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**Original Research Article**

# Qualitative and Quantitative Phytochemical Analysis of *Garcinia kola* Seeds and *Datura stramonium* Plant Parts

Happiness Adaekwu Orlu[1]*, Christopher Ejeomo[2], Christopher Unyime Ebong[3], Chioma C. Nwakanobi[4]

[1]Department of Chemistry, Faculty of Science, Rivers State University, Nkpolu-Oroworukwo, Port-Harcourt, P.M.B 5080, Nigeria
[2]Department of Industrial Chemistry, Faculty of Natural and Applied Science, Michael and Cecilia Ibru University, Agbarha-Otor, Ughelli, Delta State, Nigeria'
[3]Zirconex Mining Limited, Abuja, Nigeria
[4]Department of Chemistry, School of Integrative Biological and Chemical Sciences, University of Texas Rio Grande Valley

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***Corresponding author:** Happiness Adaekwu Orlu
Department of Chemistry, Faculty of Science, Rivers State University, Nkpolu-Oroworukwo, Port-Harcourt, P.M.B 5080, Nigeria

## Abstract

This study examined the qualitative and quantitative phytochemical composition of *Datura stramonium* (leaves, flowers, fruits, stems) and *Garcinia kola* (seed and seed coat) using successive solvent extractions and standard phytochemical screening methods. Qualitative phytochemical analysis revealed solvent-dependent variations. In *D. stramonium*, methanol and ethyl acetate extracts of leaves showed the presence of alkaloids, flavonoids, and saponins, while dichloromethane and n-hexane extract predominantly contained alkaloids and steroids. Flowers exhibited alkaloids in all extracts, flavonoids and saponins mainly in methanol and ethyl acetate, and steroids in nonpolar solvents. Fruits displayed alkaloids across all solvents, flavonoids chiefly in methanol, and steroids in dichloromethane and hexane. Stems showed alkaloids in methanol, ethyl acetate, and dichloromethane, with steroids and tannins restricted to dichloromethane and hexane. For *G. kola*, seeds contained alkaloids in methanol and dichloromethane, flavonoids in all solvents, saponins in methanol and dichloromethane, and steroids in ethyl acetate and hexane. The seed coat exhibited alkaloids only in methanol, flavonoids in methanol and dichloromethane, tannins in methanol and dichloromethane, and steroids in ethyl acetate and hexane. Quantitative analysis revealed that alkaloids were highest in *D. stramonium* leaves ($10.60 \pm 0.53\%$) and fruits ($10.40 \pm 0.23\%$) as well as in *G. kola* seeds ($9.30 \pm 0.86\%$). Flavonoids peaked in *G. kola* seeds ($14.00 \pm 0.23\%$) and *D. stramonium* flowers ($7.20 \pm 0.29\%$), while saponins were abundant in *D. stramonium* leaves ($11.40 \pm 0.25\%$) and *G. kola* seeds ($11.50 \pm 0.08\%$). Tannin levels were generally low (<1.30%), with the highest in G. kola seed coat ($1.26 \pm 0.21\%$). In conclusion, the phytochemical richness of *D. stramonium* and *G. kola* validates their traditional use and highlights their potential as valuable sources of bioactive compounds.

**Keywords:** *Datura stramonium, Garcinia kola,* Phytochemicals.



## 1. INTRODUCTION

Medicinal plants have been integral to human healthcare for centuries, serving as primary sources of therapeutic agents in traditional medicine and as precursors for modern pharmaceuticals. Their wide accessibility and bioactive potential have made them indispensable in managing various diseases, particularly in regions where conventional drugs are limited or costly (Ekor, 2014). Over 60% of people in Nigerian rural areas depend on the traditional medicines for the treatment of their ailments. In Nigeria, traditional plants play an important role in the medical system and plants remain an important resource to combat serious diseases worldwide (Ajoko *et al.*, 2020).

Phytochemicals are naturally occurring bioactive compounds present in the leaves, stems, bark, fruits, and roots of medicinal plants. They play vital roles in the defense mechanisms of plants and contribute to protecting both animals and humans that consume them against various diseases. Among these, alkaloids, tannins, flavonoids, and phenolic compounds are considered the most significant due to their wide-ranging pharmacological and therapeutic properties (Amos-Tautua *et al.*, 2020; Ajoko *et al.*, 2020).

Among medicinal plants, *Datura stramonium* (Solanaceae), commonly known as Jimson weed, and *Garcinia kola* (Clusiaceae), or bitter kola, are widely recognized within African and Asian traditional

medicine for their broad pharmacological properties. *Datura stramonium* has long been used to treat respiratory ailments, pain, inflammation, and infections, primarily due to its rich content of tropane alkaloids such as atropine, scopolamine, and hyoscyamine (Soni *et al.*, 2012). Phytochemical surveys of the plant consistently report alkaloids, flavonoids, saponins, tannins, phenolics, and steroids as major constituents (Srivastava & Srivastava, 2020). Despite its medicinal utility, caution is warranted due to its narrow therapeutic window and documented anticholinergic toxicity (Mutebi *et al*., 2022).

Similarly, *Garcinia kola* seeds are valued in ethnomedicine for treating malaria, gastrointestinal disorders, bronchitis, rheumatism, and oral infections (Emmanuel *et al.*, 2022). Phytochemical investigations highlight high levels of flavonoids, particularly kolaviron biflavonoids, alongside alkaloids, phenolics, tannins, glycosides, and steroids, which underlie its antioxidant, anti-inflammatory, antimicrobial, and neuroprotective properties (Tauchen *et al.*, 2023).

While numerous studies report these phytochemical classes, there is a relative paucity of comparative, solvent-dependent qualitative profiling across multiple plant parts, coupled with quantitative assessments of major phytochemicals. Specifically, the influence of extraction polarity on the detection and abundance of alkaloids, flavonoids, saponins, tannins, and steroids remains limited.

Hence, this study aims to investigate the qualitative and quantitative phytochemical profiles of *D. stramonium* (leaves, flowers, fruits, stems) and *G. kola* (seed, seed coat) using solvents of varying polarity (methanol, ethyl acetate, dichloromethane, and n-hexane) and determine the quantitative levels of key phytochemicals. This approach seeks to elucidate solvent-dependent phytochemical distribution and provide a scientific basis for their ethnopharmacological relevance and potential drug development applications.

## 2. MATERIALS AND METHODS

### *2.1 Sample Collection*

Fresh *Datura stramonium* plants were collected from residential areas around Rivers State University Port Harcourt. The plant was identified and authenticated at the Department of Microbiology, Rivers State University, Port-Harcourt. The freshly harvested *D. stramonium* plants were dismembered into the different parts, rinsed with distilled water, and shade-dried on clean aluminium foil lined trays. They were dried to a constant weight to avoid decay during storage. The leaves were dried for 7 days, the flowers took 9 days to dry, the fruits dried for 17 days and the stems dried for 13 days. The dried plant parts were then pulverised to powder using a blender. *Garcinia kola* seeds were dried for 15 days and the seed coat was dried for 6 days. The dried plant materials were then powdered using an electric blender.

Fresh *Garcinia kola* seeds were purchased from a market in Port Harcourt and authenticated by a taxonomist. Fresh *Garcina kola* seeds were purchased from Local markets in Port Harcourt, River's state, Nigeria. The plant was identified and authenticated at the Department of Microbiology, Rivers State University, Port-Harcourt. The seeds were manually peeled to obtain the seed coats. The seeds were chopped into smaller sizes with the aid of a stainless-steel knife. *Garcinia kola* seeds were dried for 15 days and the seed coat was dried for 6 days. The dried plant materials were then powdered using an electric blender.

### *2.2 Extraction of Plant Materials*

A total of 500 g of each powdered plant part was initially extracted with methanol by cold maceration for 72 hours. The mixtures were filtered through Whatman No. 1 filter paper, and the filtrates were concentrated to near dryness under reduced pressure using a rotary evaporator to obtain the crude methanol extracts. The residual marc was then sequentially extracted with solvents of increasing polarity in the following order: n-hexane, dichloromethane (DCM), and ethyl acetate, following the same maceration and filtration procedure. Each filtrate was subsequently concentrated and dried in a water bath maintained at 45 °C to remove residual solvents completely. The dried crude extracts were finally transferred into pre-weighed bottles and stored appropriately until further analysis.

### *2.3 Qualitative Phytochemical Screening*

Crude extracts obtained from leaves, fruits, stems and flowers of *Datura stramonium* as well as the seed and seed coat of *Garcinia kola* were separately tested for the presence of alkaloids, steroids, saponins, flavonoids and glycosides using standard procedures.

#### *2.3.1 Test for Alkaloids*

Into a clean test tube, 2 mL of filtrate was poured and few drops of dilute HCL added. The content was swirled for thorough mixing. The presence of a cloudy cream precipitate indicated the presence of alkaloids.

#### *2.3.2 Test for Flavonoids*

Into a test tube, 2mL of filtrate with few drops of concentrated HCl and magnesium turnings were added. Pink-red coloured precipitate indicated the presence of flavonoids.

#### *2.3.3 Test for Saponins*

Into a test tube, 2 mL of the filtrate with 1ml ammonia solution and1ml lead acetate solution were mixed and shaken vigorously. The observation of a black- green precipitation or deep green foam, indicated the presence of saponins.

#### *2.3.4 Test for steroids (Salkwoski's test)*

5 mL of chloroform was added to about 0.1g of the oil, shaken well and filtered using filter paper. 3 mL of concentrated sulphuric acid was slowly poured into the filtrate through the side of the test-tube. Colour change of reddish-brown at the interface indicates existence of steroids.

#### *2.3.5 Test for Tannins*

Into a test tube, 2 mL of filtrate were added to 10 mL distilled water and a drop of ferric chloride ($FeCl_3$) added. The observation of a blue precipitate indicated the presence of tannins.

### 2.4 Quantitative Determination of Phytochemicals

#### *2.4.1 Determination of Alkaloids*

Alkaloids content was determined according to the procedure of Chukwuma *et.al.* (2016). 200 mL of 10% acetic acid in ethanol was added to 2.5 g of a crude extract in a 250 mL beaker and allowed to stand for 4 hours. The mixture was concentrated by heating it on a water bath, and ammonia solution was added to the extract drop wise until no further precipitate was formed. The precipitate was then left for 3 hours to sediment. After sedimentation, the supernatant was discarded, and the precipitate was washed with 20 mL of 0.1 M ammonium hydroxide and then filtered using 12.5cm Whatman filter paper. The residue was dried in an oven, weighed and the percentage of alkaloid was expressed mathematically as in equation 1.

$$\%\ Alkaloid = \frac{weight\ of\ residue}{weight\ of\ extract} \times 100. \qquad \text{Equation 1}$$

#### *2.4.2 Determination of Flavonoids*

Flavonoids were quantitatively determined by the method reported by Ejikeme *et al.* (2016) with modification. To 2.50 g of crude extract, 50 ml of 80% aqueous methanol was added in a 250 $cm^3$ beaker. The beaker was covered and allowed to stand for 24 hours at room temperature. The resulting supernatant was discarded, and the residue was reextracted (three times) with the same volume of aqueous methanol. Whatman filter paper number 42 (125 mm) was used to filter whole solution of extract. Each extract filtrate (residue) was later transferred into a weighed crucible and evaporated to dryness over a water bath. The content in the crucible was cooled in a desiccator and weighed until constant weight was obtained. The percentage of flavonoid was calculated as (equation 2)

$$\%\ Flavonoid = \frac{weight\ of\ residue}{weight\ of\ sample} \times 100. \qquad \text{Equation 2}$$

#### *2.4.3 Determination of Saponins*

Quantitative determination of saponins was carried out using the method reported by Obadoni & Ochuko, (2002). 100 mL of 20% aqueous ethanol was added to 5 grams of each powdered crude extract in a 250 ml conical flask. The mixture was heated at 55 $^oC$ over a hot water bath for 4 hours with continuous stirring. The residue of the mixture was re-extracted with another 100 $cm^3$ of 20% aqueous ethanol. The extracts were combined and evaporated to 40 $cm^3$ over water bath at 90°C. 20 $cm^3$ of diethyl ether was added to the concentrate in a 250 $cm^3$ separatory funnel and shaken vigorously from which the aqueous layer was recovered while the ether layer was discarded. This purification process was repeated twice. 60 $cm^3$ of n-butanol was added to and extracted twice with 10 $cm^3$ of 5% sodium chloride. After discarding the sodium chloride layer, the remaining solution was heated in a water bath for 30 minutes, after which the solution was transferred into a crucible and was dried in an oven to a constant weight to obtain the residue. The saponin content was calculated as a percentage. (Equation 3)

$$\%\ Saponin = \frac{weight\ of\ residue}{weight\ of\ sample} \times 100. \qquad \text{Equation 3}$$

#### *2.4.4 Determination of Tannins*

Tannin content was quantified using the Folin–Denis's method as described by Ejikeme *et al.* (2014). Folin–Denis's reagent was prepared by refluxing sodium tungstate, phosphomolybdic acid, and phosphoric acid in distilled water for 2 hours, followed by dilution to 100 mL. Saturated sodium carbonate solution was obtained by dissolving anhydrous sodium carbonate in hot water (70 °C), cooling, and decanting the clear supernatant. A tannic acid standard (0.2–1.0 mg/mL) was prepared, reacted with Folin–Denis's reagent and $Na_2CO_3$, incubated at 25 °C for 30 min, and used to generate a calibration curve at 700 nm. For sample analysis, 1 g of powdered plant material was extracted in water, filtered, and reacted similarly with Folin–Denis's reagent and $Na_2CO_3$. Absorbance was read at 700 nm, and tannin content (%) was calculated from the calibration curve and expressed as tannic acid equivalent. The percentage composition of tannin as tannic acid was calculated using equation 3.4.

$$Tannin\ (mg/100g) = \frac{C \times extract\ volume \times 100}{Aliquote\ volume \times weight\ of\ sample} \qquad \text{Equation 3.4}$$

Where C is the concentration of Tannic acid

## 3.0 RESULTS AND DISCUSSION

### Qualitative Phytochemical Analysis of Different Parts of *Datura stramonium*

The phytochemical screening of the different solvent extracts of *D. stramonium* leaves, flowers, fruits, and stems revealed variations in the distribution of secondary metabolites (Table 1). Alkaloids were consistently present in almost all extracts irrespective of the solvent used, except in the n-hexane stem extract where they were absent. The broad presence of alkaloids across all plant parts confirms *D. stramonium* as a rich alkaloid-bearing plant, in agreement with previous reports highlighting tropane alkaloids such as atropine, hyoscyamine, and scopolamine as the principal bioactive compounds of the species (Okwu & Igara, 2009). Their uniform distribution supports the traditional use of different parts of *D. stramonium* in ethnomedicine for analgesic and antispasmodic purposes. Flavonoids were predominantly observed in methanolic and ethyl acetate extracts of leaves and fruits, while the flowers showed detectable levels only in dichloromethane and n-hexane

extracts. Stems showed very limited occurrence. Alum *et al.* (2023) reported that *D. stramonium* leaf and seed extracts had measurable flavonoid contents, with leaves generally having higher flavonoids than seeds. Tannins were scarcely detected, appearing only in dichloromethane stem extracts and in n-hexane extracts of stems. Their limited distribution may indicate either a low abundance in *D. stramonium* or a need for more specialized solvent systems for effective extraction. This finding is consistent with earlier reports that documented the presence of similar phytochemicals in the leaf and seed extracts of *D. stramonium* (Ali & Awoke, 2021; Alum *et al.*, 2023).

**Table 1: Qualitative Phytochemical Analysis of Different Parts of Datura stramonium**

| Phytochemical | Solvent | Leaves | Flowers | Fruits | Stems |
|---|---|---|---|---|---|
| **Alkaloids** | Methanol | + | + | + | + |
| | Ethyl acetate | + | + | + | + |
| | Dichloromethane | + | + | + | + |
| | n-Hexane | + | + | + | - |
| **Flavonoids** | Methanol | + | - | + | - |
| | Ethyl acetate | + | - | - | - |
| | Dichloromethane | - | + | - | - |
| | n-Hexane | - | + | - | - |
| **Saponins** | Methanol | + | + | + | + |
| | Ethyl acetate | + | + | - | + |
| | Dichloromethane | - | - | - | - |
| | n-Hexane | - | - | - | - |
| **Steroids** | Methanol | - | - | - | - |
| | Ethyl acetate | - | - | - | - |
| | Dichloromethane | + | + | + | - |
| | n-Hexane | + | + | + | - |
| **Tannins** | Methanol | - | - | - | - |
| | Ethyl acetate | - | - | - | - |
| | Dichloromethane | - | - | - | + |
| | n-Hexane | - | - | - | + |

**Key:** + = Present; - =Absent

The quantitative analysis of secondary metabolites in the leaves, flowers, fruits, and stems of *D. stramonium* reveals significant variation in the distribution of bioactive compounds across different plant parts (Table 2). These variations are indicative of the distinct physiological roles of the phytochemicals in the plant and have implications for their medicinal and pharmacological applications. Alkaloids were most abundant in the leaves ($10.60 \pm 0.53\%$) and fruits ($10.40 \pm 0.23\%$), compared to the flowers ($4.00 \pm 0.09\%$) and stems ($5.60 \pm 0.91\%$). Alkaloids are nitrogenous secondary metabolites known for their broad pharmacological activities, including analgesic, antispasmodic, and antimicrobial effects (Singh *et al.*, 2010). The high alkaloid content in the leaves and fruits suggests that these parts may serve as the primary source of the plant's bioactive alkaloid compounds, consistent with the traditional use of leaves in herbal remedies for pain relief and respiratory disorders. This broad and relatively high alkaloid content is in line with many earlier investigations that identify tropane alkaloids as predominant constituents of Datura species and report significant alkaloid levels in leaves and seeds (Soni *et al.*, 2012). Flavonoids were most concentrated in the flowers ($7.20 \pm 0.29\%$), followed by the fruits ($6.40 \pm 0.65\%$), stems ($4.50 \pm 0.52\%$), and leaves ($3.40 \pm 0.74\%$). Flavonoids are recognized for their antioxidant, anti-inflammatory, and cardioprotective properties (Harborne & Williams, 2000). The elevated flavonoid content in flowers indicates potential for antioxidant activity, suggesting that floral extracts could serve as a natural source of free radical scavengers. Saponin levels were highest in the leaves ($11.40 \pm 0.25\%$), followed by the stems ($9.60 \pm 0.46\%$), fruits ($8.60 \pm 0.54\%$), and flowers ($6.20 \pm 0.06\%$). Saponins are glycosidic compounds known to possess antimicrobial, immunomodulatory, and cholesterol-lowering properties (Makkar *et al.*, 2007). The high saponin content in the leaves may partly explain their traditional use in managing infections and inflammation. Tannins were present at relatively low levels across all plant parts, with flowers exhibiting the highest concentration ($1.23 \pm 0.07\%$), followed by leaves ($1.03 \pm 0.14\%$), fruits ($0.68 \pm 0.12\%$), and stems ($0.60 \pm 0.02\%$). Tannins contribute to antimicrobial, antiviral, and astringent effects, and their presence in the flowers and leaves may provide additional therapeutic value, particularly in managing infections and gastrointestinal disorders (Edeoga *et al.*, 2005).

**Table 2: Quantitative Phytochemical values of leaves flowers, fruits and stems of *Datura stramonium***

| S/N | Plant sample | Tannin (%) | Alkaloids (%) | Flavonoids (%) | Saponins (%) |
|---|---|---|---|---|---|
| 1 | Leaves | 1.03±0.14 | 10.60±0.53 | 3.40±0.74 | 11.40±0.25 |
| 2 | Flowers | 1.23±0.07 | 4.00±0.09 | 7.20±0.29 | 6.20±0.06 |
| 3 | Fruits | 0.68± 0.12 | 10.40±0.23 | 6.40±0.65 | 8.60±0.54 |
| 4 | Stems | 0.60± 0.02 | 5.60±0.91 | 4.50±0.52 | 9.60±0.46 |

**Qualitative and Quantitative Phytochemical Analysis of *Garcinia kola* Seeds and Seed Coats**

Presented in Table 3 is the qualitative phytochemical analysis of Garcinia kola seeds and seed coats, which revealed the presence of alkaloids, flavonoids, saponins, steroids, and tannins in varying proportions depending on the solvent system and plant part. In the *G. kola* seed extracts, alkaloids, flavonoids, saponins, steroids, and tannins were detected. Alkaloids were present in the methanol and dichloromethane extracts, indicating that they are moderately polar compounds. Flavonoids were detected in all solvent extracts, suggesting that the seed is particularly rich in these compounds, which are known for their antioxidant and anti-inflammatory properties. Saponins were found in the methanol and dichloromethane extracts, while steroids were identified in the ethyl acetate and n-hexane extracts, indicating their non-polar nature. Tannins were also present in the methanol, ethyl acetate, and dichloromethane extracts, confirming that the seed contains significant phenolic compounds. The results are similar to the work of Jackie *et al*. (2014), and Ezeamama *et al*. (2025), who also reported the presence of tannins, saponins, flavonoids, and alkaloids in Garcinia kola seeds.

In the *G. kola* seed coat extracts, alkaloids, flavonoids, steroids, and tannins were detected, while saponins were absent. Alkaloids and flavonoids were mainly present in the methanol extract, indicating a lower concentration compared to the seed. Steroids were found in the ethyl acetate and n-hexane extracts, showing that the seed coat also contains some non-polar phytochemicals. Tannins were observed in the methanol and dichloromethane extracts, reflecting their solubility in polar solvents. The absence of saponins in the seed coat suggests that they are concentrated mainly in the seed kernel.

The results indicate that the seed of *Garcinia kola* possesses a higher diversity and abundance of phytochemicals than the seed coat.

**Table 3: Qualitative Phytochemical Analysis of *Garcinia kola* Seeds and Seed Coats**

| Phytochemical | Solvent | Seeds | Seed Coats |
|---|---|---|---|
| Alkaloids | Methanol | + | + |
| | Ethyl acetate | - | - |
| | Dichloromethane | + | - |
| | n-Hexane | - | - |
| Flavonoids | Methanol | + | + |
| | Ethyl acetate | + | - |
| | Dichloromethane | + | + |
| | n-Hexane | + | - |
| Saponins | Methanol | + | - |
| | Ethyl acetate | - | - |
| | Dichloromethane | + | - |
| | n-Hexane | - | - |
| Steroids | Methanol | - | - |
| | Ethyl acetate | + | + |
| | Dichloromethane | - | - |
| | n-Hexane | + | + |
| Tannins | Methanol | + | + |
| | Ethyl acetate | + | - |
| | Dichloromethane | + | + |
| | n-Hexane | - | - |

**Key:** + = Present; - =Absent

The quantitative phytochemical analysis of *Garcinia kola* seed and seed coat revealed significant differences in the distribution of secondary metabolites between the two plant parts (Table 4). Flavonoids were the most abundant phytochemicals in the seeds (14.00 ± 0.23%), compared to 5.60 ± 0.03% in the seed coat. This observation is consistent with the report of Ibedu *et al.* (2018), who recorded a similarly high flavonoid content

(10.20%) in *G. kola* seed extract, confirming that the seeds are particularly rich in flavonoids. The higher flavonoid content in the seed suggests a greater potential for therapeutic applications targeting oxidative stress-related disorders. Flavonoids are known to possess free radical scavenging and metal-chelating properties, which may account for the protective effects traditionally associated with *G. kola* consumption (Eleyinmi *et al.*, 2006). Alkaloid concentrations were significantly higher in the seed (9.30 ± 0.86%) compared to the seed coat (2.60 ± 0.06%). The elevated alkaloid content in the seed underscores its potential as a source of bioactive compounds for pharmaceutical development. Saponins were detected in higher concentrations in the seed (11.50 ± 0.08%) compared to the seed coat (4.20 ± 0.16%). This finding contrasts with the report of Ibedu *et al.*, (2018), who observed no detectable quantitative presence of saponins in the *G. kola* seed extract. The increased saponin content in the seed may contribute to its broader therapeutic applications. Tannin levels were slightly higher in the seed coat (1.26 ± 0.21%) than in the seed (1.12 ± 0.53%).

**Table 4: Quantitative Phytochemical values of *Garcinia kola* seed and seed coat**

| Plant sample | Tannins (%) | Alkaloids (%) | Flavonoids (%) | Saponins (%) |
|---|---|---|---|---|
| *G. kola* seed | 1.12±0.53 | 9.30±0.86 | 14.00±0.23 | 11.50±0.08 |
| *G. kola* seed coat | 1.26±0.21 | 2.60±0.06 | 5.60±0.03 | 4.20±0.16 |

## CONCLUSION

The phytochemical investigation of *Datura stramonium* and *Garcinia kola* revealed significant qualitative and quantitative variations influenced by plant parts and solvent polarity. Alkaloids were consistently present across all parts of both plants, indicating their broad distribution and pharmacological importance. Flavonoids and saponins predominated in polar solvent extracts, while steroids were mainly associated with nonpolar solvents, highlighting the influence of solvent polarity on phytochemical recovery. Quantitative analysis showed that *D. stramonium* leaves and fruits contained the highest alkaloid levels, while *G. kola* seeds were rich in flavonoids and saponins, supporting their reported antioxidant, antimicrobial, and anti-inflammatory activities. Tannin levels were generally low, reducing concerns of excessive astringency. The results validate the ethnomedicinal uses of both plants and establish their potential as sources of bioactive compounds for pharmaceutical applications. Future studies should focus on bioactivity-guided isolation, structural characterization of active constituents, and pharmacological evaluation to further substantiate their therapeutic value.

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