells and are considered to be super immune charger, fight natural inflammation, detoxifies the body, heart booster, aids digestion and a power house for antioxidant, all due to the presence of high packed limonene, hespendin, flavonoids, limonene etc. bioactive compounds (Naomi, 2025). These bioactive substances have been investigated by scholars in the different parts of *Citrus aurantifolia*. According to Omale *et al.* (2024), the roots and leave contain flavonoids, saponins, alkaloids, carbohydrate, phenol, tannins, protein and amino acid. Bukola *et al.* (2016) reported flavonoids, phenol, and terpenes in the juice. The

*Corresponding author: L. O. Abuh

Email address: leonardabuh@gmail.com (L. O. Abuh)

ORCID: <https://orcid.org/0000-0003-3017-1735>

Received: 04/07/2026; Accepted: 30/07/2026; Published: 31/07/2026



Copyright: © The Author(s), 2026. This is **Open Access** article, distributed under the terms of the Creative Commons Attribution 4.0 License (<http://creativecommons.org/licenses/by/4.0/>).

juice was also analyzed by Ehigbai *et al.* (2015) to contain flavonoids, steroids, terpenoids, saponins, cardiac glycosides and reducing sugar. Alkaloids, oxalate, phytate, tannin and glycosides were investigated to be present in the fruit peel (Moji *et al.*, 2019). The bioactive composition of the juice powder analyzed by Nur *et al.* (2023) shows it to contain flavonoids, saponins, terpenoids, and steroids.

Alkaloids, steroids, tripenes, flavonoids, saponins, tannins, carbohydrates, reducing sugar, and coumarins were identified as bioactive components in the root (Nazer *et al.*, 2018). The fruit of *Citrus aurantifolia* on analysis present alkaloids, tannins, saponins, cardiac glycosides, coumarins and quinones as phytochemicals (Sandra *et al.*, 2025); the researchers further reveals the quantitative content of alkaloids and saponins to be 0.881%, glycoside, 2.54mg/mL as well as tannins, 4.4mg/mL.

According to Mohammad *et al.* (2018), the stem's bioactive components include alkaloids, flavonoids, steroids, anthraquinone, and carbohydrates. The analysis of the stem bark conducted by Adam *et al.* (2025) reveals high concentration of therapeutic alkaloids, flavonoids, steroids, free anthraquinones, and saponins. The fruit peel was assayed, analyzed and confirmed with evidence of alkaloids, carbohydrate, flavonoids, glycosides, phenolic compound, protein, steroids, terpenoids and tannins (Sana *et al.*, 2025). They further reiterate the phytochemical richness of the fruit peel of *Citrus aurantifolia* by elucidating the total phenolic and flavonoids contents and reveals it to be 81.74 ± 0.126 mg/g and 4.71 ± 0.052 mg/g respectively.

Similarly, an evaluation of the total phenolic and flavonoids content of the methanolic extract of the peel of *Citrus aurantifolia* shows 2010mg/100g phenol, 2.2mg/100g of flavonols and 90mg/100g of flavonoids (Humaira *et al.*, 2024). Essential oil from the peel of *Citrus aurantifolia* was analyzed of its bioactive constituents and D – Limonene, 69.99%; β – pinene, 10.28% and α – pinene 13.08% were observed as the bioactive substances (Quoc *et al.*, 2025). This research evidence is a prove of its usage and a displayed of its therapeutic potential.

Citrus aurantifolia components are useful in the prevention and treatment of a number of illnesses because they have the capacity to scavenge free radicals from the body. *Citrus aurantifolia* juice has a considerable antioxidant activity, according to Ujung *et al.* (2023), with an IC₅₀ of 32.59 mg/mL compared to ascorbic acid's 8.57 mg/mL in an experiment conducted using the 2,2-diphenyl-1-picrylhydrazyl (DPPH) technique. Maha *et al.* (2018) found that the oil extracted from *Citrus aurantifolia* had an antioxidant potential with an IC₅₀ of 21.57 μ g/mL. Additionally, Ehigbai *et al.* (2015) confirm that *Citrus aurantifolia* juice's antioxidant capacity in 2,2-diphenyl-1-picrylhydrazyl (DPPH) radical scavenging method is

significantly greater than that of the standard ascorbic acid.

Also, oil from the peel of *Citrus aurantifolia* displayed significant free scavenging potential at IC₅₀ as the DPPH assay showed it to be 13.99 ± 184 mg/mL and 1.52 ± 0.09 mg/mL respectively. Similarly, extract from the juice powder reveal strong antioxidant activities with an IC₅₀ value of 32.59mg/mL as compared with the ascorbic acid 8.57mg/mL (Nur *et al.*, 2023).

Citrus aurantifolia's parts are medicinally active due to their antioxidant potential and the existence of bioactive compounds, which may explain their efficacy in traditional health management, prevention, and treatment.

Several researches have been conducted on parts of *Citrus aurantifolia* in many regions but this particular search has not been exploited in the research domain where this plant parts are used individually and in combination with other plants to treat ailment like cold, constipation, congestion, fever etc. also, the peel of *Citrus aurantifolia* are considered waste in most cases, after the juice is extracted or consumed, the peel is been thrown away; the medicinal importance is not known to many, and for few that incorporate it for treatment; either the traditional doctors or their patient knows little or nothing about the active ingredients responsible for their medicinal potency, hence, the need to examine the curative components of these plant parts for its full utilization, this will improve medicinal knowledge of these plant parts by all a sundry. In this context, *Citrus aurantifolia*'s bark and fruit peel are assessed for their bioactive compounds and antioxidant properties because they are utilized in local therapies for health management.

2. Materials and Methods

2.1. Materials

Citrus aurantifolia bark and fruit peel, Ferric chloride solution, Pyridine, Gelatin, Sodiumnitropruside, Chloroform, concentrated tetraoxosulphate (vi) acid, Sodium chloride (NaCl), Sodium hydroxide (NaOH), Nitric acid, Ethanol, Hydrochloric acid (HCl), Potassium tetraoxomagganate (vii) solution (KMnO₄), Ascorbic acid, Picric acid, Hydrogen peroxide (H₂O₂), UV Spectrometer, and absolute ethanol for extraction.

2.2. Techniques

2.2.1. Plant collection and preparing samples

Citrus aurantifolia fruit peels and bark were gathered from Imane, Olamaboro, Kogi State. Nigeria. A botanist from Prince Abubakar Audu University Anyigba recognized and verified the plant. The host town of the University, Anyigba is in Kogi east senatorial district, in Dekina local government area. It is centrally positioned and a major pathway to all local government area in the senatorial district.

The University is on latitude 7.4809°N and longitude

7.1875°C. The identified plant was deposited in the department of biology of our institution. The plant parts were cleaned, chopped into small pieces, allowed to dry at room temperature, and then ground into a fine powder. For an efficient extraction, 100g of each was weighed, 300 mL of pure ethanol was added, and the mixture was let to stand for two weeks. After filtering the mixtures, the solutes were extracted sacrificially and kept at room temperature (Leonard *et al.*, 2022).

2.2.3. Estimation of yield extracts

The Percentage (%) yield of the extracted solutes was obtained from Equation 1

$$\% \text{ yield} = \frac{W_e}{W_p} \times 100 \quad (1)$$

where W_e = weight of the extract; W_p = weight of the pulverized sample

2.3. Preparation of solutions

The solutions were prepared as described by Isaac *et al.* (2016).

2.3.1. Preparation of Ascorbic Acid Solution

Ascorbic acid, 0.1g was weighed and dissolved in 100 mL of distilled water to make 0.011mol/dm³ of ascorbic acid.

2.3.2. Preparation of Potassium Permanganate Solution

Potassium permanganate, 0.02g was also weighed and dissolve in 100 mL of distilled water to produce 0.0012mol/dm³ of KMnO₄

2.3.3. Acidification of Potassium Permanganate

KMnO₄ solution was acidified by adding 10 mL of 2M H₂SO₄ solution.

2.4. Phytochemical screenings

The experimental procedure employed for the identification of the bioactive substances of the bark and fruit peel of *Citrus aurantifolia* was that as described by Prashant *et al.* (2011) and Junaid *et al.* (2020). These methods were adopted for its simplicity, accessibility of the reagents and its fast reaction time.

2.4.1. Detection of alkaloids

Picric acid test: The extracts (1g each) were dissolved in diluted hydrochloric acid (HCl) and filtered. The filtrate was then treated with Hager reagent, and the presence of alkaloids would be indicated by the formation of a brown or reddish precipitate (Prashant *et al.* 2011)

2.4.2. Detection of carbohydrates

Benedicts test: The extract, 1g was dissolved in 5mL distilled water and filtered. The filtrate was treated with Benedict reagent and heated gently; formation of orange precipitate would Indicates the presence of carbohydrates (Prashant *et al.*, 2011).

2.4.3. Detection of Glycosides

Concentrated H₂SO₄ test: The extract, 1g was treated with sodium nitropruside in pyridine and sodium hydroxide. Formation of pink to blood red color will indicate the presence of glycosides (Junaid *et al.*, 2020).

2.4.4. Detection of Saponins

Foam test: The extract, 1g was dissolved in 2 mL of water. The solution was shaken and allowed to stand for ten minutes. Persistent foam formation for this period of time would show the presence of saponins (Junaid *et al.*, 2020).

2.4.5. Detection of phytosterols

Salkowski's test: The extract, 1g was treated with Chloroform and filtered. The filtrate was treated with few drops of concentrated sulphuric acid; it was shaken and allowed to stand. Golden yellow colour formation will indicate the presence of phytosterols (Prashant *et al.*, 2011).

2.4.6. Detection of phenols

Ferric Chloride test: The ferric chloride test involved treating 1g of the extract with few drops of ferric chloride solution. The combination was examined for a bluish-black development, which indicated the presence of phenol (Prashant *et al.*, 2011).

2.4.7. Identification of tannins

Braymer's test: A 1% gelatin solution with sodium chloride was added to the extract. The formation of a white precipitate will signify the presence of tannins (Junaid *et al.*, 2020).

2.4.8. Flavonoid detection

Alkaline reagent test: The extract (1g) was treated with a few drops of sodium hydroxide solution; the production of a yellow hue, which becomes colourless upon the addition of weak hydrochloric acid, indicates the presence of flavonoids (Junaid *et al.*, 2020).

2.4.9. Identification of proteins and amino acids

Xanthoproteic test: One gram of the extract was treated with a few drops of strong nitric acid, and the development of a yellow colour indicates the presence of proteins and amino acids (Prashant *et al.*, 2011).

2.5. Antioxidant actions

The radical scavenging technique utilizing acidified potassium permanganate is implemented. This method is employed because of the cost effectiveness of the reagent, very rapid reaction time, and high standard electrode potential capable of detecting a broad range of reducing agents. This method employed ascorbic acid at a concentration of 2.0 mg/mL (specifically 2.0, 1.5, 1.0, 0.5, and 0.25 mL) as an antioxidant. 0.5 mL of acidified KMnO₄ solution and 0.5 mL of hydrogen peroxide (H₂O₂) were formulated as pro-antioxidants. The absorbance of KMnO₄

with ascorbic acid and KMnO_4 with *Citrus aurantifolia* sample extracts (bark and fruit peels) was measured spectrophotometrically at a wavelength of 520 nm following a 30-minute incubation period using UV – VIS 2700 spectrophotometer.

The percentage KMnO_4 radical scavenging effect was determined via Equation 2:

$$\% \text{KMnO}_4 \text{ scavenging effect} = \frac{A_c - A_t}{A_c} \times 100 \quad (2)$$

Where: A_c = Absorbance of control; A_t = Absorbance of the tested sample. (Isaac *et al.*, 2016).

3. Results

3.1. Percentage yield (%)

The percentage yield of the extracts is 10.52% and 8.4% for the bark and fruit peel of *Citrus aurantifolia* respectively

Table 1: Percentage yield (%) of the Bark and Fruit Peel of *Citrus aurantifolia*

Samples	Wtp (g)	Wte (g)	% yield
Bark of <i>Citrus aurantifolia</i>	100	10.50	10.52
Fruit peel of <i>Citrus aurantifolia</i>	100	8.40	8.4

(see Table 1).

3.2. Phytochemical findings

The phytochemical result demonstrates the presence of alkaloids in the fruit peel. Carbohydrates, glycoside, saponins, phenols, tannins, flavonoids, protein and amino acid in both the bark and the fruit peel with the absent of alkaloids in the bark and phytosterols in both the bark and the fruit peel. (Table 2).

3.2. Antioxidant result

The % KMnO_4 radical scavenging effects at EC_{50} for the bark is 81.21% and the fruit peel is 88.57%, the reference ascorbic acid is 82.00%. These competitiveness of the antioxidant potential of the fruit peel and the bark of *Citrus aurantifolia* as compared with the reference ascorbic acid is shown graphically in Fig 1 and Fig 2 below.

Table 2. Parameters, Test conducted, Observations and Results

Parameters	Test conducted	Observations	Results	
			Bark	Fruit peel
Alkaloids	Picric acid test	Yellow precipitate was formed except for the bark	-	+
Carbohydrate	Benedict test	Orange precipitate was formed	+	+
Glycoside	Conc. H_2SO_4 test	Pink to blood red colour was formed	+	+
Saponins	Foam test	There was persistent formation of foam	+	+
Phytosterols	Salkowski's test	Golden yellow colour was not observed	-	-
Phenols	Ferric chloride test	Bluish black colour was formed	+	+
Tannins	Braymer's test	White precipitate was formed	+	+
Flavonoids	Alkaline reagent test	Yellow color was observed on the addition of NaOH solution which turn colourless on addition of HCl	+	+
Protein and amino acid	Xanthoproteic test	Yellow precipitate was formed	+	+

Key: (+) = present and (-) = absent

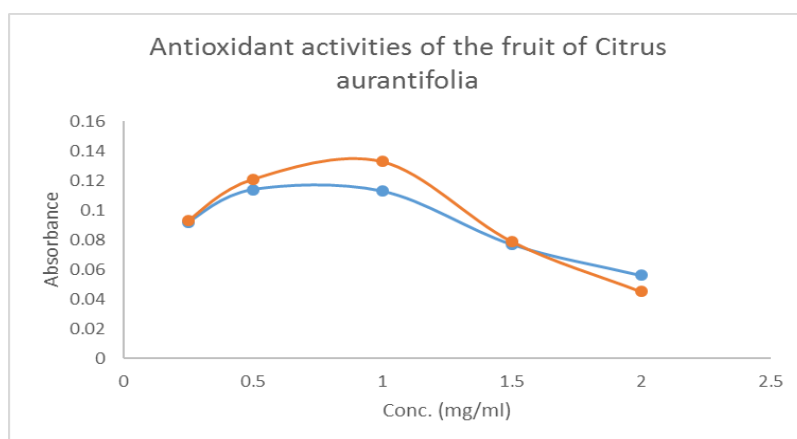


Figure 1. Performance representation of the antioxidant activity of the fruit peel of *Citrus aurantifolia* and standard ascorbic acid. The Blue line-marker represent the Standard and Orange line-marker represent the Sample.

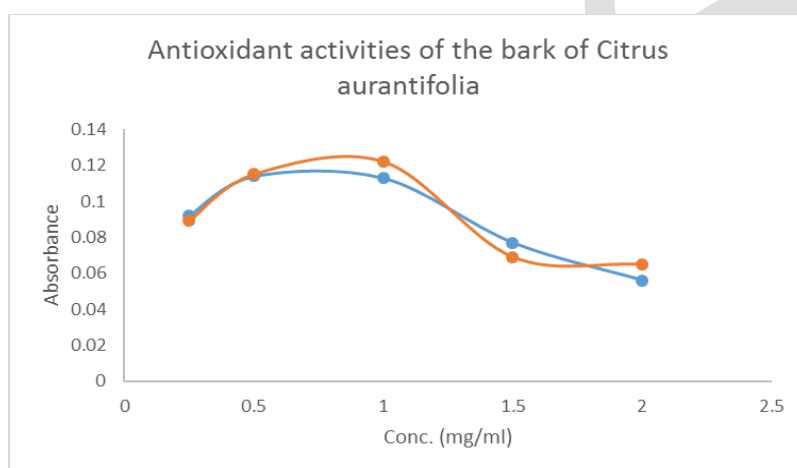


Figure 2. A plot of the performance of the antioxidant activities of the bark of *Citrus aurantifolia* compared with the standard ascorbic acid

4. Discussion

The phytochemical result of this study shows the bark and the fruit peel of *Citrus aurantifolia* to be a potential therapeutic for health management as it discloses some bio – active substances present in both the bark and fruit peel of the plant.

Work conducted previously by some scholars justified the presence of these active substances but with slight variations. Okunlola *et al.* (2019) analyzed the phytochemical constituents of the leaf and bark of *Citrus aurantifolia* in Minna, Nigeria using ethanol as the solvent of extraction, their findings show the presence of phenol, flavonoids, steroids, saponin, tannin, alkaloid, anthraquinone, glycosides in the bark.

In Java Indonesia, Jeffery *et al.* (2020) uses methanol to extract bioactive substances from the fruit peel of *Citrus aurantifolia*; Phenol, flavonoid, steroids terpenoid, saponin, alkaloid were found to be present. Also, in Shimoga, India, the result of phytochemicals as revealed by M' *et al.* (2017) show phenol, flavonoid, steroid, terpenoids, saponin, tannin

alkaloid and glycoside to be present in the fruit peel of *Citrus aurantifolia*.

In a similar vein, Adam *et al.* (2025) in Maiduguri, Borno state, Nigeria present alkaloids, flavonoids, steroids, saponins, tannin as phytochemicals in the stem bark of *Citrus aurantifolia*. Also, alkaloids, flavonoids, carbohydrate, glycosides, phenol, tannins, steroids, protein and terpenoids are confirmed present in the fruit peel (Sana *et al.*, 2025). The stem bark extract show carbohydrate, alkaloids, glycoside, saponin, steroid and phenol (Dhage *et al.*, 2025). This work shows similar bioactive substances except for the absent of pytosteroids in both parts and alkaloids in the bark. These variations could be as a result of the geographical location of the plants, as different location or origin of plants possesses different soil nutritional content and hence different phytoconstituents. Additionally, as different solvents have varying polarity, the extraction solvent may be the cause of the difference.

The antioxidant activities as displayed by the % KMnO_4 radical scavenging effects show that the plant parts; bark and

fruit peel of *Citrus aurantifolia* can scavenge free radical and hence, can be good therapeutics. These findings are in agreement with Jae – Hee *et al.* (2014) where they conducted antioxidant activities on the fruit peel of *Citrus aurantifolia* using DPPH method and reported it to have high antioxidant activity and hence, considered to be use as nutraceutical and as functional agents in food. Similarly, the antioxidant activities of 3 citrus were investigated using DPPH method as reported by Julfi *et al.* (2024), all possesses antioxidant potential with a much stronger antioxidant activity by the fruit peel of *Citrus aurantifolia*. Also, in agreement is the finding of Quoc *et al.* (2025) in a work they conducted in Vietnam on the peel of *Citrus aurantifolia* in DPPH assay, they confirm the peel oil to possess a significant free scavenging potential, they further affirm the antioxidant capacity to the presence of limonene and pinene compounds present in the peel.

Citrus aurantifolia bark and fruit peel have demonstrated that they hold significant medicinal and pharmaceutical value driven by the bioactive compounds present with relevant implications for antioxidant, antimicrobial and green drug development. The plant parts especially the peel waste can be utilized into low - cost active pharmaceutical ingredients and excipients. If careful toxicity analysis and clinical evaluation is conducted, these plant parts could transmit to a safely commercial therapeutic, hand antiseptic, insect repellent and hence full utilization of their medicinal potential.

5. Conclusion

The need to acquire prompt and proper knowledge of medicinal bioactive substances present in plants is of great importance as it helps provide therapeutic knowledge to all and sundry. The bioactive components in *Citrus aurantifolia*'s bark and fruit peel were determined to be carbohydrates, glycosides, saponins, phenols, tannins, flavonoids, protein, and amino acids. These bioactive substances could be responsible for their medicinal potency. The percentage KMnO₄ radical scavenging effects shows the potential of the antioxidant activities of the bark and the fruit peel of *Citrus aurantifolia*; hence, these plant parts can scavenge free radicals from the body, a display of its importance as a good therapeutic and a prove for its use traditionally for prevention and treatment of certain diseases in our locality. These findings can serve as a precursor or lead to scientific drug discovery and medicine by acting as a blueprint for modern prescription medicine and antibiotics as well as providing the bases upon which novel drugs and biotechnology can advance.

Recommendation

This study has demonstrated great therapeutic benefit of *Citrus aurantifolia*'s bark and fruit peel; nonetheless, for

purity and effective efficacy, isolation and standardization into pure forms are strongly advised.

Abbreviations

Wt _p	Weight of pulverized sample
Wt _e	Weight of the extract
EC50	Effective concentration
IC50	Inhibitory concentration

Author Contributions

Leonard Omachoko Abuh:

Conceptualization, Investigation, Validation, Methodology, Writing – Original Draft, Project Administration.

Ugdedejo Emmanuel Omale: Data Curation, Investigation, Formal Analysis, Writing – original draft, Supervision.

Lynda Egene: Data Curation, Investigation, Formal Analysis, Writing - original draft, Supervision.

Acknowledgments

We acknowledge Mr. David Agih, the chief laboratory technologist of the department of chemistry and all the support staff for their time and support in the course of this investigation.

Conflicts of Interest

The authors declare that they have no known competing financial interests, professional affiliations or personal relationships that could have appeared to influence the work reported in this paper.

Funding

None

References

- Adams, S. Mamman, I. A., Samuel, I. D. and Shettima, M. B. (2025). Phytochemical and Elemental analysis of stem bark of *Citrus aurantifolia* (Lime). *International Academic Journal of Advanced Pure and Applied Science Research*, 10(2), 46 – 57.
- Al Namani, J. Baqir, E., Al Abri, A. Al Hubaishi, T., Husain, A. and Khan, S. A. (2018). Phytochemical screening phenolic content and antioxidant activity of citrus aurantifolia L leaves grown in two regions of Omas. *Pharmaceutical science*, 14, 47 – 58
- Bukola, C. A., Temitayo, O. A and Oubusola, A. O. (2016). Phytochemical composition and comparative evaluation of antimicrobial activities of the juice extract of citrus aurantifolia and its silver nano particles. *Nigeria Journal of Pharmaceutical Research*, 12(1). 59 – 64
- Ehigbai, I. O., Ehiwenma, S. O., Faith, E. O. and Kelly, O.

- (2015). Phytochemical, antimicrobial and antioxidant activities of different citrus juice concentrate. *Food science and nutrition*, 4(1), 103 – 109. <http://dx.doi.org/10.1002/fsn3.2681v13i1.242-249>
- Dhage, S., Sarge, S., Shagufta, F., Inge, V., Gaiknad, V. and Ghiware, N. B. (2025). Phytochemical and Pharmacological Evaluation of *Citrus aurantifolia* (Christm) SW Stem and Bark extracts for Antidepressant Activity. *World Journal of Pharmaceutical Science and Research*, 4(2), 1711 – 1718 doi:<https://doi.org/10.5281/zenodo.20026961>
- Healthessential, (2025). 6 Benefits of Lime. Accessed 31st July, 2026 from <https://health.clevelandclinic.org>
- Humaira, A., Lahtisham, U., Massod, S. B., Gulzar, A. N., Seema, R., Teferi, D. M., Suleiman, A. A. and Mohammad, J. A. (2024). Phytochemical and antioxidant profile of Citrus peels extract in relation to different extraction parameters. *Internation Journal of Food Properties*, 27(1), 286 – 299. <https://doi.org/10.1080/10942912.2024.2304274>
- Isaac, K. A., Emmanuel, O., Abraham, Y. M., Francis, M.S., Francis, A. and Linda, M. S. (2016). Development and validation of radical scavenging antioxidant assay using potassium permanganate. *Journal Scientific and Innovation Research*, 5(2), 36 – 42.
- Jae – Hee, P., Minhee, L. and Eunju, P. (2014). Antioxidant activity of orange of flesh and peel extract with various solvent. *Prev. nutri. and food sci.*, doi:10.3746/pnf.2014.19.4.291
- Jeffery, J., Salari, M. H., Kurnia, D. and Sudigdoadi, S. (2020). Inhibition of streptococcus mutans growth induced by the extract of *Citrus aurantifolia* peel. *Journal of Internal Dental & Medical Research*, 13(1), 122 – 127.
- Julfi, R. A., Fildzah, H. S. and Giyatmi, I. N. A. (2024). Comparative study of antioxidant of tropical citrus fruits (fruit & peel). *Journal Teknik Pertanian Lampung*, 13(1), 242 – 249.
- Junaid, R. S. & Patil, M. K. (2020). Quantitative tests for preliminary phytochemical screening: An overview. *International Journal of Chemical studies*, 8(2), 603 – 608. doi:<https://doi.org/10.22271/chemi.2020.v8.i2i8834>
- Leonard, O. A., Salifu, V. and Samuel, A. S. (2022). Dyestuff utilization of the bark of *Parkia biglobosa* grown in Ankpa, Koogi, Nigeria. *FUW Trend in Science and Technology Journal*, 7(2), 862 – 866.
- M', P., Ck, R., V, K., Parveen, S. and L, N. S. (2017). Quantitative phytochemical analysis and antioxidant activities of some citrus fruit of south India. *Asian Journal of Pharmaceutical and Chemical Research*, 10(12), 98. Doi:10.22159/ajper.2017.v10i12.20912
- Maha, S. A., Nour, M. A., Sausan, S. A., Tanveer, A. and Shah, A. K. (2018). Chemical composition and in – vitro antioxidant and antimicrobial activities of essential of *Citrus aurantifolia* leaves grown in Oman. *Journal of Taiban*, 13(2), 108 – 112.
- Micheal, C. (2016). *Citrus aurantifolia* (PROSEA). Accessed 7th November, 2025 from https://www.usen.plantnetproject.org/citrus_au...
- Mohammad, K. N., Mahmood, N. D., Omoye, B., Abdurrahman, A., Kibiru, S. Ibrahim, B., and Umar, K. A. (2018). Phytochemical screening and antioxidant activities of *Citrus sinensis* (L) osbeck (orange) and *Citrus aurantifolia* (christm) swingle (lime) stem from bacterial associated with Dental cares. *Journal of Advance Microbiology*, 8(4), 1 – 4.
- Moji Sola, A. A., Pete, A.D. and Bolaji, A. (2019). Phytochemical composition and antmicrobail activities of citrus *sinensis* and *Citrus auaratifolia* peels on selected pathogenic bacteria isolated from jollof rice. *International Journal of Pathogen Research*, 2(3), 1 – 7. Doi:10.9734/ijpr/2019/v2i330075
- Naomi, V. (2025). 15 Impressive Health Benefits of Lime Peel You Might Know About. Accessed 31st July, 2026 from <https://healthyahoo.com>
- Nazer, H. O. E., Ragaa, S. M. A. and Saad, M. H. A. (2018). Phytochemical screening and assessment of antioxidant and antimicrobial activities of the root extract of tree Sudanese citrus species. *American Journal of Research Communication*, 6(4), 1 – 9.
- Nur, R., Retino, S. and Tutik, S. W. (2023). Phytochemical and Antioxidant Activity, Evaluation of Lime (*Citrus aurantifolia*) juice powder. *Galenike Journal of Pharmacy*. 9(2), 197 – 207. <https://doi.org/10.22487/j24428744.2023.v9.i216347>
- Okunlola, B. M., Ijah, U. I., Yisa, Y. and Aboiye, O. P. (2019). Phytochemicals and Phytodisinfectant, properties of *Citrus aurantifolia* and *Citrus sinensis* for pond water purification GSC. *Biological & Pharmaceuticals science*, 38(2), 34 – 44.
- Omale, M. O., Isah, A. A., Abuh, L. O. and Omale, U. E. (2024). Phytochemical Screening and Antioxidant Activities of the Roots and Leaves of *Citrus aurantifolia* (Lime Orange) grown in Imane, Olamaboro, Kogi, Nigeria. *Shodh Sari-An International Multidisciplinary Journal*, 3(1), 55 – 65. <https://doi.org/10.59231/SARI7654>

- Prashant, T., Bimlesh, K. Mandeep, K. Gupreet, K. and Harleen, K. (2011). Phytochemical screening and extraction. A review. *International Pharmaceutical Sciencia*, 1(1). 98 – 106.
- Quoc, L.P.T. and Phuong, L. B. B. (2025). Essential from Lime peel (*Citrus aurantifolia*) Grown in Long an Province, Vietnam. Chemical Composition and Biological Activities, *Journal of Turkish Chemical Society Association (JOTCSA)*, 12(2), 99 – 106. <https://doi.org/10.18596/jotcsa.1623631>
- Sana, S. S., Supriya, M. K. and Manish, S. H. (2025). Phytochemical analysis and assessment of the in Vitro antimicrobial and antioxidant potential of Citrus X aurantifolia (christm) swingle fruit peel. *Plant Science Today*, 12(3). <https://doi.org/10.14719/pst.7217>
- Sandra, C. O., Cornelius, A. M. and Victor, C. N. (2025). Phytochemical Analysis of Citrus aurantifolia (Lime) Fruit. *World Journal of Advanced Research and Review*, 26(2), 4158 – 4163. doi:10.30574/wjarr.2025.26.2.2113